Appendix A: Project Planning and Development

A-7 Re-evaluation Statement

TAPPAN ZEE HUDSON RIVER CROSSING PROJECT

Re-evaluation Statement

Rockland and Westchester Counties, New York

Federal Lead Agency: Federal Highway Administration

Joint Lead Agencies: New York State Department of Transportation
and New York State Thruway Authority

July 2012

U.S. Department of Transportation
Federal Highway Administration

New York Division

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July 18, 2012

In Reply Refer To:
HEA-NY

Phillip Eng, P.E.
Chief Engineer
New York State Department of Transportation
50 Wolf Road
Albany, New York 12232

Donald R. Bell, P.E.
Acting Chief Engineer
New York State Thruway Authority
200 Southern Boulevard, PO Box 189
Albany, New York 12201-0189

Dear Mr. Eng and Mr. Bell:

We received your July 17 letter transmitting the document titled *Tappan Zee Hudson River Crossing Project Re-evaluation Statement* for the Tappan Zee Hudson River Crossing Project, PIN 8TZ1.00. The project is located in Rockland and Westchester counties.

In accordance with 23 Code of Federal Regulations 771.130 this document was prepared by the New York State Thruway Authority (NYSTA), New York Department of Transportation (NYSDOT) and the Federal Highway Administration (FHWA). This *Tappan Zee Hudson River Crossing Project Re-evaluation Statement* considers project design refinements and other new information received subsequent to the publication of the Draft Environmental Impact Statement (DEIS) for the subject project in January 2012. The purpose of this re-evaluation is to determine whether a Supplemental DEIS (SDEIS) should be prepared for the project in accordance with the National Environmental Policy Act (NEPA) prior to the issuance of the Final EIS (FEIS).

After review of the documentation, we concur with the NYSTA and NYSDOT conclusion that the refinements to the project design and new information received subsequent to the publication of the DEIS do not have the potential to result in significant environmental impacts that were not previously evaluated in the DEIS. Therefore, further evaluation of these changes through an SDEIS is not necessary, and the environmental review of the project should proceed with an FEIS.

If you have any questions or concerns, please contact John Burns at 518-431-8875.

Sincerely,

Jonathan D. McDade
Division Administrator

cc:
Ted Nadratowski, NYSTA
Dave Capobianco, NYSTA
Mike Anderson, NYSDOT

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July 17, 2012

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Attn: John Burns, P.E.. Major Projects Engineer, HDO-NY
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Re: Re-evaluation Statement
PIN 8TZ1.00, Tappan Zee Bridge Hudson River Crossing Project
Rockland and Westchester Counties

Dear Mr. McDade:

The New York State Department of Transportation and the New York State Thruway Authority ("the agencies") have prepared a Re-evaluation Statement considering project design refinements and other new information received subsequent to the publication of the Draft Environmental Impact Statement (DEIS) for the subject project. The Re-evaluation Statement has been prepared in close coordination with your staff.

Under separate cover, you will be receiving a copy of the Re-evaluation Statement and Exhibits.

If you have any questions, please contact Michael Anderson, P.E., Project Director, NYSDOT, or David Capobianco, P.E., NYSTA.

Sincerely,

Phillip Eng, P.E.
Chief Engineer, NYSDOT

Donald R. Bell
Donald R. Bell, P.E.
Acting Chief Engineer, NYSTA

Tappan Zee Hudson River Crossing Project
Re-evaluation Statement

1-1 INTRODUCTION

This re-evaluation statement considers project design refinements and other new information received subsequent to the publication of the Draft Environmental Impact Statement (DEIS) for the Tappan Zee Hudson River Crossing Project in January 2012. The purpose of this re-evaluation is to determine whether a Supplemental DEIS (SDEIS) should be prepared for the project in accordance with the National Environmental Policy Act (NEPA) and the New York State Environmental Quality Review Act (SEQRA) requirements prior to the issuance of the Final EIS (FEIS).

As provided by Federal Highway Administration (FHWA) regulations, 23 CFR 771.130:

(a) A draft EIS, final EIS, or supplemental EIS may be supplemented at any time. An EIS shall be supplemented whenever the Administration determines that:

1. Changes to the proposed action would result in significant environmental impacts that were not evaluated in the EIS; or

2. New information or circumstances relevant to environmental concerns and bearings on the proposed action or its impacts would result in significant environmental impacts not evaluated in the EIS.

(b) However, a supplemental EIS will not be necessary where:

1. The changes to the proposed action, new information, or new circumstances result in a lessening of adverse environmental impacts evaluated in the EIS without causing other environmental impacts that are significant and were not evaluated in the EIS.

Accordingly, this re-evaluation uses the following criteria to evaluate the project design refinements and new information discussed herein:

- Whether or not the changes to the proposed action or new information regarding the proposed action or its impacts would result in significant impacts not evaluated in the DEIS.

Specifically, this re-evaluation documents the potential environmental significance of the following project refinements and new information:

- Design refinements to the Replacement Bridge Alternative, including a lower profile at the Rockland County landing;
- Toll revenue bonds to finance the project;

- Revised Biological Assessment (BA) and Essential Fish Habitat (EFH) Assessment and the issuance of a Biological Opinion (BO) and EFH conservation recommendations from the National Marine Fisheries Service (NMFS);
- The results of a draft analysis to be used by the U.S. Coast Guard (USCG) for its General Conformity Determination under the Clean Air Act in support of the project's General Bridge Permit application;
- The outcome of consultation with the U.S. Fish and Wildlife Service (USFWS) under Section 7 of the Endangered Species Act;
- Results of sediment sampling and subsequent determinations by the U.S. Army Corps of Engineers (USACE) and U.S. Environmental Protection Agency (USEPA) with respect to the transport of dredged materials to the Historic Area Remediation Site (HARS); and
- Refined analysis of hydroacoustic effects and ambient noise based on the results of the project's Pile Installation and Demonstration Program (PIDP).

This re-evaluation has been prepared in accordance with 23 CFR 771.130 as well as 6 NYCRR Part 617 and 17 NYCRR Part 15. The included exhibits thoroughly document the assessment of impacts and the determination of magnitude to support the summaries presented in this re-evaluation statement.

Because the design refinements and new information considered in this re-evaluation would not significantly impact the environment in a way not previously considered in the DEIS, it is not necessary to prepare an SDEIS, and the environmental review of the project should proceed with an FEIS.

1-2 ASSESSMENT OF NEW INFORMATION AND PROJECT CHANGES

1-2-1 DESIGN REFINEMENTS

Based on comments received on the DEIS regarding the impacts of the Replacement Bridge Alternative on parklands, historic resources, and the South Broadway Bridge in South Nyack, the New York State Department of Transportation (NYSDOT) and the New York State Thruway Authority (NYSTA) explored design modifications to lower the profile of Interstate 87/287 in Rockland County. **Table 1** and **Exhibit 1-1A** and **1-1B** present the proposed modifications to the Replacement Bridge Alternative. As a result of these modifications, the Replacement Bridge Alternative no longer requires replacement of the South Broadway Bridge or acquisition of two historic properties and two parkland properties.

Overall, the refinements at the Rockland County landing would result in fewer environmental impacts than those identified in the DEIS as described below.

- **Transportation:** The design refinements would have no effect on long-term traffic, maritime, or non-motorized (pedestrian and bicycle) vehicle operations as compared to the analysis presented in the DEIS.

Table 1
Proposed Design Refinements

Replacement Bridge Alternative (DEIS)	Replacement Bridge Alternative with Refinements
Western limit of construction on I-87/287 ends approximately 150 feet west of South Broadway Bridge	Western limit of construction on I-87/287 ends approximately 300 feet east of the South Broadway Bridge
Reconfiguration of the Rockland County landing would require reconstruction of the South Broadway Bridge slightly east of its existing location	Revisions to the vertical alignment of the Rockland County landing eliminate the need to replace the South Broadway Bridge
12 parcels were identified for full or partial acquisition or temporary easements along the right-of-way in Rockland County. One small permanent easement would be required in Westchester County. The property acquisitions would result in the relocation of nine households	The project would result in a small partial acquisition and permanent easement from a large apartment complex in the Village of South Nyack and a condominium complex in the Village of Tarrytown, and easement from New York Central Railroad in Westchester County, and acquisition of a river parcel owned by the Village of Tarrytown. No property owners or residents would be displaced.
Increase in elevation of the western approach roadway in proximity to 3 River Road / Bight Lane -approximately 4-7 feet under the Short Span Option, compared to the existing approach, and up to 30 feet under the Long Span Option, as presented in the DEIS	Increase in elevation of the western approach roadway in proximity to 3 River Road / Bight Lane - approximately 5 feet over existing elevation for both the Short and Long Span Options with addition of a potential noise barrier based on input from property owners and residents
Superstructure depth as it crosses River Road – approximately 15 feet under the Short Span and 40 feet under the Long Span	Superstructure depth as it crosses River Road - approximately 6-8 feet under the Short and Long Spans. Superstructure depth under the Short Span – 10 feet. Superstructure depth under the Long Span – 10-40 feet between Rockland County landing and Pier 5, and 40 feet for remainder of superstructure.
The shared-use path would terminate on the north side of I-87/287 at South Broadway in South Nyack	The shared-use path would terminate at Smith Avenue just west of the Bradford Mews apartments in South Nyack

- **Community Character:** The design refinements at the Rockland County landing would no longer require a permanent acquisition of the unnamed green space in South Nyack and views from Grandview-on-Hudson would be improved as compared to the design presented in the DEIS. There would be no substantial change in the previously predicted results of the traffic, air quality, and noise analyses that would adversely impact neighborhood character. Therefore, the design refinements would not change the conclusions of the DEIS with respect to community character.

- **Land Acquisition, Displacement, and Relocation:** The design refinements to the Rockland County landing would result in less property acquisition than was identified in the DEIS. The DEIS identified the need to acquire, in full or in part, 11 parcels in South Nyack and one parcel Tarrytown. The proposed design refinements would result in a partial fee acquisition and a small permanent easement of a large apartment complex in Rockland County. In Westchester County, the design refinements require a partial fee acquisition and a permanent easement from a condominium complex, an easement over Metro-North Commuter Rail Road's Hudson Line, and acquisition of a river parcel owned by the Village of Tarrytown. Whereas the DEIS design would have resulted in the displacement of nine households, the proposed design refinements would not displace any households.

- **Parklands and Recreational Resources:** The design refinements would eliminate the need for a temporary easement at Elizabeth Place Park, and the temporary and permanent acquisition of the unnamed green space across South Broadway from Elizabeth Place Park.
- **Socioeconomic Conditions:** The design refinements would eliminate the need to displace nine households in Rockland County. As it would result in no residential displacement and the acquisition of less private property, it would have less impact on tax revenues in both Westchester and Rockland Counties compared to the design presented in the DEIS.
- **Visual and Aesthetic Resources:** The design refinements would lessen adverse visual impacts as compared to the design presented in the DEIS. However, like the DEIS design, the greater height and depth of the western approach in the Hudson River under the Short Span Option and Long Span Option for the refined Replacement Bridge Alternative would obstruct views to the Hudson River and Westchester County land mass from a limited number of residences on River Road as compared to the No Build Alternative, resulting in adverse visual impacts. The construction of a possible new noise barrier along the south side of the Interstate 87/287 right-of-way in Rockland County under the Short Span Option and Long Span Option would obstruct views to the Hudson River and Westchester County land mass from a limited number of residences not screened by vegetation on Bight Lane (at River Road) and at lower elevations on Ferris Lane. While these impacts would remain with the design refinements, these impacts were analyzed and identified in the DEIS.
- **Historic and Cultural Resources:** The design refinements would have no effect on previous conclusions with respect to archaeological resources. As the lowered Rockland County landing would no longer require reconstruction of the South Broadway Bridge, the historic properties at 78 Smith Avenue and 21 Cornelison Avenue would not be acquired and demolished. Therefore, the refinements would eliminate an adverse effect on the South Nyack Historic District. The executed Section 106 Memorandum of Agreement reflects the refinements in the Rockland County landing and the resultant change in the effects determination for the South Nyack Historic District.
- **Air Quality:** The design refinements would not change vehicle volumes or substantially alter emissions characteristics; therefore, it would result in no changes in regional or local air quality compared to the analysis in the DEIS.
- **Noise:** The refined Rockland County landing would nominally change noise levels at nearby receptor sites. As predicted in the DEIS, there would be exceedances of Noise Abatement Criteria (NACs) at properties south of the Interstate 87/287 right-of-way in Rockland County, and a noise barrier is recommended to abate this impact (see **Exhibit 1-2**). The design refinements would also result in an exceedance of the NACs at one property north of the Interstate 87/287 right-of-way, which was not predicted in the DEIS. Therefore, an additional noise barrier is recommended along the north side of the Interstate 87/287 right-of-way in Rockland County to abate the impact on this property. With this barrier, noise levels at this property would be less than shown in the DEIS. There would be no change in impacts or mitigation in Westchester County.

- **Energy and Climate Change:** The design refinements would not change vehicle volumes or other operational characteristics of the Replacement Bridge Alternative. Therefore, there would be no changes in the DEIS conclusions with respect to energy and climate change.
- **Topography, Geology, and Soils:** The design refinements would require less cut and fill activity than was previously predicted.
- **Water Resources:** The design refinements would result in an approximately 20,000 square foot reduction in impervious surface at the landing itself, but there would be an overall increase in impervious area of approximately 9,000 square feet for the entire Replacement Bridge Alternative. However, this change in surface area would only minimally change total pollutant concentrations compared to the DEIS analysis and would not result in an impact on water quality.
- **Ecology:** The design refinements would not alter the analysis or conclusions of the DEIS with respect to ecological resources.
- **Hazardous Waste and Contaminated Materials:** The design refinements would avoid the demolition of residential structures, and therefore, could reduce the amount of contaminated materials abatement that would be required for implementation of the Replacement Bridge Alternative.
- **Construction Impacts:** The design refinements eliminate the need to reconstruct the South Broadway Bridge; thereby, avoiding certain construction impacts in South Nyack. Nonetheless, NYSDOT and NYSTA would continue to implement the Environmental Performance Commitments (EPCs) and other mitigation measures identified in the DEIS.
- **Environmental Justice:** The DEIS did not predict any disproportionately high and adverse effects on environmental justice communities. As described above, the design refinements would result in the same or less impacts as the design presented in the DEIS.
- **Coastal Area Management:** The Replacement Bridge Alternative would continue to be subject to a coastal zone consistency determination. Overall, the proposed design refinements would not substantively change the consistency determinations identified in the DEIS.
- **Indirect and Cumulative Effects:** The design refinements would avoid the reconstruction of the South Broadway Bridge and associated property acquisition, but otherwise, it would not substantively change construction or operation of the Replacement Bridge Alternative. There would also not be changes in other foreseeable projects identified in the DEIS. Therefore, the design refinements would not result in new or different indirect or cumulative effects.

The impacts of the design refinements have been identified, and these impacts are less than or comparable to the anticipated impacts documented in the DEIS. Because the design refinements would not significantly impact the environment in a way not previously considered in the DEIS, it is not necessary to prepare an SDEIS based on these changes.

1-2-2 TOLL REVENUE BONDS

Subsequent to publication of the DEIS, toll revenue bonds have been identified as a means to finance the Replacement Bridge Alternative (see **Exhibit 3-1**). The potential toll adjustments would not change the project limits, and therefore, would not impact physical conditions, property requirements, or natural resources in the study area (i.e., community character, parklands and recreational resources, visual and aesthetic conditions, historic and cultural resources, noise and vibration, energy and climate change, topography, geology and soils, water quality, ecology, hazardous materials, or construction impacts). Because toll adjustments have the potential to divert traffic to other Hudson River crossings, analyses were conducted to assess the maximum volume of traffic that would be diverted as well as the resulting effects on local and regional air quality. In response to environmental justice concerns, potential economic effects on low-income and minority households were also examined. The economic and environmental ramifications of the toll adjustments are discussed in this section.

- **Transportation:** The New York Metropolitan Transportation Council (NYMTC) Best Practices Model (BPM) was run for the 2017 analysis year to determine the potential diversions that may result from toll adjustments. The model assessed the potential traffic diversions to other Hudson River crossings as a result of the toll adjustments at the Tappan Zee Bridge (see **Exhibit 3-1**). The analysis assumed a worst-case scenario under which the new car and truck tolls at the Tappan Zee Bridge would be equal to the Port Authority of New York and New Jersey (PANYNJ) tolls for 2017 at its Hudson River crossings. The analysis examined potential diversions to the following Hudson River crossings: George Washington Bridge, the Lincoln and Holland Tunnels, the Bear Mountain Bridge, and the Newburgh-Beacon Bridge. After assessing factors including travel time, cost, congestion, and trip distance, the worst-case scenario predicted a diversion of approximately 8 percent (620 of the 7,300) eastbound AM peak hour vehicles from the Tappan Zee Bridge to other Hudson River Crossings. Approximately 380 of these diverted vehicles would use the George Washington Bridge. Considering the many approaches to that crossing as well as the overall volumes on that bridge in general, these impacts would be minimal. Projected estimates of the change in daily vehicle miles of travel (VMT) in the NYMTC region indicate that a very small (0.06 percent) decrease in regional VMT would result from the analyzed worst-case toll adjustment.
- **Socioeconomic Conditions.** The toll diversion analysis revealed only minimal diversion or elimination of trips. As this analysis found minimal diversion or elimination of trips, it is not expected that the potential toll adjustments would result in regional shifts in employment and housing in Rockland or Westchester County. This is consistent with other studies and assessments of the socioeconomic impact of both newly implemented tolling or increases to existing tolls. In an FEIS recently completed in 2011 for the Columbia River Crossing,[1] transportation demand and potential residential and commercial development scenarios with and without tolling on the proposed river crossing forecast only minimal changes in employment location and housing demand. Other research such as an assessment of broader

[1] http://www.columbiarivercrossing.org/FileLibrary/FINAL_EIS_PDFs/CRC_FEIS_Chapter3_S4_Land_Use_and_Economic_Activity.pdf

issues such as congestion pricing (toll-ring strategies) or the costs of transportation (such as gasoline pricing) in the United States and in Europe, generally have similar conclusions regarding the relatively small impact on business location decision-making, housing and workplace choices. The studies reviewed include: “Transport and Location Effects of Road Pricing: A Simulation Approach,” “The Importance of Transport in Business’ Location Decisions,” “Location Choice vis-à-vis Transportation: The Case of Recent Homebuyers,” and “The Effect of Gasoline Prices on Household Location.”[1]

- **Air Quality:** The traffic diversion analysis was reviewed in detail to determine if air quality analyses are required (see **Exhibit 2-2**). Overall, the diversions would result in lower regional VMT and would not change vehicle mix or substantially change vehicle speeds (diversions are mostly on highway routes, and the use of local routes for the diverted trips near their origin and destination points would be similar if not identical); therefore, the toll increase would not adversely affect regional air quality. Traffic volume increases along diversion routes were also examined, and it was found that local increases would screen out under NYSDOT’s The Environmental Manual (TEM) guidance.

  The Interagency Consultation Group (ICG) for air quality conformity in New York State includes representatives from FHWA, the Federal Transit Administration (FTA), USEPA, the New York State Department of Environmental Conservation (NYSDEC), NYSDOT, and the Metropolitan Planning Organizations. In accordance with the transportation conformity regulations and associated USEPA guidance, the ICG concurred that the vehicle diversions, including truck trips, resulting from potential toll adjustments on the Tappan Zee Bridge do not significantly increase the volumes on any affected roadways on the diversion routes. The estimated volume increases on the affected roadways are also below the NYSDOT thresholds for requiring a CO “hot-spot” analysis. Therefore, per 40 CFR Parts 93.116 and 93.123, the vehicle diversions due to potential future toll adjustments will not cause or contribute to any new localized CO, PM_{10}, and/or $PM_{2.5}$ violations, increase the frequency or severity of any existing CO, PM_{10}, and/or $PM_{2.5}$ violations, or delay timely attainment of any National Ambient Air Quality Standards (NAAQS) or any required interim emissions reductions or other milestones.

- **Environmental Justice.** The effects of the potential toll adjustments on minority and low income populations were examined to determine if there would be any disproportionately high and adverse impacts on environmental justice communities (see **Exhibit 2-3**). An analysis determined that the potential toll adjustments would not result in any disproportionately high and adverse effects on minority and low-income populations.

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[1] http://www.federalreserve.gov/pubs/feds/2010/201036/201036pap.pdf; http://www.ce.utexas.edu/prof/kockelman/public_html/TRB06HomeChoice.pdf; http://www.stopstanstedexpansion.com/documents/SSE10_Appendix_9.pdf; http://docserver.ingentaconnect.com/deliver/connect/lse/00225258/v35n3/s5.pdf?expires=1339438132&id=69235135&titleid=1311&accname=Guest+User&checksum=2C7E5D3BDFB68601C8F9F1DC9C9C5FDD

Because the potential toll adjustments would not significantly impact the environment in a way not previously considered in the DEIS, it is not necessary to prepare an SDEIS based on these changes.

1-2-3 BIOLOGICAL ASSESSMENT, ESSENTIAL FISH HABITAT (EFH) ASSESSMENT, AND BIOLOGICAL OPINION

In support of the project's consultation with NMFS pursuant to Section 7 of the Endangered Species Act (ESA), the DEIS included a draft Biological Assessment (BA) to determine the potential impacts of the Replacement Bridge Alternative on threatened and endangered fish species. In response to comments received from NMFS and NYSDEC on the DEIS and the draft BA, additional analyses were performed to estimate the effects of project activities on shortnose and Atlantic sturgeon. The additional analyses were presented in a revised BA, which was submitted to NMFS in April 2012. That assessment used benchmarks to establish potential effects to sturgeon that were based on West Coast interim criteria for onset of physiological effects on fish. The analyses relied on a conservative cumulative sound exposure level (SEL_{cum}) of 187 dB re 1 $\mu Pa^2 \cdot s$ for onset of physiological effects and considered higher levels of cumulative noise for onset of injury and mortality.

In their Biological Opinion (BO), NMFS provided an analysis of effects on shortnose and Atlantic sturgeon that relied on the Peak Sound Pressure Level (SPL) (of a single strike) criterion to assess the potential number of sturgeon affected by pile driving activities (see **Exhibit 3**). Based on this analysis NMFS concluded that the number of sturgeon that may experience physiological impacts would be limited to 70 or fewer shortnose sturgeon and 70 or fewer Atlantic sturgeon for the Short Span Option, and 43 or fewer shortnose and 43 or fewer Atlantic sturgeon for the Long Span Option. These estimates are less than those predicted in the DEIS and the revised BA. NMFS further anticipates serious injury or mortality of no more than one shortnose sturgeon and no more than one Atlantic sturgeon for either bridge option for pile driving activities. NMFS based its estimates for Atlantic sturgeon effects on estimates derived for shortnose sturgeon and on the fact that Atlantic sturgeon is less abundant than shortnose sturgeon in the Hudson River.

In its BO, NMFS indicated that the proposed dredging activities at the site may result in three or fewer shortnose sturgeon and three or fewer Atlantic sturgeon captured over the three year dredging period. NMFS also indicated that they expected no more than one of the three shortnose and one of the three Atlantic sturgeon captured to be injured or killed during dredging operations.

An Essential Fish Habitat (EFH) Assessment was published with the DEIS in January 2012. Subsequent to publication of the DEIS, NMFS issued comments on the EFH. The EFH was updated in response to NMFS comments and was provided to NFMS in April 2012. NMFS conservation recommendations, which were issued in June 2012, are based on the April 2012 EFH.

Because the information in the revised BA and EFH Assessment as well as the BO and EFH conservation recommendations would not significantly impact the environment in a way not previously considered in the DEIS (and in fact demonstrate a lessening of the adverse environmental impacts identified in the DEIS), it is not necessary to prepare an SDEIS based on this information.

1-2-4 CONFORMITY WITH STATE AIR QUALITY IMPLEMENTATION PLANS

The DEIS included a detailed analysis of the potential air quality impacts associated with construction and operation of the Replacement Bridge Alternative. During the long-term operation of the project, no exceedances of the NAAQS were predicted. To reduce pollutant emissions during construction, a number of EPCs were proposed which would substantially reduce emissions from diesel engines. With these EPCs, the DEIS concluded that construction activities would not result in any exceedances of the NAAQS. There has been no change with respect to these conclusions.

The DEIS also included a description of the emissions associated with dredging operations which the USEPA requested in support of a General Conformity Determination (GCD) that they believed at that time would be necessary for the issuance of a permit from USACE. Subsequent to publication of the DEIS, USCG also requested a similar accounting of emissions, but for the entire multi-year bridge construction process for their GCD in support of the project's permit application under the General Bridge Act of 1946. Therefore, in support of USCG's GCD, the project sponsors have prepared a conformity analysis (see **Exhibit 4**), which concludes that the project activities subject to the USCG Bridge Permit would conform to the State Implementation Plan (SIP).

Because the results of the draft analysis to be used by USCG for their general conformity determination would not significantly impact the environment in a way not previously considered in the DEIS, it is not necessary to prepare an SDEIS based on this information.

1-2-5 ENDANGERED SPECIES CONSULTATION

The DEIS analyzed potential effects to three species that are listed on the USFWS database as occurring within Rockland and/or Westchester Counties, including the bog turtle (*Clemmys muhlenbergii*), the New England cottontail (*Sylvilagus transitionalis*), and the Indiana bat (*Myotis sodalis*). The analysis presented in the DEIS concluded that there would be no effect on the bog turtle or New England cottontail based on lack of appropriate habitat for these species within the study area. Regarding the Indiana bat, the DEIS stated that the study area is within sufficient proximity to a known bat hibernaculum in Ulster County for individuals associated with this hibernaculum to possibly migrate to, and establish a breeding site within, the study area.

The DEIS further indicated that additional coordination with USFWS would occur prior to the publication of the FEIS. Since the publication of the DEIS, FHWA has initiated an informal consultation under Section 7 of the Endangered Species Act (ESA) for these three species. The conclusions of the additional consultation remain the same as those discussed in the DEIS, including a "no effect" determination for the bog turtle and New England cottontail and a "may affect, but not adversely affect" determination for the Indiana bat. As part of its consultation with USFWS, FHWA has committed to restrict the project's removal of four-inch diameter trees so that these trees are only removed during the Indiana bat's winter hibernation season (October 1 through March 31). **Exhibit 5** presents the Section 7 consultation and related correspondence, including the USFWS concurrence letter.

Because the outcome of the additional Section 7 ESA consultation with USFWS concluded that the project would not significantly impact the environment in a way not previously considered in the DEIS, it is not necessary to prepare an SDEIS based on this information.

1-2-6 HISTORIC AREA REMEDIATION SITE

The DEIS analyzed the potential impacts associated with the transport and disposal of dredged material to the Historic Area Remediation Site (HARS). Since publication of the DEIS, the required sediment sampling and analysis in support of the permit application to the USACE for the transport and placement of that material at HARS was undertaken. Based on that sampling, the USEPA and USACE determined that the sediment resulting from Stages 1 and 2 of the dredging program would be suitable for placement at the HARS.

Because the results of sediment sampling and subsequent determinations by USACE and USEPA found that the transport of dredged materials to the HARS would not significantly impact the environment in a way not previously considered in the DEIS, it is not necessary to prepare an SDEIS based on this information.

1-2-7 PILE INSTALLATION AND DEMONSTRATION PROGRAM

The DEIS included an extensive analysis of the hydroacoustic effects of pile driving on the aquatic resources of the Hudson River, particularly as it relates to the endangered shortnose and Atlantic Sturgeon as well as the species protected under EFH. The DEIS also described EPCs to minimize adverse effects on these resources. Many of these measures focused on minimizing the in-water noise associated with the driving of large diameter steel pipe piles that would be necessary to construct the project's foundations in the soft river sediments. The results of the analysis were reflected in the DEIS and draft BA.

A Pile Installation Demonstration Program (PIDP) was conducted in the spring of 2012. The PIDP provided detailed data on the short- and long-range transmission of noise from pile driving within the Hudson River as well as information related to the efficacy of various EPCs identified in the DEIS. A total of seven test piles, at four sites, ranging in size from 4 to 10-feet in diameter were installed between April 28 and May 18, 2012. Hydroacoustic monitoring was performed at one short-range and 11 long-range sites during the program. Noise data were collected during both vibratory and impact hammering. The measurements indicated that the modeled impacts in the DEIS of pile driving were conservative and overstated the sound levels expected during the actual construction. The DEIS modeling did not account for the presence of barges. As confirmed by the PIDP, barges tend to substantially reduce the transmission of noise beyond the area of the barge. In addition, the testing of the various noise attenuation systems demonstrated that they all exceeded attenuation of 10 dB assumed in the DEIS analysis. Peak SPL noise levels were reduced up to 17 dB while rms SPL values were reduced by up to 16 dB.

The results of the PIDP ambient noise monitoring conducted on the Rockland and Westchester County shorelines was used to adjust the noise source levels contained within the FHWA's Roadway Construction Noise Model (RCNM) for impact pile driving. While the estimated noise level at 50 feet from the pile driving operation in the field was higher than shown in the RCNM, the predicted impacts were similar to those in the

DEIS. In fact, due to additional noise abatement measures proposed for the construction of the project, the maximum noise predicted levels based on the model adjustments are lower than those estimated in the DEIS at many locations.

Because the analysis of hydroacoustic effects and ambient noise based on the results of the PIDP would not significantly impact the environment in a way not previously considered in the DEIS (and in fact demonstrate a lessening of the adverse environmental impacts identified in the DEIS), it is not necessary to prepare an SDEIS based on this information.

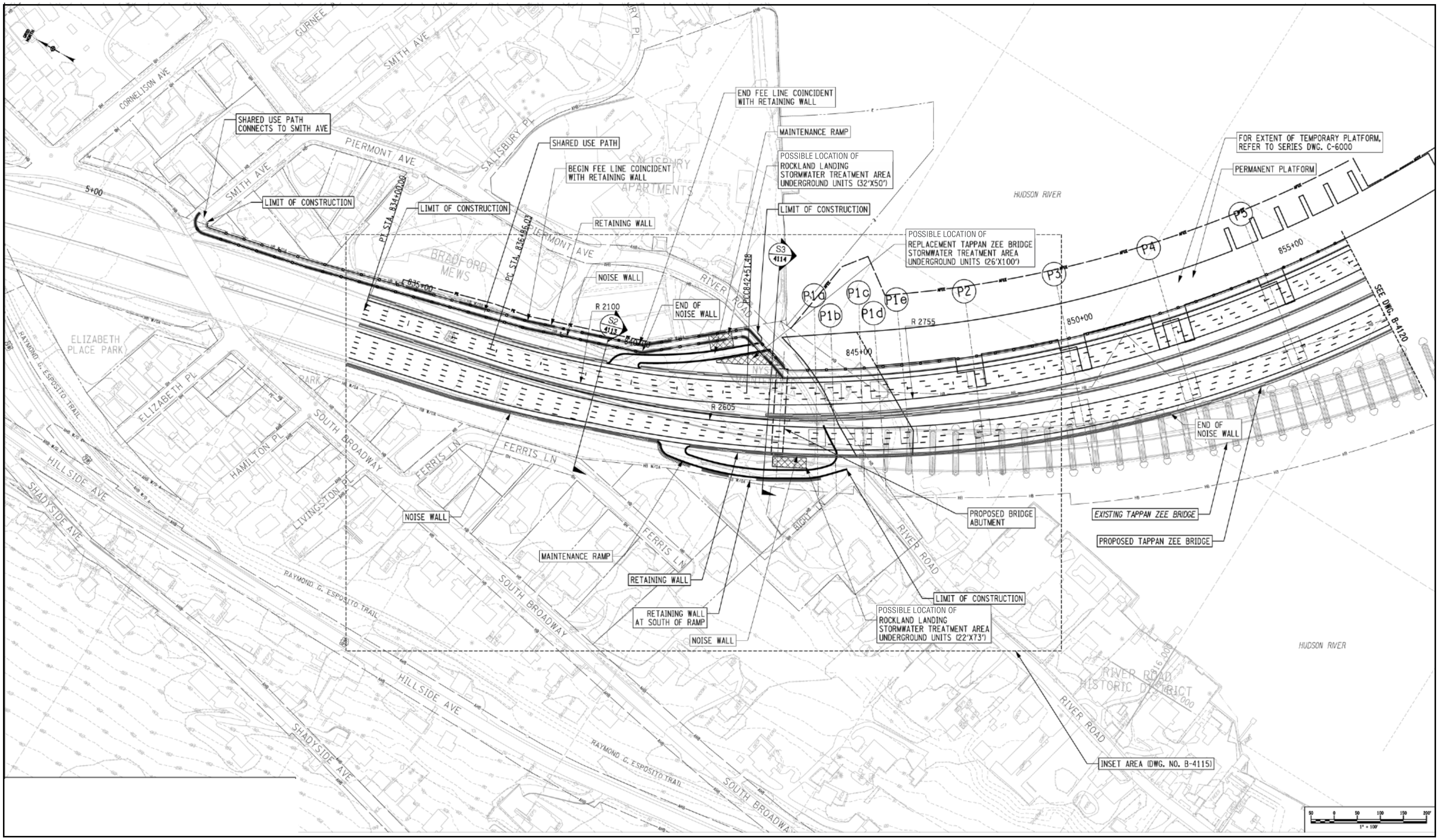
1-3 CONCLUSIONS

Based on the above evaluation, it has been determined that the refinements to the project design and new information received subsequent to the publication of the DEIS do not have the potential to result in significant environmental impacts that were not previously evaluated in the DEIS. The conditions of 23 CFR 771.130(a) have not been met; therefore, further evaluation of these changes through an SDEIS is not necessary, and the environmental review of the project should proceed with an FEIS.

LIST OF EXHIBITS

Exhibit 1: Design Refinements

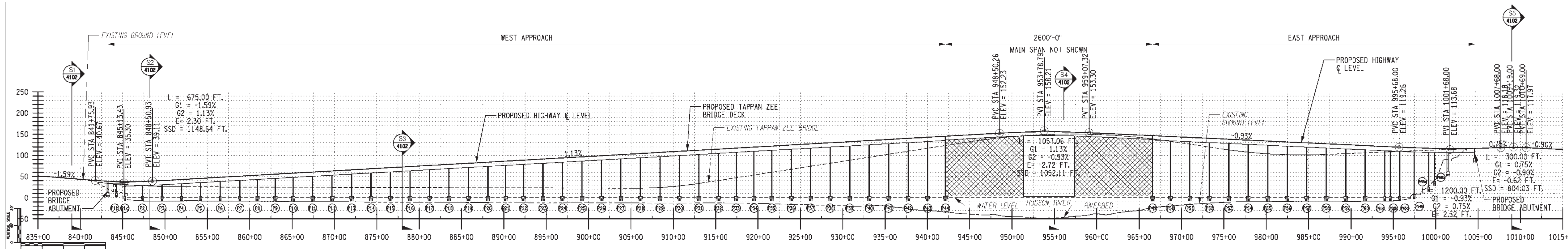
1-1 Design Plans



TAPPAN ZEE HUDSON RIVER CROSSING
Reevaluation Statement

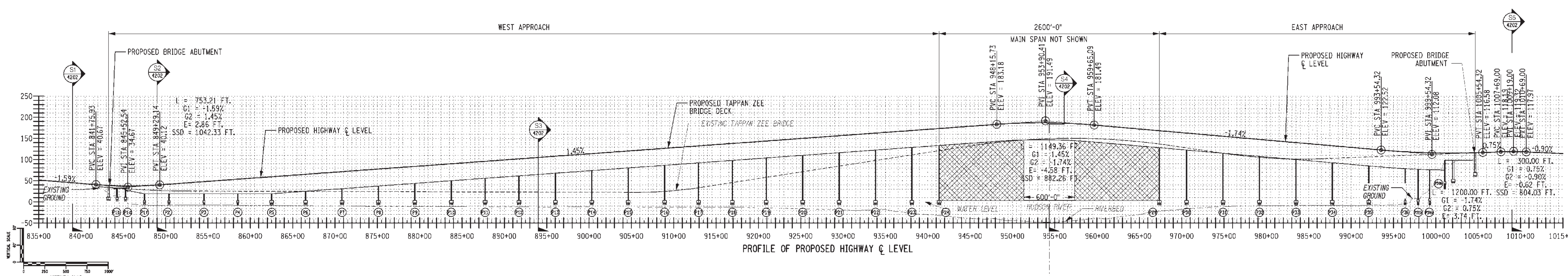
Exhibit 1-1A
Rockland Landing

Short Span Option



Short Span Plan View

Long Span Option



Long Span Plan View

Exhibit 1-1B
Approach Spans Options

Exhibit 1: Design Refinements

1-2 Noise Analysis

1 INTRODUCTION

This exhibit describes the potential noise effects resulting from operation of the Tappan Zee Hudson River Crossing Project. Subsequent to publication of the DEIS, design refinements have resulted in a lower profile for the Rockland County landing. The lowering of the roadway would change noise levels at receptor sites as compared to the profile presented in the DEIS, and therefore, this revised noise analysis was prepared. This analysis was prepared consistent with the methodology described in the DEIS, and the revised analysis shows exceedances of Noise Abatement Criteria (NACs) at locations north of the Interstate 87/287 right-of-way in Rockland County that were not identified in the DEIS. Therefore, an additional noise barrier is recommended.

2 ENVIRONMENTAL EFFECTS

2-1 REPLACEMENT-BRIDGE ALTERNATIVE—SHORT SPAN OPTION

Table 1 shows predicted $L_{eq(1)}$ noise levels at the selected 11 receiver sites during the AM peak period in the year 2047 for the Short Span Option.

Table 1
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	72	0	No
R4	78	78	0	No
R5	76	76	0	No
R6	76	72	-4	No
W1	69	64	-5	No
W2	73	72	-1	No
W3	63	62	-1	No
W4	76	75	-1	No
W5	76	74	-2	No

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

As shown in the table future noise levels at the eleven receiver sites would be within 5 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 receiver sites. The maximum increase in

$L_{eq(1)}$ noise levels at any selected property in the study area, comparing the Short Span Option with existing conditions, would be less than 1 dBA, a barely perceptible change. More importantly, the predicted increases in $L_{eq(1)}$ noise levels with the Short Span Option would be much less than the FHWA/NYSDOT 6 dBA substantial increase criteria.

1 At 88 properties (i.e., the sum of land use categories B, C, and E) and 389 receptors in the project study area, the Short Span Option would result in exceedances of the FHWA/NYSDOT NACs (see **Table 2**). Compared to the existing conditions, results obtained using the TNM 2.5 model predict that the Short Span Option would result in two additional receivers where the NAC impact criteria would be exceeded, but there would be no locations where noise levels would exceed the FHWA/NYSDOT 6 dBA substantial noise impact criteria. The predicted exceedances of the NACs require the examination and evaluation of noise abatement measures.

Table 2
Short Span Option-Number of Properties/Receptors Exceeding NAC*

Land Use Category	Short Span Option			
	B&C Properties	B&C Receptors	E Properties	E Receptors
Rockland County	82	288	0	0
Westchester County	4	99	2	2

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

2-1-1 LONG SPAN OPTION

Table 3 shows predicted $L_{eq(1)}$ noise levels at the 11 selected receiver 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 receiver sites would be within 5 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 receiver sites. The maximum increase in $L_{eq(1)}$ noise levels at any selected property in the study area, comparing the Long Span Option with existing conditions, would be less than 1 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.

At 88 properties (i.e., the sum of land use categories B, C, and E) and 389 receptors in the project study area, the Long Span Option would result in exceedances of the FHWA/NYSDOT NACs (see **Table 4**). Compared to the existing conditions, results obtained using the TNM 2.5 model predict that the Long Span Option would result in two additional receivers 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 3
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	72	0	No
R4	78	78	0	No
R5	76	76	0	No
R6	76	72	-4	No
W1	69	64	-5	No
W2	73	72	-1	No
W3	63	62	-1	No
W4	76	75	-1	No
W5	76	74	-2	No
Note: Noise levels and differences are rounded-off to the nearest decibel.				

Table 4
Long Span Option-Number of Properties/Receptors Exceeding NAC*

Land Use Category	Long Span Option			
	B&C Properties	B&C Receptors	E Properties	E Receptors
Rockland County	82	288	0	0
Westchester County	4	99	2	2
Note: *Some properties contain multiple dwelling units, which results in multiple noise receptors.				

2-2 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 the same properties, and, in most cases, these properties exceed the NACs for existing conditions.

In should be noted that consistent with NYSDOT policy the preceding analyses are based upon ground level receiver locations. Noise impacts are accessed at elevated locations when there is outdoor activity space at the elevated locations. Depending upon receptor/roadway geometry and shielding effects, noise levels for Existing, No Build, and Bridge Replacement Alternative conditions at receivers at elevated locations may be slightly higher than the ground level receiver location noise levels shown. However, noise levels for No Build and Replacement Alternative conditions, at elevated locations, would not be expected to result in a substantial increase in noise levels compared to existing conditions.

3 MITIGATION

3-1 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 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 (i.e., those receptors that would receive at least a 5 dBA noise reduction) 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.

3-2 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 U.S. Department of Transportation (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 substantial, 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 substantial noise reductions. Further use of exclusive lane designation would not be warranted.

3-3 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.

3-4 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.
- **Viewpoints:** The viewpoints of property owners and residents of the benefited receptors shall be considered.

In the DEIS, TNM 2.5 was used to examine noise barriers at various locations including on and off structure. The DEIS concluded that where construction of barriers on structure was feasible, barriers on structure would achieve greater benefits to impacted receivers than barriers off structure (on ground). Therefore, this mitigation analyses examined barriers on structure, except for those locations where the adjacent roadway was not on structure. The TNM 2.5 model was also used to examine various heights and widths of noise barriers to determine whether and where this type of noise abatement measure satisfied FHWA/NYSDOT criteria.

Noise barriers 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 structure, and Wall 2 was assumed to be on the ground (No barrier was evaluated for the commercial uses at 400 South Broadway where the NAC is exceeded.) **Table 5** shows the barrier analysis results. Both barriers would satisfy NYSDOT criteria for acoustic effectiveness and cost effectiveness. The 10-foot tall Wall 1 barrier would meet the barrier design goal of a 7 dBA reduction at the majority of the benefited receptors. A total of 100 receptors would be benefited from this wall.

Table 5
Summary of Noise Barrier Reasonableness
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)	Meets 7 dBA Design Goal	Benefited Receptors with IL>=5 dBA	Approximate Wall Cost	Barrier Wall Size per Benefited Receptor (ft^2)	Meets NYSDOT Criteria?
TZB South to Exit 9							
Wall 1	1,055	10	Yes	100	$ 422,000	106	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.

Noise barriers were examined at one location south of Interstate 87/287 and two locations north of Interstate 87/287 in Rockland County for the Short and Long Span Options. The barrier on the south side of Interstate 87/287 (Wall 1) was recommended in the DEIS. However, because of the changes in the vertical profile of the Rockland County landing, on the north side of interstate 87/287, Wall 2 which would be on ground, and an additional noise barrier Wall 3 (which would consist of two components Wall 3a which would be on ground and Wall 3b which would be on structure) were examined. TNM 2.5 modeling results indicate that Wall 1 and Wall 3 (the combined Wall 3a and 3b) would satisfy FHWA/NYSDOT criteria. Wall 3 would provide mitigation at the Salisbury Point Condominiums. In addition, it is recommended that the existing noise barrier near Bradford Mews be reconstructed.

Table 6 shows the barrier analysis results for the Short Span Option and Long Span Options in Rockland County. As shown in **Table 6**, only Wall 1 and Wall 3 would satisfy NYSDOT criteria for acoustic effectiveness and cost effectiveness.

Table 6
Summary of Noise Barrier Reasonableness
Short Span Option and Long Span Option--Rockland County

Wall ID	Wall Length (ft)	Wall Height (ft)	Meets7 dBA Design Goal	Benefited Receptors with IL>=5 dBA	Approximate Wall Cost	Barrier Wall Size per Benefited Receptor (ft^2)	Meets NYSDOT Criteria?
TZB South to Interchange 10							
Wall 1	2,420	18	Yes	30	$ 1,734,000	1,452	Yes
Wall 1	2,420	24	Yes	68	$ 2,324,000	854	Yes
TZB North to Interchange 10							
Wall 2	290	16	No	0	$ 185,000	N/A	No
Wall 2	290	24	No	0	$ 278,000	N/A	No
Wall 3a	440	18	No	194	$ 1,454,000	187	No
Wall 3b[1]	2,030	14					
Wall 3a	440	18	Yes	194	$ 1,778,000	229	Yes
Wall 3b	2,030	18					

Note: Costs rounded off to nearest $1,000 and barrier wall size rounded off to nearest 10 ft^2.
1. Wall 3b at 14 feet high would not meet the criterion of achieving a design goal of 7 dBA at a majority of the benefited receptors.

Wall 1 would be acoustically effective at 18 feet. Increasing the height of Wall 1 from 18 to 24 feet, would result achieve the minimum acoustical effectiveness with a 5 dBA noise reductions at 68 rather than 30 receptors. However, Wall 1 at either height would satisfy NYSDOT acoustical effectiveness and cost effectiveness criteria.

Wall 2 would not be acoustically effective at 18 or 24 feet as it would not benefit any receptors. Consequently, this noise barrier would not meet the NYSDOT acoustical effectiveness and cost effectiveness criteria and is not considered to be a feasible and reasonable noise abatement measure.

As stated above, Wall 3 consists of two pieces, Wall 3a and Wall 3b. Wall 3a is an extension of the existing noise barrier on ground which provides abatement of noise at the Salisbury Point Cooperative. Wall 3b in conjunction with Wall 3a would be acoustically effective at an 18-foot height in order to achieve a design goal of a minimum 7 dBA reduction at the benefited receptors within the Salisbury Point Condominium complex . Walls 3a and 3b would benefit a total of 194 receptors.

It should be noted that consistent with FHWA/NYSDOT policy, noise abatement is based upon consideration of potential impacts for proposed Build alternatives based upon ground level noise levels at areas of frequent human use. Potential exceedance of NACs at elevated residential receptor locations is not a consideration if ground level areas of frequent human use are available. However, noise barriers typically would have beneficial effects at elevated receptor locations. For example at the Salisbury Point Cooperative in Rockland County the recommended barriers would be expected to reduce noise levels at receptors located at the fourth floor by 4 to 6 dBA, and at receptors located at the seventh floor by 1 to 4 dBA. Similar at the Quay Condominium complex in Westchester County, the proposed barriers would be expected to reduce noise levels at elevated receptor locations by up to 10 dBA.

The effective implementation of noise-compatible planning measures is a shared responsibility between NYSTA, NYSDOT, and the local governments where barriers are proposed. NYSTA and NYSDOT have begun an ongoing process of outreach working with local officials for jurisdictions where noise barriers are recommended. During this outreach effort, NYSTA and NYSDOT will provide the local officials with information to support the recommendations and noise compatible planning concepts and will solicit comments from local governmental officials. NYSTA and NYSDOT will document all contact and meetings with local governmental officials for the project record.

Following publication of the DEIS, NYSDOT and NYSTA met with the benefited receptors (property owners, homeowners, and tenants) based upon the noise barriers identified in the DEIS (i.e., Wall 1 and Wall 2 in Westchester County, and Wall 1 in Rockland County). At the time of those meetings the alignment for the Short and Long Options had not revised and Wall 3 in Rockland County had not been recommended for noise abatement. The majority of benefitted receptors indicated support for the recommended noise barriers (i.e., Wall 1 and Wall 2 in Westchester County, and Wall 1 in Rockland County). While Wall 3 in Rockland County was not recommended at the time of those meetings, representatives of the Board of the Salisbury Condominium complex, as well as residents of the condominiums were present at the meetings, and requested a noise barrier be provided adjacent to the condominium for noise abatement. Based on the revised analysis, including the recommendation of Wall 3 in Rockland County, NYSDOT and NYSTA will solicit the views of the benefited receptors regarding the recommended noise barriers.

The initial indications of likely recommended sound barriers for noise 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.

3-5 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.

Exhibit 2: Financial Plan

2-1 Diversion Analysis

DIVERSION ANALYSIS FOR POTENTIAL TOLL ADJUSTMENTS ON THE TAPPAN ZEE BRIDGE: SUMMARY OF RESULTS

OVERVIEW

For the purpose of this diversion analysis, it was assumed as a worst-case scenario that the tolls on the Tappan Zee Bridge (TZB) would be adjusted to no more than the approved Port Authority of New York and New Jersey (PANYNJ) tolls in 2017. While a broad range of toll adjustments are under review, the analyzed option represents a worst-case scenairo of the most probable of those options. To understand the impact of this toll adjustment on parallel Hudson River crossings, the diversion of traffic from the TZB was analyzed using the regionally adopted MPO Planning Model, the NYMTC BPM.

Figure 1: Hudson River Crossings

The analysis focused on future eastbound diversion patterns in the weekday morning peak hour, using the 2017 No-Build analysis year as developed for the *Tappan Zee Hudson River Crossing DEIS* ("the DEIS"). The same Best Practice Model (BPM) that was developed and used for all transportation analyses in the DEIS was used for these toll diversion analyses. The products of the analysis were:

1) Estimated eastbound total traffic diversion from the TZB for the four-hour (6AM-10AM) peak period and the 7AM-8AM peak hour for the specified toll adjustments; and
2) Estimated eastbound traffic increases on parallel Hudson River crossings (see Figure 1) -- George Washington Bridge (GWB), Lincoln and Holland Tunnels (LT and HT), Bear Mountain Bridge (BMB), and Newburgh-Beacon Bridge (NBB).

Eastbound AM peak-hour volumes (all crossings are tolled in the eastbound direction) were selected for analysis as they would represent the highest volume of diversions in any one hour. Volumes were also developed and analyzed in each of the four BPM analysis periods – AM, Midday, PM and Nighttime – which collectively cover the entire 24-hour day. The projected change in daily vehicle miles of travel (VMT) in the NYMTC region and its member counties due to the worst-case TZB toll adjustment were also calculated using the BPM's air quality post-processor to support SIP conformity review procedures.

As discussed below, the approach used in these analyses provided a conservative estimate of traffic diversion, as it did not take into account such additional reactions to toll adjustments as cancelled trips or diversions to other modes (transit, car pool, etc.) or time periods.

THE TRAVEL DEMAND FORECASTING PROCESS

The Best Practice Model (BPM), developed by the New York Metropolitan Transportation Council (NYMTC), was used to forecast future travel demand for all the transportation analyses included in the DEIS. This model forecasts future travel based on projected land use, employment, and demographic patterns, as well as planned transportation facilities and services. The BPM was adopted by NYMTC as the transportation planning model for the New York Metropolitan Area. It is frequently used by FHWA and other Federal agencies for large transportation projects in the region, and the Tappan Zee Bridge project was assessed using the BPM. The BPM also plays a central role in the mobile source air quality Conformity Determination studies completed by NYMTC for all Transportation Improvement Programs and Regional Transportation Plans. As with the application of this complex model to any project, the Tappan Zee Bridge Project used a recalibrated version of NYMTC's BPM. Among the analyses included in the DEIS, future conditions were analyzed for 2017 (the project's projected Build year) and 2047 (the mandated 30-year Design Year horizon mandated under State and Federal guidelines for major bridges).

While the present NYMTC BPM conformity analysis year is 2014, the analyses for this memo were completed for 2017 for the following reasons:

- The BPM model calibrated for use in the TZB DEIS analyses was developed for two analysis years – 2017 (Build year) and 2047 (Design year).
- It is projected that all of the planned (PANYNJ) or proposed (TZB) toll adjustments would not be in place by 2014. The earliest full year in which the toll adjustments on all involved crossing would be in place is 2016.
- Diversion estimates for 2017 would be more conservative due to the projected growth in traffic from 2014 to 2017.

The analyses started with the 2017 TZB BPM model runs already completed for the DEIS. The following steps were then taken:

Establish New 2017 Baseline Conditions

- The TZB BPM model's assumed 2017 average car and truck tolls at the Port Authority crossings were updated to be consistent with existing and announced future toll levels and policies at those locations. Tolls at the other crossings were assumed to remain unchanged.
- The 2017 model was re-run in its entirety to establish a new 2017 Baseline.

Estimate the Diversion Impacts of Adjusted TZB Tolls

- The TZB car and truck tolls in the new 2017 Baseline model assumed as a worst case scenario that the tolls on the TZB would be no more than the approved PANYNJ tolls. For this worst-case scenario, the TZB tolls, including the commercial vehicle tolls were adjusted in rough proportion to the change in car cash tolls. The model uses a blended toll rate reflecting the approximate mixture of vehicles by payment method (cash, E-ZPass, Commuter E-ZPass, etc.). Tolls for the Bear Mountain and Newburgh-Beacon Bridges (both presently at $1.50 cash toll for cars) were assumed to remain unchanged.
- The relevant components of the model were then re-run to estimate traffic diversions at the following Hudson River crossings:
    - George Washington Bridge
    - Lincoln and Holland Tunnels
    - Bear Mountain Bridge and Newburgh-Beacon Bridge
- The BPM model analyzes potential travel times and costs faced by travelers, including congestion, the tolls encountered and trip distance, and projects the number of trips made between each of about 4,000 traffic analysis zones across the entire 28-county BPM analysis area. Relevant to the present analyses, the model estimates the river crossing choices that travelers would make in response to time, cost and distance, and as part of that assignment process projects the likely diversions that would result due to changes in tolls.

Only selected components of the model (i.e., the highway assignment module) were run for the diversion analyses. This approach conservatively assumes that all auto and truck vehicle trips occurring in the revised Baseline would make the same highway trips they made before the TZB tolls were adjusted. The highway assignment module estimates the number of vehicle trips that would shift their route with the introduction of the TZB toll adjustment. This approach therefore takes no credit for the likely diversions of some of these drivers to other modes (transit, carpool), for trips that would no longer be made or that might shift to other time periods (when congestion is less and tolls are often lower).

RESULTS OF THE DIVERSION ANALYSIS

The model's estimate of traffic diversions was analyzed to assess the potential impacts at the other River crossings. Table 1 shows the amount of traffic that was estimated to divert to the parallel crossings in the weekday AM peak, assuming as a worst case scenario that the tolls on the TZB would be no more than the approved PANYNJ tolls in 2017.

Table 1: Preliminary Estimate of AM Period and Peak Hours Eastbound Diversion Due to TZB Toll Adjustment (vehicles)

	AM Peak Period (6-10am)[1]	*AM Peak Hour (7-8am)*[1]
Tappan Zee Bridge	*-2,300*	*-620*
George Washington Bridge	*+1,400*	*+380*
Lincoln Tunnel	*+200*	*+50*
Holland Tunnel	*+100*	*+30*
Bear Mountain Bridge	*+300*	*+80*
Newburgh-Beacon Bridge	*+300*	*+80*

[1] *Numbers rounded*

Related diversion figures in the eastbound direction for all analyzed Hudson River Crossings in the full 4-hour AM (6-10AM) and PM (4-8PM) peak periods, the 6-hour Midday period (10AM-4PM) and the Nighttime period (8PM-6AM) are also included in Appendix A of this memo. The estimated daily diversion of 11,700 vehicles from the Tappan Zee is also approximately 8% of the average daily two-way traffic.

Approximately 7,400 vehicles (4% of which are trucks) are projected to cross the TZB in the AM Peak hour in 2017. Of these, approximately 620 vehicles or 8% of total eastbound volumes would divert from the TZB due to the analyzed toll adjustments. As noted, it is possible that some of these diverting AM Peak travelers would transfer to other modes (transit and/or car pool) or time periods or would cancel some trips rather than diverting to other crossings. Of the assumed diverted traffic, the only crossing receiving over 100 vehicles per hour (vph) would be the approximately 380 vph that would divert to the GWB. In considering the potential impact of this diversion at the GWB, it must be remembered that there are multiple ways that eastbound traffic can approach the GWB, with traffic on each approach spread over multiple lanes. The potential impact of diverted traffic at any one location is projected to be small. For example:

- About one-third of the diverted traffic (about 115 vehicles per hour, or 60 vehicles per hour per lane) could likely approach the GWB via the Palisades Interstate Parkway.
- Less than half (about 170 vehicles per hour, or 60 vehicles per hour per lane) could approach via NJ Route 4 (coming from NJ Route 17).
- About one fourth (about 90 vehicles per hour, or 15 vehicles per hour per lane) would approach via I-95 (coming from the NJ Turnpike and I-80).

Overall, the diverted volumes to the GWB would be very small in comparison to the amount of traffic using the GWB – approximately 3.5% of the 11,000 eastbound vehicles projected on the GWB in the AM peak hour in 2017. This diversion would in fact be well below the typical day-to-day variation in traffic volumes. As noted, the diversion of some of the drivers to other modes or time periods alone would further reduce the diversion numbers shown in Table 1 above. For example, rather than diverting to other crossings, some travelers faced with this toll adjustment could choose to continue using the TZB and take advantage of the substantial carpool discount (for cars with 3 or more occupants), which is only 10% of the cash toll for cars.

PROJECTED CHANGE IN REGIONAL VMT

Using the BPM model and its air quality post-processor, daily vehicle miles of travel (VMT) for 2017 were calculated for conditions with and without the proposed TZB toll adjustment. The toll adjustment assumed a worst-case scenario, with TZB tolls assumed to be no more than the approved PANYNJ tolls in 2017. As indicated in Table 2:

- Overall total VMT for the NYMTC region would decrease slightly, by approximately 120,000 VMT, or 0.06%.
- New York County would experience the largest increase in daily VMT (approximately 0.2%) due to the proposed toll adjustment. This change is consistent with the projected minor shift in trans-Hudson traffic from the TZB to the GWB. For similar reasons, Westchester and Rockland Counties collectively would experience a daily VMT decrease of approximately 0.5% due to the TZB toll adjustment.

Table 2: Estimated Change in 2017 Daily Vehicle Miles of Travel due to TZB Toll Adjustments

2017 Daily Vehicle Miles of Travel (Thousands)

County	*No Toll Adjustment*	*With Toll Adjustment*	*Change*	*% Change*
New York	*13,373*	*13,397*	*24*	*0.18%*
Queens	*28,725*	*28,723*	*-2*	*-0.01%*
Bronx	*11,958*	*11,953*	*-6*	*-0.05%*
Kings	*18,061*	*18,066*	*6*	*0.03%*
Richmond	*7,049*	*7,055*	*5*	*0.08%*
Subtotal	***79,167***	***79,194***	***27***	*0.03%*
Nassau	*37,181*	*37,186*	*5*	*0.01%*
Suffolk	*46,364*	*46,367*	*4*	*0.01%*
Subtotal	***83,545***	***83,553***	***8***	*0.01%*
Westchester	*27,383*	*27,286*	*-97*	*-0.35%*
Rockland	*9,164*	*9,073*	*-91*	*-0.99%*
Putnam	*7,674*	*7,706*	*32*	*0.42%*
Subtotal	***44,221***	***44,065***	***-156***	***-0.35%***
NYMTC Region Total	***206,933***	***206,812***	***-120***	***-0.06%***

SUMMARY

- BPM forecasts indicate that a worst-case scenario in which TZB tolls would be adjusted to no more than those approved for PANYNJ crossings in 2017 would result in the diversion of approximately 620 AM peak hour vehicles from the TZB to other Hudson River crossings.
- This is a very conservative estimate as it does not take into account travelers considering other modes, times of travel or trip reduction strategies, which would reduce these diversion estimates further.
- The BPM forecasts that approximately 380 of these TZB-diverted vehicles would utilize the George Washington Bridge. Considering the overall volumes on the bridge and the myriad approaches to that crossing, the impacts on any one approach or overall bridge operations are projected to be minimal.
- Projected estimates of the change in daily VMT in the NYMTC region indicate a very small (0.06%) decrease in regional VMT would result from the analyzed worst-case TZB toll adjustment.

APPENDIX A
PROJECTED CHANGE IN EASTBOUND VOLUMES ON
SELECTED HUDSON RIVER CROSSINGS DUE TO PROPOSED TZB TOLL ADJUSTMENTS

Table A-1: Year 2017 No-Build Average Weekday Volumes on Selected Hudson River Crossings [1]

Bridges	2017 N2					2017 N3				
	AM	MD	PM	NT	Daily	AM	MD	PM	NT	Daily
HOLLAND TUNNEL EB	13,400	15,190	8,710	9,830	47,130	13,500	15,270	8,790	9,890	47,450
BEAR MOUNTAIN BRIDGE EB	5,660	6,120	5,210	2,670	19,660	5,950	6,450	5,500	2,890	20,790
NEWBURGH BEACON BRIDGE - EB	12,980	13,500	8,880	9,230	44,590	13,230	13,750	9,000	9,650	45,600
TAPPAN ZEE BRIDGE EB	24,260	23,190	15,360	11,710	74,520	21,930	19,910	13,060	7,960	62,860
LINCOLN TUNNEL - EB	19,390	21,370	9,820	12,950	63,530	19,540	21,630	9,890	13,020	64,080
G WASHINGTON BRIDGE - EB	45,350	53,130	36,960	27,080	162,520	46,770	55,440	38,650	30,080	170,930
TOTAL	**121,040**	**132,500**	**84,940**	**73,470**	**411,950**	**120,920**	**132,450**	**84,890**	**73,490**	**411,710**

Table A-2: Change is Year 2017 No-Build Average Weekday Volumes on Selected Hudson River Crossings [2]

Bridges	Volume Change: 2017 N2				
	AM	MD	PM	NT	Daily
HOLLAND TUNNEL EB	100	100	100	100	400
BEAR MOUNTAIN BRIDGE EB	300	300	300	200	1,100
NEWBURGH BEACON BRIDGE - EB	300	300	100	400	1,100
TAPPAN ZEE BRIDGE EB	(2,300)	(3,300)	(2,300)	(3,800)	(11,700)
LINCOLN TUNNEL - EB	200	300	100	100	700
G WASHINGTON BRIDGE - EB	1,400	2,300	1,700	3,000	8,400
TOTAL	-	-	-	-	-

AM: AM Peak Period	**6AM - 10AM**
MD: Midday Peak Period	**10AM - 4PM**
PM: PM Peak Period	**4PM - 8PM**
NT: Nighttime Period	**8PM - 6AM**

[1] 2017 N2 = Revised No-Build with adjusted tolls on PANYNJ crossings and TZB tolls unchanged. 2017 N3 = adjusted tolls on both PANYNJ crossings and TZB.
[2] Numbers rounded to nearest 100. Daily totals represent summary of rounded values.

Exhibit 2: Financial Plan

2-2 Air Quality Analysis

1 INTRODUCTION

The bridge toll rate adjustments under consideration could result in the diversion of some vehicle trips which would otherwise use the Replacement Bridge to alternative routes. The effect of this toll change on regional (i.e., mesoscale) emissions and local concentrations near diversion routes is examined below.

2 CONFORMITY WITH STATE IMPLEMENTATION PLANS AND REGIONAL (MESOSCALE) ANALYSIS

The conformity requirements of the CAA and regulations promulgated thereunder (conformity requirements) limit the ability of federal agencies to assist, fund, permit, and approve projects in non-attainment or maintenance areas that do not conform to the applicable SIP. When subject to this regulation, the lead federal agency is responsible for demonstrating conformity of its proposed action. Conformity determinations for federal actions related to transportation plans, programs, and projects which are implemented, funded, or approved under title 23 U.S.C. or the Federal Transit Act (49 U.S.C. 1601 et seq.) must be made by the project's lead federal transportation agency—in the case of this project, FHWA—according to the requirements of 40 CFR §93, Subpart A (federal transportation conformity regulations).

The following criteria and procedures apply for projects from a currently conforming TIP and regional transportation plan:

- The project must not cause or contribute to any new localized CO, PM_{10}, and/or $PM_{2.5}$ violations, increase the frequency or severity of any existing CO, PM_{10}, and/or $PM_{2.5}$ violations, or delay timely attainment of any NAAQS or any required interim emission reductions or other milestones in CO, PM_{10}, and $PM_{2.5}$ nonattainment and maintenance areas.
- The project must comply with any PM_{10} and $PM_{2.5}$ control measures in the applicable implementation plan. This criterion is satisfied if the project-level conformity determination contains a written commitment from the project sponsor to include in the final plans, specifications, and estimates for the project those control measures (for the purpose of limiting PM_{10} and $PM_{2.5}$ emissions from the construction activities and/or normal use and operation associated with the project) that are contained in the applicable implementation plan.

The Interagency Consultation Group (ICG) in New York State includes representatives from the FHWA, USEPA, NYSDEC, New York State Department of Transportation (NYSDOT), and the Metropolitan Planning Organizations. The ICG provides multi-agency concurrence on the assumptions and methodologies used in the travel demand models, the results of which form the basis of the regional emissions analysis in the TIPs and Plans. The modeling inputs and parameters used in the analyses for the current NYMTC 2011-2015 TIP and 2035 Plan were established in consultation with the NYSDEC and the New York State ICG.

The ICG determined that the 8-lane Replacement Bridge Alternative is a non-exempt project under the air quality conformity regulations and thus must be included in the regional transportation emissions analyses. The existing analyses of NYMTC's current conforming Plan and TIP includes the existing operational configuration of a 7-lane facility with a movable barrier that provides four lanes in the peak direction. The 8-lane alternative without a movable barrier would be operationally very similar. The 8-lane alternative will be included in the emission analyses for the amended 2011-2015 TIP and 2035 Plan in July, before the Record of Decision for the project is published.

Regarding the transportation conformity process for quantitative hot-spot analyses, the ICG reviewed and accepted the models, methods and assumptions used in this environmental document.

Furthermore, on May 16th, 2012, ICG concluded that the impact of the potential toll changes has been reasonably considered, is consistent with 40 CFR Part 93.110, and would not change the conclusions of NYMTC's regional emissions analysis that began in January 2012.

As described in Exhibit 1-1, and later in this chapter, the project is not expected to increase vehicle miles traveled or the ensuing on-road emissions during the operation of the project as compared to the future condition included in the currently conforming TIP and plan. According to the conformity regulations (40 CFR §93.116), the project will not cause or contribute to any new local CO, PM_{10}, and/or $PM_{2.5}$ violations, increase the frequency or severity of any existing violations, or delay timely attainment of any NAAQS, emissions reductions, or other milestones, if the project is not identified in the following criteria (40 CFR §93.123):

- For projects in or affecting locations, areas, or categories of sites which are identified in the applicable implementation plan as sites of violation or possible violation;
- For projects affecting intersections that are at Level-of-Service D, E, or F, or those that will change to Level-of-Service D, E, or F because of increased traffic volumes related to the project (for PM, this applies only to intersections with a large number of diesel vehicles);
- For any project affecting one or more of the top three intersections in the nonattainment or maintenance area with highest traffic volumes or the top three intersections in the nonattainment or maintenance area the worst level of service, as identified in the SIP.

In addition, for PM only, procedures for hotspot analysis are required to be used—

- For new highway projects that have a substantial number of diesel vehicles, and expanded highway projects that have a substantial increase in the number of diesel vehicles;
- New bus and rail terminals and transfer points that have a substantial number of diesel vehicles congregating at a single location; and

- Expanded bus and rail terminals and transfer points that substantially increase the number of diesel vehicles congregating at a single location.

In cases other than those described above, the demonstrations required may be based on qualitative consideration of local factors, if this can provide a clear demonstration that the above requirements (40 CFR §93.116) are met. Since the project is not a new highway, will not affect traffic volume or vehicle classification, will not affect any intersections, and will not introduce any bus or rail components, hotspot analyses are not required for conformity purposes.

A screening analysis is included to address potential increases in traffic volumes along routes to which some vehicles may divert due to potential toll rate adjustments under consideration. The analyses presented below demonstrate that the project would not cause or contribute to any new localized CO, PM_{10}, or $PM_{2.5}$ violations.

3 LOCAL (MICROSCALE) ANALYSIS

This assessment follows the procedures outlined in NYSDOT's *The Environmental Manual (TEM),* January 2001, and NYSDOT's *Project Level Particulate Matter Analysis Policy*, September 2004.

According to the NYSDOT *TEM* 'capture criteria,' CO microscale analysis is required if the Build condition level of service is at D, E, or F and the project would result in a 10 percent or more reduction in the distance between source and receptor (locations where potential air quality is analyzed, such as residential or open space locations), and if traffic volume screening thresholds would be exceeded. The slight shift in the replacement bridge's location would require an adjustment in the roadway on the bridge landing sites and connection to the existing roadway, resulting in the nearest lane being closer by more than 10 percent to some adjacent residential locations (and further from receptors on the opposite side), and the free flow traffic volumes on the bridge would exceed the volume screening threshold. Therefore, a detailed CO analysis was conducted in the area of both bridge landings (on the Rockland and Westchester sides). In addition, a screening analysis was prepared for locations to which traffic may be diverted as a result of the potential toll adjustments under consideration.

The toll adjustment diversion screening analysis focused on 2017. Since the 2017 emission rates are nearly identical to the highest future year emission rates (0.3 percent difference), and since the growth rates in both diverted traffic increments and No Build traffic would be the same, fractional increases due to diversions would not be different for future years.

The NYSDOT policy, like the conformity hotspot guidance described above, does not require analysis for projects that would not result in increased traffic volumes, unless other factors have potential to result in increased PM emissions, but does not otherwise provide any screening procedures. Although the project would not increase emissions, and therefore PM analysis is not strictly required according to the NYSDOT policy, the project would shift the roadway source closer to some receptor locations, as described above for CO. Therefore, detailed PM analyses were prepared for the same locations described above for CO.

The potential effect of diversions resulting from the bridge toll rate adjustments under consideration was reviewed. The 2017 No Build traffic volumes and incremental volumes at the various crossings for peak hours and daily are presented in **Table 1**. The highest resulting fractional increment would be a 3.3 percent increase in peak hour and daily traffic projected at the Bear Mountain Bridge.

Table 1
No Build and Diversion Increment Daily Traffic Volumes, 2017

Crossing	Scenario	Daily
Tappan Zee Bridge East Bound	No Build	74,520
	Increment	-11,700
		-15.7%
Lincoln Tunnel East Bound	No Build	63,530
	Increment	700
		1.1%
George Washington Bridge East Bound	No Build	162,520
	Increment	8,400
		5.2%
Holland Tunnel East Bound	No Build	47,130
	Increment	400
		0.8%
Bear Mountain Bridge East Bound	No Build	19,660
	Increment	1,100
		5.6%
Newburgh Beacon Bridge East Bound	No Build	44,590
	Increment	1,100
		2.5%

In addition to the crossings themselves, roadways leading to and from the crossings were examined to assess whether air quality analysis is warranted. Existing annual average daily traffic volumes on these routes were obtained from NYSDOT and NJDOT traffic counts.[1] Diversion routes were estimated with the following assumptions:

- Newburgh-Beacon Bridge (NBB) trips:
  - All of these trips would use New York Route 9D (Breakneck Road), New York Route 9 (Albany Post Road), the Taconic State Parkway, or I-84/I-684, and would continue south on these routes (merging with diversions to the BMB on Route 9A south of Peekskill and on the Taconic State Parkway south of Yorktown).
  - These diversions would be distributed as follows:

[1] NYSDOT, Traffic Data Viewer, http://gis.dot.ny.gov/tdv/, accessed 6/1/2012; and
NJDOT, Roadway Information and Traffic Counts, http://www.state.nj.us/transportation/refdata/roadway/traffic_counts, accessed 6/5/2012.

- 5 percent on New York Route 9D (Breakneck Road);
- 25 percent on New York Route 9 (Albany Post Road);
- 35 percent on Taconic State Parkway; and
- 35 percent on I-84/I-684.

- Bear Mountain Bridge (BMB) trips:
  - 10 percent would head north on New York Route 9D while 90 percent would head south;
  - Of those heading south:
    - Approximately one-third (30 percent of the total BMB traffic) would head east in Peekskill (on Bear Mountain State Parkway), with all 30 percent then heading south on the Taconic State Parkway; and
    - Two-thirds (60 percent of the diverted BMB traffic) would head south on New York Route 9 (Briarcliff-Peekskill Parkway) south of Peekskill.
- Trips south of the Tappan Zee Bridge:
  - About one-third of the diverted traffic (about 115 vehicles per hour, or 60 vehicles per hour per lane) could likely approach the GWB via the Palisades Interstate Parkway.
  - Less than half (about 170 vehicles per hour, or 60 vehicles per hour per lane) could approach via NJ Route 4 (coming from NJ Route 17).
  - About one fourth (about 90 vehicles per hour, or 15 vehicles per hour per lane) would approach via I-95 (coming from the NJ Turnpike and I-80).

The worst-case daily average existing and incremental traffic volumes along the various diversion routes are presented in **Table 2**.

Since the diversions would not increase traffic at any location by 10 percent or more, according to the NYSDOT guidance for CO, no significant adverse CO impact would occur due to diversions and more detailed microscale analysis is not required.

The reasonable worst-case microscale PM screening analysis projected a maximum 24-hour average increase of 0.20 $\mu g/m^3$ 0.40 $\mu g/m^3$ for $PM_{2.5}$ and PM_{10}, respectively, and annual average increase of 0.04 $\mu g/m^3$ $PM_{2.5}$. These incremental concentrations are all lower than the applicable screening thresholds in the NYSDOT policy (5 $\mu g/m^3$ for 24-hour average $PM_{2.5}$ and PM_{10} and 0.3 $\mu g/m^3$ for annual average $PM_{2.5}$.) Therefore, no significant adverse PM impact would occur due to diversions and more detailed microscale analysis is not required per the NYSDOT policy.

Overall, the potential diversions associated with the bridge toll rate adjustments under consideration would not cause any significant adverse impact on air quality.

Table 2
Summary of Diversion Distribution (Average Daily Vehicles)

Location	2017 Volume	Assigned Diversion Volume	Diverted Volume Fraction
New York Route 9 (Albany Post Road)	17,900	275	1.5%
Taconic Parkway North of Yorktown	31,500	385	1.2%
I-684 South of Brewster	67,800	385	0.6%
Bear Mountain Bridge Road	13,000	990	7.6%
New York Route 9 (Briarcliff-Peekskill Parkway)	48,200	935	1.9%
Taconic Parkway South of Yorktown	71,500	715	1.0%
I-684 Near Katonah	81,100	385	0.5%
Bear Mountain State Parkway	16,500	330	2.0%
Palisades Interstate Parkway (north of 287)	41,187	339	0.8%
Palisades Interstate Parkway (south of 287)	60,574	1,139	1.9%
I-95	180,015	4,210	2.3%
NJ Turnpike	180,015	870	0.5%
I-80	149,672	4,210	2.8%
NJ-17	145,086	5,155	3.6%
NJ-4	102,371	3,072	3.0%
I-87	43,004	1,040	2.4%

-3-1-1 REGIONAL (MESOSCALE) EMISSIONS

As described above, in the event that a modified tolling scheme for Tappan Zee Bridge users is adopted, and the future toll rates at the Tappan Zee are set equivalent to the tolls at the Port Authority of New York and New Jersey and the New York Metropolitan Transportation Authority facilities, some users would prefer a shorter route (where previously users may have opted for longer but cheaper, routes.) As a result, there would be a reduction in vehicle use on the order of 121,000 vehicle-miles traveled daily. (See Chapter 4, “Transportation,” for details.) This represents a reduction of 0.06 percent in vehicle-miles traveled in the NYMTC region, and would result in a similar reduction in on-road emissions in the NYMTC region. Therefore, there would be no adverse impact to air quality as a result of any potential bridge toll rate adjustments.

4 MITIGATION

Since no exceedances of the NAAQS or applicable incremental thresholds were projected to result from the Replacement Bridge Alternative, mitigation is not required.

Exhibit 2: Financial Plan

2-3 Environmental Justice Analysis

Environmental Justice Analysis of Potential Toll Increases

1 INTRODUCTION

To satisfy Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations* (February 11, 1994), this analysis has been prepared to identify and address any disproportionately high and adverse impacts on minority or low-income populations that could result from the project. Executive Order 12898 also requires federal agencies to work to ensure greater public participation in the decision-making process. This environmental justice analysis will also serve to assist the New York State Department of Environmental Conservation (NYSDEC) in its environmental permit review process associated with the proposed permit actions and its application of the State Environmental Quality Review Act (SEQRA), and is consistent with the intent of CP-29, “Environmental Justice and Permitting,” which is the NYSDEC’s policy on environmental justice.

The environmental justice analysis for the project follows the guidance and methodologies recommended by the federal Council on Environmental Quality (CEQ) in *Environmental Justice Guidance under the National Environmental Policy Act* (December 1997), the U.S. Department of Transportation (USDOT) in its Updated Environmental Justice Order 5610.2(a) (Actions to Address Environmental Justice in Minority Populations and Low-Income Populations)[1], and the Federal Highway Administration (FHWA) in *FHWA Actions to Address Environmental Justice in Minority Populations and Low-Income Populations* (December 1998). These orders establish policies and procedures for the agencies to use in complying with Executive Order 12898. The Executive, USDOT, and FHWA orders on environmental justice reaffirm the principles of Title VI of the Civil Rights Act of 1964 (Title VI) and the National Environmental Policy Act (NEPA), emphasizing the importance of those provisions in the environmental and transportation-related decision-making process. On December 16, 2011, FHWA issued supplemental guidance on environmental justice and NEPA, which was also consulted in preparing this environmental justice analysis. In addition, FHWA’s guidance on environmental justice issues related to road pricing projects was reviewed in *Environmental Justice Emerging Trends and Best Practices Guidebook* (November 2011). In addition, to better address Limited English Proficient (LEP) populations, “Implementing the Department of Transportation’s Policy Guidance Concerning Recipients’ Responsibilities to Limited English Proficient (LEP) Persons: A Handbook for Public Transportation Providers” (April, 2007), issued by the Federal Transit Administration (FTA), was utilized to address certain concerns regarding public transit ridership and LEP populations.

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1 This Order updates USDOT’s original Environmental Justice Order, which was published April 15, 1997.

2 METHODOLOGY

The assessment of environmental justice for the project was based on the CEQ, USDOT, FTA, and FHWA documents identified above. It involved five basic steps:

1. Identify the areas where the project may cause adverse impacts either during construction or operation (i.e., the study areas);
2. Compile minority and low-income data for the census block groups within the study areas and identify minority and low-income populations;
3. Identify the project's potential adverse impacts on minority and low-income populations; and
4. Evaluate the project's potential adverse effects on minority and low-income populations relative to its overall effects to determine whether any potential adverse impacts on those communities would be significant and disproportionately high.
5. Discuss mitigation measures for any identified disproportionate adverse impacts and describe the public outreach and participation process for effectively engaging minority and low-income populations in the decision-making process.

2-1 DELINEATION OF STUDY AREA

a study area for the environmental justice analysis of toll adjustments was selected. For this project, the primary issue is whether adverse effects of toll adjustments on low-income populations would be disproportionately high compared with the general population. Increased tolls would be expected to primarily affect commuters who cross the Tappan Zee Bridge (Tappan Zee Bridge) for work. Based on Census Transportation Planning Package (CTPP) data product based on 2006-2008 3-year ACS data (i.e. journey-to-work data) and data available from the New York State Thruway Authority (NYSTA) for individual E-ZPass tag customers, the "commuter shed," or the area where the vast majority of these commuters originate was determined to be Rockland, Orange, and Westchester Counties (see **Figure 1**). (Because E-ZPass users compose a relatively large proportion of total Tappan Zee Bridge users (approximately 75 percent), it was assumed that the origin of Tappan Zee Bridge commuters with E-ZPass is similar to the origin of all Tappan Zee Bridge commuters). Thus, the study area for the analysis of the project's potential environmental justice effects related to toll adjustments consists of the counties that make up the commuter shed.

2-2 IDENTIFICATION OF ENVIRONMENTAL JUSTICE POPULATIONS

To identify minority and low-income populations in the study area, data were gathered from the U.S. Census Bureau's *Census 2010* and 2*006–2010 American Community Survey,* respectively, for all census block groups within the study areas.[1]

- *Minority Populations.* The guidance documents define minorities to include American Indians or Alaskan Natives, Asians and Pacific Islanders, Black or African American persons, and Hispanic persons. This environmental justice analysis also considers minority populations to include persons who identified themselves as being either "some other race" or "two or more races" in the *Census 2010*. Following CEQ guidance, minority populations were identified where either: (1) the minority population of the affected area exceeds 50 percent; or (2) the minority population percentage of the affected area is meaningfully greater than the minority population percentage in the general population or other appropriate unit of geographic analysis. For this analysis, Rockland County was used as the project's primary statistical reference area for the census block groups located in Rockland County. In Rockland County, the minority population in 2010 was 34.7 percent. Westchester County was used as the reference area for the study area's census block groups located in Westchester County. In Westchester County, the minority population in 2010 was 42.6 percent. In Orange County—the reference area for the block groups in the toll adjustments study area that are in Orange County—the minority population in 2010 was 31.8 percent. For this environmental justice analysis, census block groups having total minority populations greater than in the respective county reference areas were identified as minority areas.

- *Low-Income Populations.* The percent of individuals below poverty level in each census block group (based on the 2000 Census), available in the U.S. Census Bureau's *2006–2010 American Community Survey,* was used to identify low-income populations. This analysis considers any census block group with a percentage of individuals below poverty level that is greater than its respective reference area (i.e., Rockland, Westchester, or Orange County) to be low-income. In Rockland and Orange Counties, approximately 11.3 and 11.1 percent of individuals live below the federal poverty threshold, respectively; therefore, any census block group located in Rockland or Orange County with more than 11.3 and 11.1 percent of its individuals living below the poverty level, respectively, is considered to be low-income area. Similarly, any census block group in Westchester County having a low-income population greater than the percentage of individuals living below poverty in Westchester County (8.2 percent) is considered to be a low-income area.[2]

3 AFFECTED ENVIRONMENT

3-1 MINORITY STATUS ANALYSIS

As discussed above, the primary issue regarding the potential environmental justice effects of toll adjustments is whether adverse effects would be disproportionately high for low-income populations compared with the general population. Minority populations in the study area that are not low-income would not be disproportionately affected by adverse toll adjustments effects since the financial burden of increased tolls would equally affect both minority and non-minority communities, assuming neither is low-income. FHWA's guidance on environmental justice related to road pricing projects was reviewed for other issues related to toll increases that could result in disproportionately high adverse effects. Such issues include whether a project would result in diverting through minority and/or low-income communities; whether a project would cause adverse impacts on transit users, which generally include minority and low-income residents; and whether all affected populations, including minority populations, had the opportunity to participate in the planning and decision-making process.

The project would not have disproportionately high and adverse toll adjustments effects on minority populations. For instance, the *Diversion Analysis for Potential Tolling on the*

[2] The low-income population percentages are presented to the tenth decimal place rather than as a whole number as was presented in the DEIS to more accurately identify potential low-income communities in the toll adjustments study area.

Tappan Zee Bridge (see Appendix B) concluded that approximately 620 (8 percent) of the total number of vehicles projected to cross the bridge in the AM peak hours in 2017 would divert from the Tappan Zee Bridge. Roughly 4 percent of these vehicles would be trucks. This is a worst case assumption as it does not take into account diversions to other modes (transit and/or car pool), to other time periods, and trip avoidance that are also possible. Even with the conservative assumptions, the only crossing receiving over 100 vehicles per hour (vph) would be the approximately 380 vph that would divert to the George Washington Bridge (GWB). Considering the overall volumes on the GWB and the myriad of approaches to that crossing, the impacts on any one approach or overall bridge operations are projected to be minimal. As noted, the diversion of some of the drivers to other modes or time periods alone would further reduce the projected diversion estimates. Also, rather than diverting to other crossings, some travelers faced with the toll adjustment could choose to continue using the Tappan Zee Bridge and take advantage of the carpool discount (for cars with 3 or more occupants), which is 10 percent of the cash toll for cars, or currently $0.50 based on the $5.00 cash toll for cars. The diversion analysis also estimates that overall total vehicle miles of travel (VMT) would decrease slightly for the New York Metropolitan Area (by approximately 12,000 VMT, or 0.06 percent); and New York County would experience the largest increase in daily VMT (approximately 0.2 percent) due to the proposed toll adjustment. This change is consistent with the projected minor shift in trans-Hudson traffic from the Tappan Zee Bridge to the GWB and is considered to be very small. Given that the diversions are projected to be minimal, it is not expected that the proposed toll adjustments would result in disproportionately high and adverse toll adjustments effects on minority populations as a result of diversions through minority communities. Similarly, since the projected diversions would be minimal, it is anticipated that the toll increase would result in minimal shifts in transit ridership, which would not be expected to result in any disproportionate adverse effects on minority populations.[3]

3-2 LOW INCOME STATUS ANALYSIS

As shown in **Table 1** and **Figure 3**, the toll adjustments study area includes 343 block groups that have been identified as low-income communities in all of Westchester (216 Block Groups) Rockland (52 Block Groups), and Orange Counties (75 Block Groups). As shown on Figure 19-5, these locations are present throughout the toll adjustment study area, with notable clustering of communities in southern Westchester County as well as in urban and rural locations throughout the study area. The majority of the toll adjustments study area is not low-income.

[3] Therefore, while minority communities in the study area were identified and mapped (see **Figure 2**), this analysis of environmental justice effects does not specifically consider the race and ethnic composition of the study area population.

Table 1
Toll Adjustment Study Area Low-Income Status

Census Block Groups	Individuals Below Poverty Level (%)*	Census Block Groups	Individuals Below Poverty Level (%)*	Census Block Groups	Individuals Below Poverty Level (%)*	Census Block Groups	Individuals Below Poverty Level (%)*
Westchester County Low-Income Block Groups at or Greater than County-wide Average of 8.2 Percent							
Tract 1.01, BG 1	20.5	Tract 18, BG 1	10.3	Tract 59.01, BG 1	20.8	Tract 93, BG 3	19.2
Tract 1.01, BG 2	37	Tract 19, BG 1	8.8	Tract 59.01, BG 2	13.1	Tract 94, BG 2	27.3
Tract 1.03, BG 2	41.1	Tract 20, BG 4	13.3	Tract 59.01, BG 3	22.3	Tract 94, BG 3	17.8
Tract 1.03, BG 3	26.4	Tract 21.07, BG 1	15.5	Tract 60, BG 1	31.6	Tract 95, BG 3	8.3
Tract 2.01, BG 1	19.3	Tract 22.01, BG 1	21.2	Tract 61, BG 1	26.7	Tract 103, BG 3	9.3
Tract 2.01, BG 2	29.7	Tract 22.01, BG 2	11.1	Tract 61, BG 2	30.8	Tract 104, BG 1	17.6
Tract 2.01, BG 3	24.8	Tract 22.02, BG 2	9.2	Tract 62, BG 3	19.7	Tract 107.02, BG 4	16.7
Tract 2.01, BG 4	27	Tract 22.03, BG 2	13.6	Tract 62, BG 4	22.3	Tract 112, BG 1	11.2
Tract 2.02, BG 1	26.1	Tract 22.04, BG 2	13.1	Tract 63, BG 2	23.9	Tract 115, BG 1	17.8
Tract 2.02, BG 3	8.5	Tract 24.02, BG 2	12.6	Tract 63, BG 3	16.2	Tract 116, BG 1	23.5
Tract 2.03, BG 1	19.4	Tract 26, BG 1	27.2	Tract 63, BG 4	13.2	Tract 116, BG 2	15.9
Tract 3, BG 1	27.8	Tract 26, BG 2	17.6	Tract 63, BG 5	10.5	Tract 116, BG 4	13.5
Tract 3, BG 3	22.1	Tract 26, BG 3	13.5	Tract 64, BG 1	20.4	Tract 117, BG 2	12.6
Tract 4.01, BG 1	38.8	Tract 27, BG 1	9.6	Tract 64, BG 2	26.4	Tract 119.02, BG 1	10.5
Tract 4.01, BG 2	38.4	Tract 27, BG 2	15.4	Tract 64, BG 3	9.1	Tract 123.01, BG 1	12.1
Tract 4.01, BG 4	25.3	Tract 28, BG 1	16.3	Tract 64, BG 4	29.3	Tract 123.03, BG 3	19.8
Tract 4.02, BG 1	27.7	Tract 28, BG 2	20.4	Tract 65, BG 1	19.6	Tract 128.02, BG 2	15
Tract 4.02, BG 2	34	Tract 29, BG 1	24.4	Tract 65, BG 3	9.6	Tract 129, BG 3	15.2
Tract 4.02, BG 4	14.5	Tract 29, BG 2	12.7	Tract 65, BG 4	11	Tract 130, BG 4	11.1
Tract 5, BG 1	39.4	Tract 30, BG 2	12.4	Tract 66, BG 2	10.4	Tract 132.02, BG 1	11.8
Tract 5, BG 2	40.4	Tract 31, BG 1	21.5	Tract 66, BG 3	29.4	Tract 133.01, BG 1	41.6
Tract 6, BG 1	28.8	Tract 31, BG 2	22.8	Tract 67, BG 1	9.8	Tract 133.01, BG 2	30.7
Tract 6, BG 2	24.6	Tract 32, BG 1	44.5	Tract 67, BG 4	9.6	Tract 133.04, BG 2	10
Tract 6, BG 3	27.3	Tract 32, BG 2	17.4	Tract 70, BG 1	16.5	Tract 133.04, BG 3	8.8
Tract 6, BG 4	23.2	Tract 33, BG 1	18.8	Tract 70, BG 2	10.8	Tract 134, BG 2	15.9
Tract 7.1, BG 2	10.2	Tract 33, BG 4	17.4	Tract 72, BG 1	10	Tract 134, BG 3	24.3
Tract 8.01, BG 3	18.2	Tract 34, BG 1	9.6	Tract 73, BG 1	20	Tract 134, BG 5	14.4
Tract 8.01, BG 4	21	Tract 34, BG 2	29.8	Tract 78, BG 1	23	Tract 134, BG 1	39.2
Tract 8.01, BG 5	16.3	Tract 34, BG 3	17.5	Tract 78, BG 3	26	Tract 136, BG 3	11.3
Tract 8.03, BG 1	10.3	Tract 34, BG 4	10.9	Tract 79, BG 1	25.6	Tract 137, BG 3	8.3
Tract 9, BG 2	19.8	Tract 35, BG 1	43.6	Tract 79, BG 3	35.7	Tract 138, BG 2	15.2
Tract 10, BG 1	24.9	Tract 35, BG 2	25.4	Tract 79, BG 4	9	Tract 139, BG 2	13
Tract 10, BG 2	44.5	Tract 36, BG 1	12.2	Tract 80, BG 1	28.5	Tract 141, BG 1	31
Tract 11.01, BG 1	32.9	Tract 36, BG 2	15	Tract 80, BG 2	33.1	Tract 141, BG 4	23.3
Tract 11.01, BG 2	49.7	Tract 36, BG 3	21.4	Tract 80, BG 3	21.1	Tract 142, BG 1	23.3
Tract 11.02, BG 1	18.5	Tract 37, BG 2	32.3	Tract 81, BG 2	29.6	Tract 142, BG 2	11.4
Tract 11.02, BG 2	35.1	Tract 38, BG 2	10.3	Tract 81, BG 4	15	Tract 142, BG 3	12.9
Tract 11.02, BG 3	39.6	Tract 40, BG 1	10.1	Tract 82, BG 2	17.7	Tract 143, BG 1	23.4
Tract 12, BG 1	28.6	Tract 40, BG 2	15.4	Tract 82, BG 4	15.1	Tract 143, BG 2	33.5
Tract 12, BG 3	12.9	Tract 41, BG 1	10.8	Tract 83.02, BG 1	13.8	Tract 143, BG 3	23.3
Tract 13.01, BG 3	13.2	Tract 41, BG 2	8.3	Tract 84.04, BG 1	18.3	Tract 144, BG 2	13
Tract 13.02, BG 1	43.3	Tract 42, BG 3	13.2	Tract 84.04, BG 3	13.8	Tract 144, BG 3	8.3
Tract 13.02, BG 3	10.7	Tract 43, BG 2	13.7	Tract 88, BG 1	9.1	Tract 145, BG 2	19.8
Tract 13.03, BG 1	39	Tract 45, BG 1	16.4	Tract 89.01, BG 2	17.5	Tract 145, BG 3	32.9
Tract 13.03, BG 2	20.7	Tract 48, BG 4	8.4	Tract 89.01, BG 4	21.1	Tract 146.04, BG 1	9.6
Tract 13.03, BG 4	27.6	Tract 48, BG 5	15.4	Tract 89.01, BG 5	8.6	Tract 146.04, BG 2	19.8
Tract 14.01, BG 2	18.4	Tract 49, BG 1	11.1	Tract 89.02, BG 3	15.4	Tract 146.05, BG 1	14.4
Tract 14.02, BG 2	9.1	Tract 51, BG 4	14.1	Tract 90, BG 2	20.9	Tract 147.01, BG 1	8.9
Tract 15.02, BG 2	22.8	Tract 52, BG 2	8.7	Tract 91, BG 1	16.5	Tract 147.03, BG 1	8.5
Tract 15.02, BG 3	25.1	Tract 57.01, BG 1	11.5	Tract 91, BG 3	16.4	Tract 147.04, BG 1	10
Tract 15.03, BG 1	8.4	Tract 57.01, BG 2	8.4	Tract 92, BG 1	11.8	Tract 148.10, BG 2	9.6
Tract 15.03, BG 2	11.6	Tract 57.02, BG 1	13.6	Tract 92, BG 4	11	Tract 9810, BG 1	70.8
Tract 15.05, BG 1	13.1	Tract 57.02, BG 2	13.3	Tract 92, BG 5	29.3	Tract 9830, BG 1	79.6
Tract 17, BG 4	8.4	Tract 58, BG 2	15.5	Tract 93, BG 2	37.3	Tract 9840, BG 1	21.1

Table 1 (cont'd)
Toll Adjustment Study Area Low-Income Status

Census Block Groups	Individuals Below Poverty Level (%)*	Census Block Groups	Individuals Below Poverty Level (%)*	Census Block Groups	Individuals Below Poverty Level (%)*	Census Block Groups	Individuals Below Poverty Level (%)*
Rockland County Low-Income Block Groups at or Greater than County-wide Average of 11.3 Percent							
Tract 105.02, BG 3	17.9	Tract 115.04, BG 3	15.4	Tract 121.03, BG 2	36.2	Tract 123, BG 1	47.5
Tract 105.02, BG 4	54.9	Tract 115.05, BG 1	61.6	Tract 121.03, BG 3	17.3	Tract 123, BG 2	33
Tract 105.02, BG 5	14.5	Tract 115.05, BG 2	50.6	Tract 121.05, BG 1	56.9	Tract 123, BG 3	25.8
Tract 106.02, BG 4	13.4	Tract 115.06, BG 1	29.8	Tract 121.05, BG 2	65.9	Tract 124.01, BG 1	15.3
Tract 107.01, BG 1	34.4	Tract 115.06, BG 2	75.3	Tract 121.06, BG 1	14.2	Tract 124.01, BG 3	15.7
Tract 107.02, BG 1	20.8	Tract 116.02, BG 1	20.1	Tract 121.06, BG 2	46.2	Tract 124.02, BG 2	19.5
Tract 107.02, BG 3	21	Tract 119.01, BG 1	26.9	Tract 122.02, BG 1	23.9	Tract 124.02, BG 3	22
Tract 107.03, BG 1	30.4	Tract 121.01, BG 1	30.9	Tract 122.02, BG 2	13.3	Tract 125.01, BG 1	18.8
Tract 107.03, BG 2	15.6	Tract 121.01, BG 3	24.7	Tract 122.02, BG 3	13.3	Tract 125.02, BG 3	17.2
Tract 108.02, BG 1	17	Tract 121.02, BG 1	66.9	Tract 122.03, BG 1	15.4	Tract 130.01, BG 2	69.8
Tract 113.01, BG 2	17	Tract 121.02, BG 2	53.5	Tract 122.03, BG 2	33.3	Tract 130.02, BG 3	32.2
Tract 113.01, BG 3	13.5	Tract 121.02, BG 3	68.1	Tract 122.04, BG 1	25.1	Tract 130.03, BG 1	25.2
Tract 113.01, BG 4	27.6	Tract 121.03, BG 1	42.9	Tract 122.04, BG 2	35.6	Tract 131, BG 4	18.1
Orange County Low-Income Block Groups at or Greater than County-wide Average of 11.1 Percent							
Tract 1, BG 2	15.3	Tract 6, BG 3	17	Tract 112, BG 1	19.3	Tract 148, BG 5	11.5
Tract 1, BG 3	20.8	Tract 11, BG 1	22.5	Tract 112, BG 3	19.8	Tract 150.03, BG 1	77
Tract 3, BG 1	26.9	Tract 11 , BG 2	24.7	Tract 113, BG 3	12.2	Tract 150.03, BG 2	48.6
Tract 3, BG 2	14.1	Tract 11, BG 4	25.8	Tract 113, BG 4	17	Tract 150.04, BG 1	24.4
Tract 3, BG 3	15.5	Tract 12, BG 2	23.3	Tract 116.01, BG 3	25.3	Tract 150.04, BG 2	80.2
Tract 3, BG 4	60.3	Tract 13, BG 2	13.6	Tract 116.02, BG 3	15.1	Tract 150.04, BG 3	50.6
Tract 3, BG 5	26.6	Tract 15, BG 1	22.3	Tract 119, BG 4	31.6	Tract 150.05, BG 1	47.4
Tract 4, BG 1	17.5	Tract 15, BG 3	34.4	Tract 121, BG 2	22	Tract 150.05, BG 2	68.7
Tract 4, BG 2	49.1	Tract 16, BG 1	18.1	Tract 126.02, BG 1	16.5	Tract 150.06, BG 1	62.1
Tract 4, BG 3	35.7	Tract 16, BG 3	12.8	Tract 127, BG 1	17.6	Tract 150.06, BG 2	70.5
Tract 4, BG 4	27	Tract 21, BG 3	18.5	Tract 127, BG 4	12.3	Tract 151, BG 1	39.7
Tract 4, BG 5	37.8	Tract 22, BG 1	25.1	Tract 129, BG 1	18.4	Tract 151, BG 2	29.8
Tract 5.01, BG 1	27.3	Tract 22, BG 3	33.6	Tract 133, BG 2	23.1	Tract 151, BG 4	30.3
Tract 5.01, BG 2	21.5	Tract 101.02, BG 4	20.7	Tract 137, BG 1	13.9	Tract 151, BG 5	43.3
Tract 5.01, BG 3	13.9	Tract 105, BG 2	18.9	Tract 137, BG 2	11.8	Tract 151, BG 6	26.7
Tract 5.02, BG 1	39.7	Tract 105, BG 5	15.9	Tract 141.01, BG 1	20	Tract 152, BG 1	12.7
Tract 5.02, BG 2	36.2	Tract 106, BG 5	11.2	Tract 141.01, BG 2	35.7	Tract 152, BG 4	13.2
Tract 5.02, BG 3	48.7	Tract 107, BG 5	15.1	Tract 143.01, BG 2	18		
Tract 5.02, BG 4	35	Tract 108.02, BG 2	27.1	Tract 145.01, BG 2	21.8		
Tract 6, BG 2	18.5	Tract 110, BG 4	11.6	Tract 148, BG 4	12.3		

Notes: *Percent of individuals with incomes below poverty level, as established by the U.S. Census Bureau.
Sources: U.S. Census Bureau, 2006-2010 American Community Survey.

4 ENVIRONMENTAL EFFECTS

To assess the potential impact of toll increases on the low-income communities identified in the toll adjustment study area, the first step of the analysis was to characterize the likelihood that low-income residents are regular commuters or users of the bridge. Based on estimates derived independently from both E-ZPass data and census data, the vast majority of regular commuters or users of the bridge are not low-income residents.

A review was undertaken of all E-ZPass customers who used the bridge during the month of October 2011. Of the approximately 391,000 New York State E-ZPass customers who crossed the Tappan Zee Bridge in October 2011, approximately 21,600 (about 5 percent) were determined to be commuters that utilize the Tappan Zee Bridge as part of a full or part time daily commute (measured as an E-ZPass customer with 15 or more trips in the month). If the 21,600 of Tappan Zee Bridge commuters with E-ZPass represent 75 percent of the total number of Tappan Zee Bridge commuters (about 29,000), then these 29,000 total Tappan Zee Bridge commuters represent about 1.8 percent of the total combined population of the three county toll adjustments study area. The data also supports that the vast majority of the commuters are commuting west to east (from Rockland and Orange Counties to Westchester).

The E-ZPass-derived estimate of 29,000 Tappan Zee Bridge commuters is consistent with another measure of the regular commuting population which uses CTPP data to estimate work trips that would be most likely to cross the Tappan Zee Bridge. This journey-to-work data yields an estimated commuter base of 32,840 Tappan Zee Bridge commuters. While the CTPP-derived estimate represents a different data source and a slightly larger data collection area, is consistent with and validates the estimate derived from E-ZPass data.[4]

Based on the CTPP, an income profile of these commuters was developed which indicates that, only 1.23 percent regular commuters on the bridge are estimated to be low-income (i.e. below poverty level). The majority of the Tappan Zee Bridge commuters in the study area had household incomes over $150,000 (35.6 percent), followed by the $100,000-$149,999 range (29.8 percent), with only 0.5 percent with incomes less than $15,000 (which is roughly the poverty level for a two-person family in accordance with the 2012 Federal Poverty Guidelines). These incomes are in line with the average household incomes for the counties in the study area and are above the average household incomes for the low-income communities in the study area (see **Table 2**), which supports the notion that the vast majority of commuters are not low-income. Therefore, on a regional basis the potential toll increases would not be expected to be disproportionately borne by a low-income population.

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[4] Journey-to-work tables were collected for six counties surrounding the TZB—Rockland, Bergen, and Orange on the west of the Hudson River and Fairfield, Westchester, and the Bronx on the east side. All trips originating from a county on one side of the Hudson River and terminating at a county on the other side were considered for purposes of identifying the commuters, with the exception of trips between Bergen and Bronx Counties, since it was assumed that the trips originating in either of these counties and terminating in the other would traverse the Hudson River via the George Washington Bridge rather than the TZB.

Table 2
Toll Spending as Percent of Income by County

County	2010 Avg. HH Income County-Wide	2010 Avg. HH Income Low Income Areas
Rockland	$105,450	$82,056
Orange	$83,948	$88,183
Westchester	$128,127	$66,367
Sources: 2006-2010 ACS 5-Year Estimates		

Nonetheless, while a very small percentage of the total commuting population is low-income residents, these users would have to allocate a greater proportion of their income to pay for any potential toll increases. In addition to toll adjustments themselves, it is also noted that the existing and future burden on some low-income populations is accentuated if such users are not able to purchase an E-ZPass (due to set-up fees or lack of a credit card and/or bank account or language barriers) since tolls are and would be higher without the discounts offered to E-ZPass customers. The project would include the provision of offsetting benefits including transportation improvements and E-ZPass education such that there would not be disproportionately high and adverse effects on low-income commuting populations. For instance, as an offsetting benefit, NYSTA is committed to offering enhanced marketing efforts to expand E-ZPass use across minority and low-income populations, which would provide a discount on the proposed toll increase. In addition, as previously noted, rather than diverting to other crossings, some travelers faced with the toll adjustment could choose to continue using the Tappan Zee Bridge but share toll expenses through carpooling which also has an additional discount (for cars with 3 or more occupants) of 10 percent of the cash toll for cars, or currently $0.50 based on the $5.00 cash toll for cars.

Low-income commuters may also take advantage of existing bus transit services connecting Westchester, Rockland, and Orange Counties as well as utilizing the project's dedicated bicycle and pedestrian lanes for those potential users who don't own vehicles. For example, those with Limited English skills are more likely to take public transportation or utilize their relatives for transportation until such a time as their English skills are more proficient. According to the FTA's policy guidelines, "Public transit is a key means of achieving mobility for many LEP persons. According to the 2000 Census, more than 11 percent of LEP persons aged 16 years and over reported use of public transit as their primary means of transportation to work, compared with about 4 percent of English speakers."[5] Public transportation pools the expense of the tolls, and reduces the burdens of payment, insurance, fuel, and maintenance costs. NYSDOT will continue to interact with several local public transportation providers and also subsidizes public transportation through its Region 8 office, thus further enhancing commuter and local transit ridership opportunities.

In summary, the vast majority of regular commuters of the Tappan Zee Bridge are not low-income residents. As presented in the FEIS, the project includes mitigation measures for the project's potential adverse impacts, and includes potential offsetting

[5] " Implementing the Department of Transportation's Policy Guidance Concerning Recipients' Responsibilities to Limited English Proficient (LEP) Persons: A Handbook for Public Transportation Providers" (April 2007), p 5.

benefits such as transportation improvements and E-ZPass education. The project would provide regional transportation connectivity; an improved Hudson River crossing; structural, operational, mobility, safety, and security improvements; trans-Hudson access for cyclists and pedestrians and study area residents; and would not affect existing bus service nor would it preclude transit operations. The addition of the shared-use path would also benefit area residents with no access to a car or other vehicle transport. Moreover, as noted above, as an offsetting benefit, NYSTA is committed to offering enhanced marketing efforts to expand E-ZPass use across minority and low-income populations, which would provide a discount on the proposed toll increase.

Therefore, the project would not be expected to result in disproportionately high and adverse toll adjustments effects on environmental justice populations.

5 PUBLIC PARTICIPATION

FHWA, the New York State Department of Transportation (NYSDOT) and NYSTA have engaged in a robust public outreach effort. The public outreach program, including outreach to the affected communities of concern, will be ongoing throughout the environmental review process in accordance with applicable regulations. In addition to the opportunities for public participation to date, from publication of the FEIS and forward towards implementation of the project, there will be additional opportunities for public input. The FEIS will have a 30-day public review period, and, most notably, any toll adjustments are subject to approval by the NYSTA Board and, in accordance with NYSTA policy and the New York State Public Authorities Law, the Board would hold one or more public hearings on its proposed toll adjustments. These hearings will be widely advertised and public comments will be considered prior to a final vote by the Board. Information on tolling adjustments and public comment process is provided on the NYSTA website (http://www.thruway.ny.gov/news/adjustment/index.html).

6 MITIGATION FOR DISPROPRIONATELY HIGH AND ADVERSE EFFECTS

The Replacement Bridge Alternative would not result in any disproportionately high and adverse effects on minority and low-income populations during operation or construction and therefore no mitigation would be required.

6.8.12

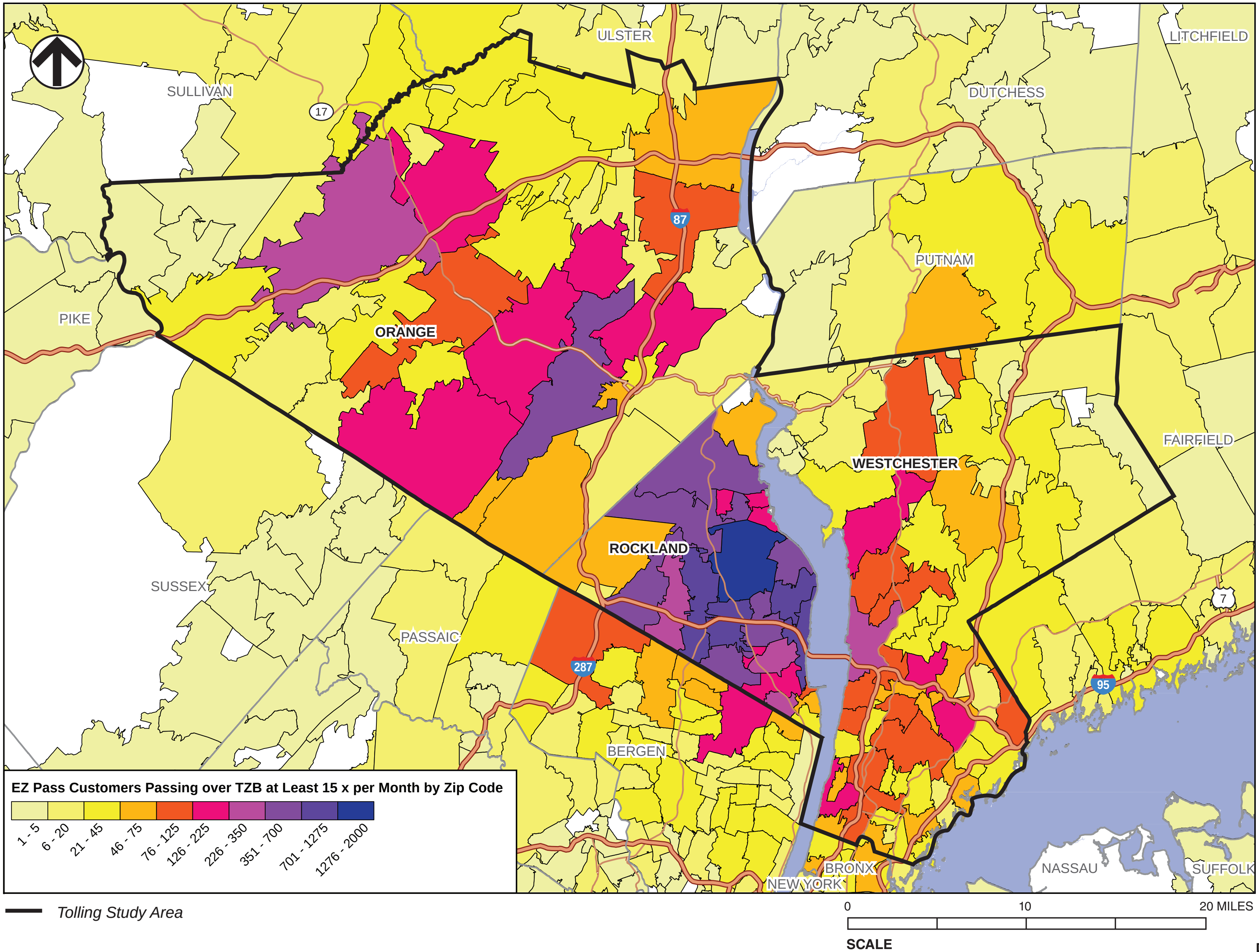


Figure 1

Tolling Study Area for Environmental Justice - Commuter Shed

6.8.12

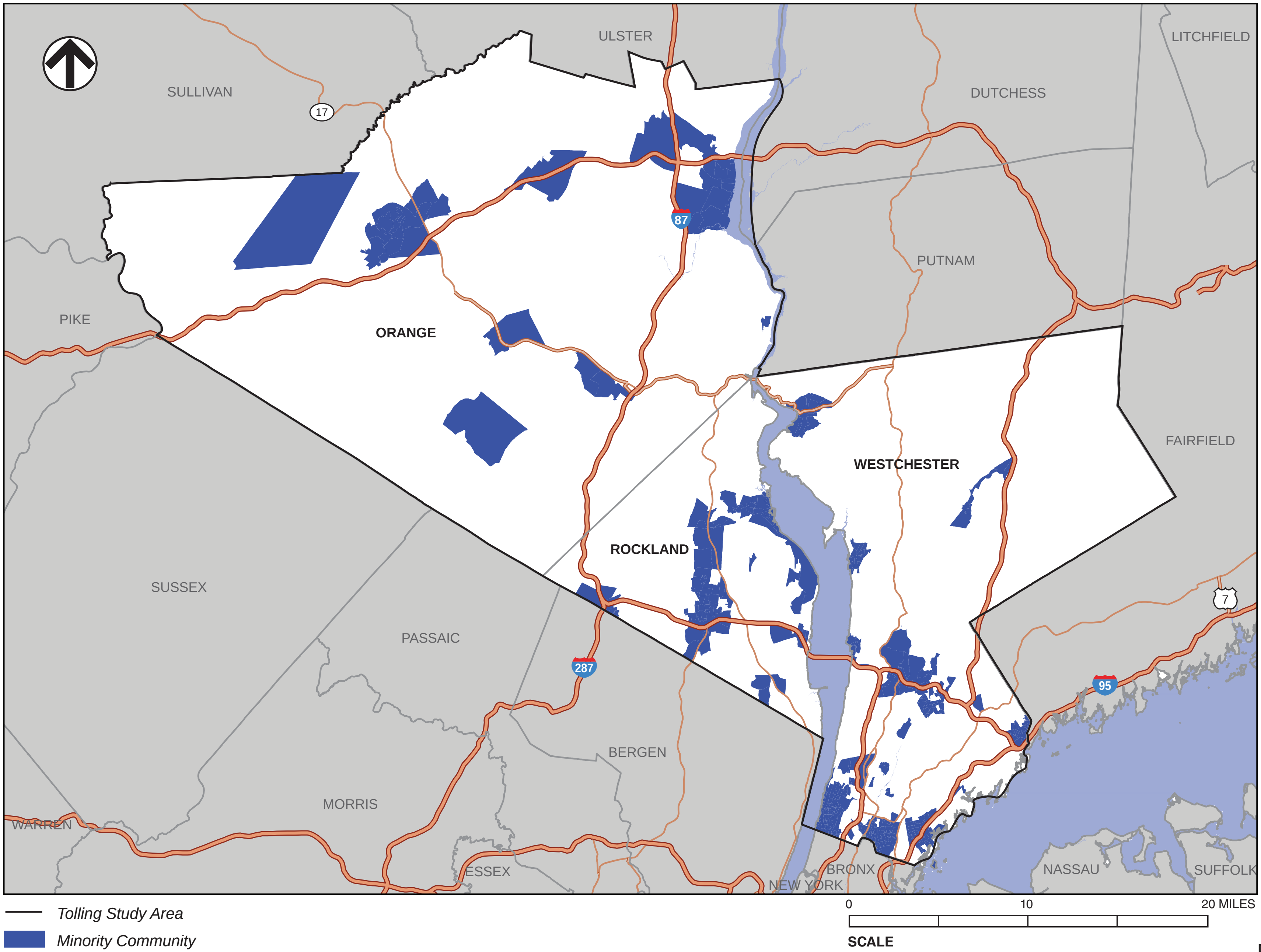
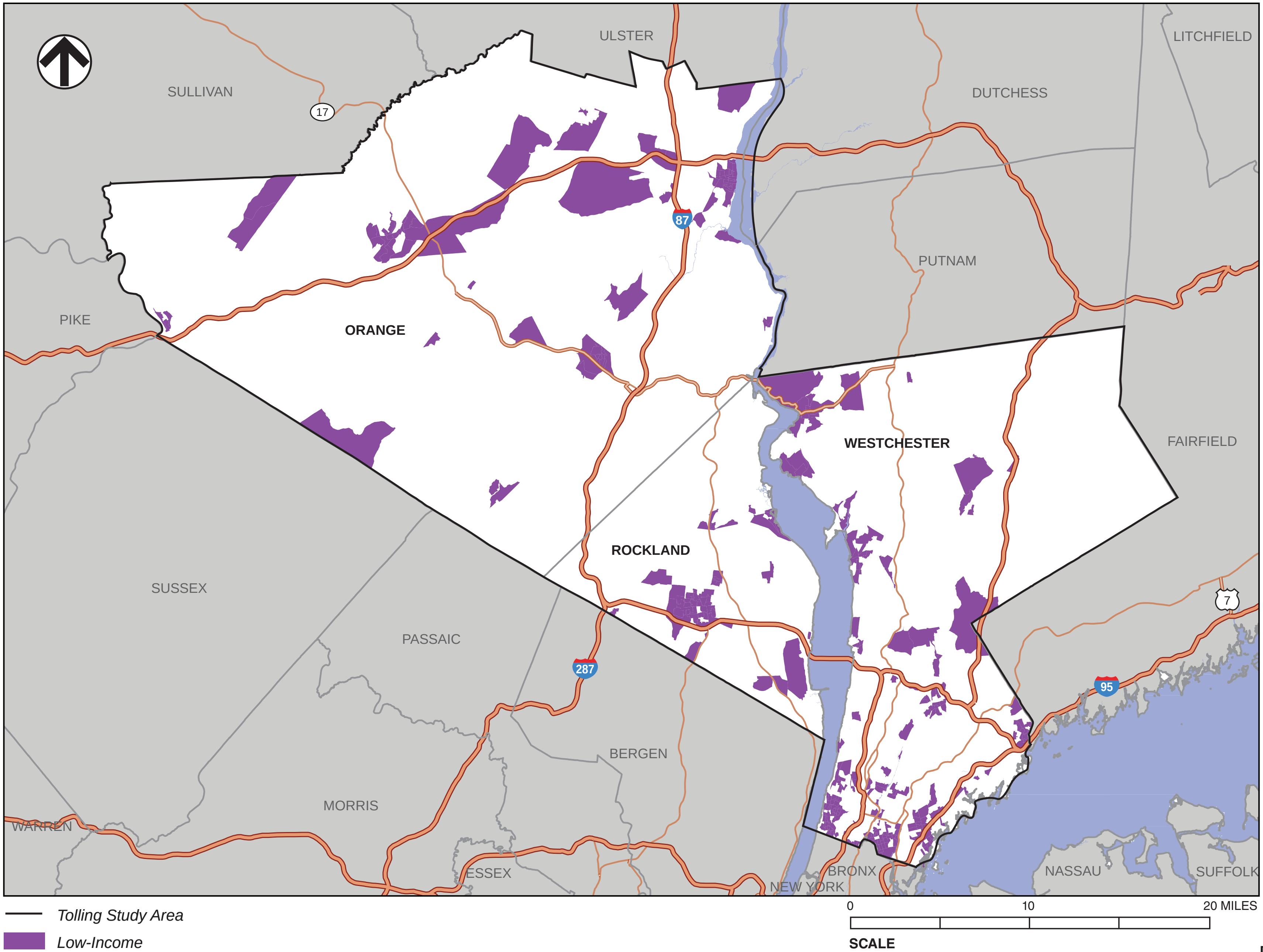


Figure 2

Tolling Study Area for Environmental Justice - Minority Communities

6.8.12



Tolling Study Area

Low-Income

Figure 3

Tolling Study Area for Environmental Justice - Low-Income Communities

Exhibit 3: Biological Assessment and Biological Opinion

3-1 Biological Assessment

Biological Assessment for the Tappan Zee Hudson River Crossing Project

Revised April 2012

Biological Assessment
For the Tappan Zee Hudson River Crossing Project

Revised April 2012

Primary Agency and Contact:

Jonathan McDade, New York Division Administrator
Federal Highway Administration

In Coordination with:

New York State Department of Transportation
New York State Thruway Authority

Prepared by:

AKRF, Inc.
AECOM
Arthur Popper, Ph.D.

Project Name: *Tappan Zee Hudson River Crossing Project*

Date: *April 2012*

Primary Agency and Contact:
Jonathan McDade, New York Division Administrator
Federal Highway Administration

In Coordination with:
New York State Department of Transportation
New York State Thruway Authority

Executive Summary

The Tappan Zee Bridge opened to traffic in 1955 as part of the New York State Thruway extension between Suffern, New York and Yonkers, New York. Over the years, the bridge and its highway connections have been the subject of numerous studies and transportation improvements. Improvements to the Tappan Zee Bridge included the installation of a movable barrier to allow for operation of a seven-lane cross section with four lanes in the peak direction, electronic toll collection, and variable pricing for commercial vehicles. Despite these improvements, congestion has grown steadily and the aging bridge structure has reached the point where major reconstruction is needed to sustain this vital link in the transportation system.

In April 2000, a Long Term Needs Assessment and Alternatives Analysis was completed by the New York State Governor's I-287 Task Force. The report concluded that while there was no single preferred solution for addressing the transportation needs in Tappan Zee Bridge/I-287 Corridor, both a short-term aggressive Transportation Demand Management (TDM) program and longer-term capital improvements were needed. All of the long-term alternatives evaluated by the Task Force called for replacement of the existing Tappan Zee Bridge. It was concluded that rehabilitation of the existing bridge would be highly disruptive, perhaps as costly, and not as beneficial in mobility enhancement or meaningful congestion relief, compared with a replacement bridge.

Over the next few years, project development continued with increasing involvement by the New York State Department of Transportation (NYSDOT). Alternatives for transit modes along the corridor were identified, as were a set of highway and bridge improvements. In 2011 it was determined that funding for the corridor project (bridge replacement, highway improvements, and new transit service) was not possible due to fiscal constraints. The financing of the crossing alone, however, was considered affordable. Therefore, it was determined that the scope of the project should be limited, and that efforts to replace the Hudson River crossing independent of the transit and highway elements should be advanced. On October 12, 2011, FHWA published an NOI to rescind the Tappan Zee Bridge/I-287 Corridor Project, thereby concluding the environmental review process for the combined study of bridge, highway, and transit elements. On that same date, FHWA published an NOI for the Tappan Zee Hudson River Crossing Project to examine alternatives for an improved Hudson River crossing between Rockland and Westchester Counties. As described in the NOI, FHWA, acting as the federal lead agency, and NYSDOT and NYSTA, acting as the co-sponsoring agencies, are preparing an EIS and other necessary documents to identify alternatives for an improved Hudson River crossing and to document the potential environmental consequences of these alternatives. Two Replacement Bridge Alternative options are being considered and are called the Long Span and Short Span Options. The two options would be constructed using the same general construction sequencing and methods over an approximately 4 ½ to 5 ½ year period, respectively.

Under Section 7 of the Endangered Species Act (ESA), the FHWA is required to consult with the United States Fish and Wildlife Service (USFWS) and National Oceanic and Atmospheric Administration (NOAA) Fisheries to determine whether any federally listed species or species proposed for listing as endangered or threatened, or their designated critical habitats, occur in the vicinity of a proposed project that is subject to United States Environmental Protection Agency

(USEPA) jurisdiction. In the event that a federally listed or proposed endangered or threatened species or its designated critical habitat occurs in the vicinity of a "major construction activity," a Biological Assessment (BA) must be prepared to determine whether the proposed federal action would affect that species. The regulations promulgated pursuant to the ESA require every federal agency to ". . .[e]nsure that any action it authorizes, funds, or carries out, in the United States or upon the high seas, is not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of critical habitat" (50 CFR § 402.01) ."

In compliance with Section 7(c) of the ESA of 1973, as amended, this BA, prepared by FHWA, addresses the proposed action and its potential to affect two species, namely the federally listed shortnose sturgeon (*Acipenser brevirostrum*) and Atlantic sturgeon (*Acipenser oxyrinchus)*. On February 6, 2012 NMFS promulgated regulations to list the New York Bight District Population Segment (DPS) of Atlantic sturgeon as endangered under the ESA with an effective date of April 6, 2012. Section 7 of the ESA requires that, through consultation (or conferencing for proposed species) with the National Marine Fisheries Service (NMFS), federal actions do not jeopardize the continued existence of any threatened, endangered, or proposed species or result in the destruction or adverse modification of critical habitat. This BA evaluates the potential effects of the proposed transportation project on these two species of sturgeon. Specific project design elements are identified that avoid or minimize adverse effects of the proposed project on listed species and/or critical habitat.

The limits of the study area considered in this BA are different than from those typically considered in an EIS. The BA study area has been determined by the potential project effects for dredging and resuspension and redeposition of suspended sediment, acoustic impacts from pile driving, and loss of habitat. The potential geographic boundaries of these effects extend across the entire width of the Tappan Zee Reach of the Hudson River, and based on modeled sound isopleths with a 10 dB reduction associated with proposed BMPs, extend a maximum of 2210 meters (m) (7,250 feet) or less in both up and downriver directions. For sediment resuspension, which is a measure for assessing impacts to water quality, project increments 10 mg/L above ambient conditions may extend in a relatively thin band approximately 305-610 m (1,000 to 2,000 ft) from the dredges. Concentrations of 5 mg/L above ambient associated with the project may extend a greater distance in either an upstream or downstream direction, depending upon the tidal stage. Because of the recent listing of the Atlantic sturgeon, the study area has been expanded to also include the HARS, where dredged material is expected to be transported to and placed.

An analysis of the potential effects of exposure to pile-driving noise on the shortnose and Atlantic sturgeon was undertaken. The number of sturgeon potentially occurring in the area ensonified by pile-driving noise is summarized for both species in **Table ES-1.**

The results of a gill-net study conducted in the vicinity of the Replacement Bridge Alternative in 2007-2008, indicated a potential take of 796 shortnose sturgeon through exposure to an SEL_{cum} of 187 dB re 1 $\mu Pa^2 \cdot s$ (i.e., potential for onset of physiological effects, without any effect on fitness) over the project duration for the Short Span Option (**Table ES-1**). Similarly, 603 sturgeon have the potential to be exposed to an SEL_{cum} of 187 dB re 1 $\mu Pa^2 \cdot s$ over the project duration for the Long Span Option. Of these amounts, a total of 298 shortnose sturgeon would be subject to an ensonified area of 197 dB re 1μPa^2·s SEL_{cum} (i.e., potential for onset of recoverable physical injury, such as external tissue effects, e.g., minor hemorrhage) for the Short Span and 218 shortnose sturgeon for the Long Span Option. The number of shortnose sturgeon that would encounter an ensonified area of 207 dB re 1μPa^2·s SEL_{cum} (i.e., potential for onset of mortal injury) during the course of the construction period was 89 shortnose sturgeon for the Short Span Option and 67 shortnose sturgeon for the Long Span Option.

Based on the proposed construction schedule the greatest take would be associated with the first six months of construction when the largest piles would be driven. Based on a population estimate of 61,057 for shortnose sturgeon in the Hudson River (of which 93% are estimated to be adults), the Short Span Option has the potential to expose up to 325 fish (0.5% of the shortnose sturgeon population) and the Long Span Option has the potential to expose up to 243 fish (0.4% of the shortnose surgeon population) in the year of maximum exposure to pile driving sounds of 187 dB re 1 μPa^2·s. Fewer shortnose sturgeon would experience pile driving sounds of 197 dB re 1 μPa^2·s during construction of the Short Span (123 fish; 0.2%) and Long Span (66 fish; 0.1%) Options in the year of greatest potential exposure. Fewer still would be exposed to pile driving sounds equal to or greater than 207 dB re 1 μPa^2·s for the Short Span (35 fish; 0.06%) and Long Span (7 fish; 0.01%) Options. Potential effects to shortnose sturgeon would be considerably less during the remaining years of construction.

For the entire construction period, 1.3% (Short Span Option) and 1.0% (Long Span Option) of the estimated population of 61,057 shortnose sturgeon would potentially be exposed to pile-driving signals that exceed the interim West Coast criterion of SEL_{cum} of 187 dB re 1 μPa^2·s. These estimates of population exposure should be viewed as a conservative maximum because they represent the encounter rate within the isopleths over several years, and some fraction of that total number of shortnose sturgeon would be encountered more than once without having experienced the necessary sound exposure for the onset of injury.

NMFS has identified five Distinct Population Segments (DPS) of Atlantic sturgeon within the western North Atlantic. The Hudson River population is included in the New York Bight DPS. A review of the literature suggests that the likelihood of the project to affect the other four DPS of Atlantic sturgeon in any meaningful way is low. In the recently prepared Biological Opinion for the Pile Installation Demonstration Project (PIDP), NMFS determined that Atlantic sturgeon in the action area are likely to originate from three DPSs at the following frequencies: Gulf of Maine 6%; New York Bight 92%; and Chesapeake Bay 2% (NMFS 2012).

Because Atlantic sturgeon were not collected in the gill-net sampling program, a different analysis approach was developed relying on the Utilities Fall Shoals collections of juvenile fish, gear-efficiency estimates of the Fall Shoals sampling gear, plus the portion of the estimated adult spawning population of 863 Atlantic sturgeon (Kahnle et al. 2007) that would be subject to risk during pile-driving activities. The analysis indicated that from 193-252 juvenile Atlantic sturgeon and 10-27 adult Atlantic sturgeon would potentially be exposed to an SEL_{cum} of 187 dB re 1 μPa^2·s (i.e., potential for onset of physiological effects without any effect on fitness) over the project duration for the Short Span Option (**Table ES-1**). Similarly, from 158-303 juveniles and 4-10 adult sturgeon have the potential to be exposed to an SEL_{cum} of 187 dB re 1 μPa^2·s over the project duration for the Long Span Option. A total of 113-116 juvenile Atlantic sturgeon and

4-13 adult sturgeon would be subject to an ensonified area 197 dB re 1μPa^2·s SEL_{cum} (i.e., potential for onset of recoverable physical effects, such as external tissue effects, e.g., minor hemorrhage) for the Short Span and 93-141 juvenile sturgeon and 2-5 adult sturgeon for the Long Span Option. The number of riverine juvenile and spawning adult Atlantic sturgeon that would encounter an ensonified area of 207 dB re 1μPa^2·s SEL_{cum} (i.e., potential for onset of mortal injury) during the course of the construction period was 49-50 juveniles and 0-5 adults for the Short Span Option and 40-57 juveniles and 0-3 adults for the Long Span Option.

For the entire construction period, 0.9% - 1.1% of the riverine juvenile population of Atlantic sturgeon would potentially be exposed to pile-driving effects of 187 dB re 1 μPa^2·s SEL_{cum} for the Short Span Option and 0.7% - 1.4% for the Long Span Option. For spawning adult Atlantic sturgeon, 1.1%-3.1% of the population would potentially be exposed to pile-driving effects of 187 dB re 1 μPa^2·s SEL_{cum} for the Short Span Option (depending on construction start-date) and 0.5% - 1.2% for the Long Span Option.

Table ES-1
Number of Sturgeon That May Occur in Ensonified Areas Over the Project Duration

Species	Life Stage	Bridge Option	Potential for Onset of Physiological Effects (187 dB re 1μPa^2·s)	Potential for Onset of Recoverable Injury (197 dB re 1μPa^2·s)	Potential for Onset of Mortal Injury (207 dB re 1μPa^2·s)
Shortnose sturgeon	Juvenile/Adult	Short Span	796	298	89
	Juvenile/Adult	Long Span	603	218	67
Atlantic sturgeon	Juvenile	Short Span	193-252	113-116	49-50
	Adult		10-27	4-13	0-5
	Juvenile	Long Span	158-303	93-141	40-57
	Adult		4-10	2-5	0-3

The analysis indicated that 35-46 juvenile Atlantic sturgeon have the potential to be exposed to an SEL_{cum} of 187 dB re 1μPa^2•s isopleths during a given year of construction for the Short Span Option and 35-67 juvenile Atlantic sturgeon for the Long Span Option; this represents 0.16 - 0.21% and 0.16 – 0.31% of the riverine juvenile population, respectively. These sturgeon would be susceptible to the physiological effects associated with exposure to this level of accumulated sound but would be expected to recover fully from any stress. Because of the smaller volume occupied by the 197 dB re 1μPa^2•s isopleths, fewer juveniles (21 sturgeon in a given year for the Short Span Option and 21-31 sturgeon for the Long Span Option; 0.09% and 0.09-0.14% of the riverine juvenile population, respectively) would be exposed to accumulated sound levels that may cause the onset of recoverable physical injury (e.g., auditory tissue damage, hemorrhaging). Even fewer juvenile Atlantic sturgeon (9 sturgeon per year for the Short Span Option and 9-13 sturgeon for the Long Span Option; 0.06% and 0.04-0.06% of the population, respectively) would be susceptible to cumulative sound exposure levels considered to be a very conservative level for the onset of mortality (i.e., 207 dB re 1µPa^2•s). At these sound levels, it is expected that avoidance behavior by sturgeon prior to the accumulation of 207 dB re 1µPa^2•s would minimize the number of fish subject to mortality.

These predictions are also likely to overestimate the number of shortnose and Atlantic sturgeon potentially affected for the following reasons:

- Since the calculations do not take into consideration the normal behaviors of the fish in response to a noxious stimulus, it is reasonable to assume that sturgeon, on hearing the pile driving sound, would either not approach the source or move around it. Since the pile driving sounds are very loud, it is also very likely that many of the fish will hear the sound, and respond behaviorally by moving away, to a quieter location, well before they reached a point at which the sound levels exceeded even the interim SEL_{cum} criterion of 187 dB re 1 µPa^2·s. Thus, the likely behavioral response of the fish would be to alter the path through which they were traveling to avoid the sounds that were too loud and then resume their regular path once the highest sound levels were skirted. Moreover, the SEL_{cum} assumes the fish are resident within the ensonified area for the entire duration of the time to drive the pile, and this is not likely to occur since fish tend to move around and avoid areas of high sound levels.

- The analysis assumed that impact hammers would be used to drive the entire length of all of the piles. In reality vibratory hammers will be used whenever feasible, which in many cases will be for at least 50% of the pile length. Caltrans (2009) reported that vibratory hammers produce sound energy that is spread out over time and is generally 10 to 20 dB lower than impact hammer driving. Moreover, vibratory piles are continuous sounds and do not have the sharp rise times associated with impact hammering. In fact, vibratory hammers more resemble continuous sounds. Since the major physiological effects on fish is from the rapid rise time of a signal (at onset), and since vibratory hammers do not have successive sharp rise times, the likelihood is that these sounds will have no more impact on fish than do the more comparable sounds used in studies of effects of high intensity sonars on fish (Popper et al. 2007; Halvorsen et al. 2012).

- The criteria used for potential onset of physiological effects that do not reduce fitness (>187 dB re 1 µPa^2·s), potential onset of recoverable injury (>197 dB re 1 µPa^2·s) and potential onset of mortal injuries (>207 dB re 1 µPa^2·s) are still very conservative, particularly based on new studies from the Transportation Research Board (Halvorsen et al. 2011). Based on this scientific study, the onset of fully recoverable injury to fish that does not lessen fitness would not occur until cumulative levels of 203 dB re 1 µPa^2·s or higher, and onset of mild injuries that could produce some decrease in fitness would not occur until cumulative sound levels are higher than 210 dB re 1 µPa^2·s. Onset of potential mortal injuries would be even higher, depending upon the species of concern. Measured by these higher values, the size of the ensonified area that could potentially cause onset of injury would be considerably reduced, as would the number of potentially affected fish.

- The analysis was conducted using a 10 dB reduction in sound energy generated by pile driving associated with implementation of BMPs. This level of attenuation may well underestimate the level of noise attenuation that can be achieved by bubble curtains or other technologies (i.e., 20 dB; Caltrans 2009).

- Carlson et al. (2007) indicated that as fish get larger there is less of a physiological impact from sounds, and that the threshold for onset to injury to larger fish, such as sturgeon, is substantially higher (i.e. 213 dB re 1 $\mu Pa^2 \cdot s$) for fish above 200 grams, than the West Coast criterion for fish > 2 gm (i.e. 187 dB re 1 $\mu Pa^2 \cdot s$).

A number of Environmental Performance Commitments (EPCs) which would also serve to minimize take will be implemented by the Project. These include:

- Driving the largest [3 and 2.4 m (10 and 8 ft)] diameter piles within the first few months of the project thereby limiting the time period of greatest potential impact.

- Using cofferdams and silt curtains, where feasible, to minimize discharge of sediment into the river.

- Using a vibratory pile driver to the extent feasible (i.e., all piles will be vibrated at least to 36.6 m (120ft) depth or to vibration refusal) particularly for the initial pile segment.

- Using bubble curtain, cofferdams, isolation casings, Gunderboom, or other technologies to achieve a reduction of at least 10 dB of noise attenuation.

- Using the results of the Hudson River site specific Pile Installation Demonstration Project (PIDP) which includes the testing of various sound attenuation devices to inform the project on the effectiveness of BMP technologies for reducing sound levels, and implementing BMPs to achieve maximum sound reduction.

- Limiting the periods of pile driving to no more than 12-hours/day.

- Limiting driving of 8 and 10 ft piles with an impact hammer within Zone C [water depths 5.5-13.7 m (18-45 feet)] to 5 hours per day during the period of spawning migration for shortnose and Atlantic sturgeon (April 1 to August 1).

- Maintaining a corridor where the sound level is below the West Coast threshold for onset of behavioral effects to fish totaling at least 5000-ft at all times during impact hammer pile driving. This corridor shall be continuous to the maximum extent possible but at no point shall any contributing section be smaller than 1500 ft.

- Pile tapping (i.e. a series of minimal energy strikes) for an initial period to cause fish to move from the immediate area.

- Development of a comprehensive monitoring plan. Elements would include:

  - Monitoring water quality parameters such as temperature, salinity, and suspended sediment concentrations in the vicinity of the pile driving.
  - Monitoring fish mortality and inspection of fish for types of injury, as well as a program for determining contaminant levels in dead sturgeon through tissue analysis methods.
  - Monitoring the rate of recovery of the benthic community within the dredged area and armored bottom and also providing site specific information on sedimentation processes and time of recovery of sturgeon foraging soft bottom habitat following construction and temporary modification of bottom habitat.
  - Supporting the Atlantic and shortnose sturgeon sonic tagging program through coordination with NMFS and NYSDEC. This may include placement of telemetry receivers in the project area.
  - Monitoring predation levels by gulls and other piscivorous birds, which would indicate an increased number of dead or dying fish at the surface.
  - Preparing a Standard Operating Procedures Manual outlining the monitoring and reporting methods to be implemented during the program.
- In addition, dredging (using a clamshell dredge with an environmental bucket) would only be conducted during a three-month period from August 1 to November 1 for the three years of the construction period in which dredging would occur, which would minimize the potential for interaction with the dredge and migration effects to sturgeon and other fish species.

The results of this BA indicate that:

1. For individual shortnose and Atlantic sturgeon within the immediate vicinity of pile driving and other in-water construction activities, there is a potential for injury.

2. There is potential for interaction with the clamshell dredge that could result in injury to a limited number of shortnose and Atlantic sturgeon.

3. Pile driving and dredging would have minimal effects to sturgeon migratory activities as there will always be large portions of the river width that will not be ensonified, and dredging will be limited to a three-month window between August 1 and November 1 during 3 of the 4 ½ or 5 ½ construction years.

4. There is no designated critical habitat for shortnose sturgeon or Atlantic sturgeon.

5. Dredging of 0.67-0.71 square kilometers (km) (165-175 acres) for access channels will create an area of reduced foraging opportunities for both shortnose and Atlantic sturgeon due to loss of benthic habitat. However, upon completion of in-water activities in a given area, estuarine depositional processes would, over time, allow the benthic habitat to return to its pre-construction condition. The temporary loss of the access channel area would represent a minor fraction of similar habitat in the Tappan Zee portion of the Hudson River.

6. Incidental vessel strikes will be insignificant because sturgeon are generally found within one meter of the bottom in the deepest available water. Based on the types of vessels to be employed and their drafts, there should always be sufficient clearance between vessels and the river bottom.

7. Indirect effects from resuspended sediments are expected to be insignificant.

8. The loss of 2.16 acres of bottom habitat associated with the permanent platform would not result in meaningful direct or indirect effects to shortnose or Atlantic sturgeon. The permanent platform will be located in 6-10 feet of water along the western edge of the river approximately 1.5 miles from the 20-ft depth contour, and is not located in primary habitat for sturgeon migration, foraging, or overwintering.

9. A review of the literature indicates that the likelihood of the project to affect the four other DPS of Atlantic sturgeon in any meaningful way is low. The Biological Opinion for the Pile Installation Demonstration Project (NMFS 2012) indicated that 92% of the Atlantic sturgeon in the action area would have originated from the New York Bight DPS, 6% from the Gulf of Maine DPS, and 2% from the Chesapeake DPS.

10. Marine mammals rarely occur in the project area and only as transients in this portion of the Hudson River. Because this portion of the Hudson River does not provide areas for spawning, nursery, or overwintering, or migratory pathways for these species, any anthropogenic sound in the river is not expected to result in adverse effects to the movement, reproduction, feeding, or sustained population of marine mammal species.

11. The transport to, and placement of project dredged material at the HARS will present minimal risks to Atlantic sturgeon, provided established protocols and permit conditions are followed.

The BA concludes that while the Replacement Bridge Alternative may potentially injure or result in mortality to some individual shortnose and/or Atlantic sturgeon in the immediate vicinity of the pile driving resulting in an incidental take, and while dredging and armoring of the bottom will result in a temporary reduction in foraging opportunities, the project will not jeopardize the continued existence of the shortnose or Atlantic sturgeon populations of the Hudson River.

Based on the fact that marine mammals are rare and transient to the study area, the proposed project will not jeopardize the continued existence of the marine mammal species that have been reported in the Tappan Zee Reach of the Hudson River.

Effect Determination for Critical Habitat

There is no designated critical habitat for the shortnose sturgeon or Atlantic sturgeon.

Overall Effect Determination

Overall project effects are summarized in **Table ES-2** below that lists affected species and major project elements, and the effect determinations associated with each.

Table ES-2
Overall Project Effects

Jurisdiction	Federal Status	Common Name	Effect Determination					
			Pile Driving	Interaction with Dredge	Permanent Loss of Habitat Due to Dredging	Vessel Traffic	Sediment Resuspension	Overall Project
NMFS	Endangered	Shortnose Sturgeon	Likely to adversely affect	Likely to adversely affect	No effect	No effect	No effect	Likely to adversely affect
NMFS	Endangered	Atlantic Sturgeon	Likely to adversely affect	Likely to adversely affect	No effect	No effect	No effect	Likely to adversely affect
NMFS	Various	Marine Mammals	No effect	No effect	No effect	No effect	No effect	No effect

Reasonable and Prudent Measures to Minimize Take

As outlined previously, every effort will be made to ensure that the potential for incidental take of Atlantic and shortnose sturgeon is minimized by observing a number of environmental commitments and assurances. Briefly, these include: 1) pilot testing of various noise abatement and sediment containment measures during the PIDP, 2) reduction of noise impacts through the implementation of BMPs and by limiting the duration of pile-driving activities with impact hammers, particularly during biologically significant time periods (e.g., spawning migrations), 3) use of vibratory hammers to the fullest extent possible, 4) maintenance of a minimum 5,000-ft corridor of passage outside of the ensonified area to allow fish migration through the study area, 5) minimization of suspended sediments using cofferdams and silt curtains, 6) monitoring of water quality and sturgeon for injury and mortality during pile-driving to ensure re-consultation with NMFS if warranted, and, 7) use of a clamshell dredge and limiting dredging to a three-month period from August 1 to November 1 for the three years of the construction period in which dredging would occur, and 8) development of a comprehensive monitoring plan.

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Chapter 1 Project Overview

The Tappan Zee Bridge opened to traffic in 1955 as part of the New York State Thruway extension between Suffern, New York and Yonkers, New York. Over the years, the bridge and its highway connections have been the subject of numerous studies and transportation improvements. Improvements to the Tappan Zee Bridge included the installation of a movable barrier to allow for operation of a seven-lane cross section with four lanes in the peak direction, electronic toll collection, and variable pricing for commercial vehicles. Despite these improvements, congestion has grown steadily and the aging bridge structure has reached the point where major reconstruction is needed to sustain this vital link in the transportation system.

In April 2000, a Long Term Needs Assessment and Alternatives Analysis was completed by the New York State Governor's I-287 Task Force. The report concluded that while there was no single preferred solution for addressing the transportation needs in Tappan Zee Bridge/I-287 Corridor, both a short-term aggressive Transportation Demand Management (TDM) program and longer-term capital improvements were needed. All of the long-term alternatives evaluated by the Task Force called for replacement of the existing Tappan Zee Bridge. It was concluded that rehabilitation of the existing bridge would be highly disruptive, perhaps as costly, and not as beneficial in mobility enhancement or meaningful congestion relief as compared with a replacement bridge.

1.1. Federal Nexus

On November 28, 2000, the New York State Thruway Authority (NYSTA) and the Metropolitan Transportation Authority Metro-North Commuter Railroad (MNR) announced that an Environmental Impact Statement (EIS) would be undertaken to identify and evaluate alternatives to address the mobility needs of the I-287 Corridor, as well as the structural and safety needs of the Tappan Zee Bridge. The alternatives contained in the I-287 Task Force report, as well as those suggested by elected officials, transportation and environmental groups, community groups, and the public, were considered and an approach to evaluating and advancing alternatives was established. On December 23, 2002, the Federal Highway Administration (FHWA) published a Notice of Intent (NOI) to prepare an Alternatives Analysis (AA) and EIS for the Tappan Zee Bridge/I-287 Corridor in the Federal Register.

Over the next few years, project development continued with increasing involvement by the New York State Department of Transportation (NYSDOT). Alternatives for transit modes along the corridor were identified, as were a set of highway and bridge improvements. Also, in 2005, the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) was enacted, which incorporated changes in the metropolitan planning and environmental review processes for transportation projects. FHWA determined that a revised NOI should be published to update the public and interested agencies on the alternatives development, to identify NYSDOT as the Project Director, and to incorporate the provisions of SAFETEA-LU. The revised NOI was published on February 14, 2008.

In 2011, while advancing financial analysis, it was determined that funding for the corridor project (bridge replacement, highway improvements, and new transit service) was not possible at that time. The financing of the crossing alone, however, was considered affordable. Therefore, it was determined that the scope of the project should be limited, and efforts to replace the Hudson River crossing independent of the transit and highway elements should be advanced. On October 12, 2011, FHWA published an NOI to rescind the Tappan Zee Bridge/I-287 Corridor Project, thereby concluding the environmental review process for the combined study of bridge, highway, and transit elements.

On that same date, FHWA published an NOI for the Tappan Zee Hudson River Crossing Project to examine alternatives for an improved Hudson River crossing between Rockland and Westchester Counties. As described in the NOI, FHWA, acting as the federal lead agency, and NYSDOT and NYSTA, acting as the co-sponsoring agencies, are preparing an EIS and other necessary documents to identify alternatives for an improved Hudson River crossing and to document the potential environmental consequences of these alternatives.

Under Section 7 of the Endangered Species Act (ESA), the FHWA as the Federal Sponsor is required to consult with the United States Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) to determine whether any federally listed species or species proposed for listing as endangered or threatened species, or their designated critical habitats, occur in the vicinity of a proposed project. While there are no federally listed species under the jurisdiction of the USFWS in the vicinity of the proposed project, the shortnose sturgeon (*Acipenser brevirostrum*), an endangered aquatic species, and the New York Bight District Population Segment (DPS) of Atlantic sturgeon (*Acipenser oxyrinchus*), which was listed with an effective date of April 6, 2012, occur throughout the estuarine portion of the Hudson River. In the event that a federally listed or proposed endangered or threatened species or its designated critical habitat occurs in the vicinity of a “major construction activity,” a Biological Assessment (BA) must be prepared to determine whether the proposed federal action would affect that species. The regulations promulgated pursuant to the ESA require every federal agency to “. . .[e]nsure that any action it authorizes, funds, or carries out, in the United States or upon the high seas, is not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of critical habitat” (50 CFR § 402.01).

This BA, prepared by FHWA, addresses the proposed action in compliance with Section 7(c) of the ESA of 1973, as amended. Section 7 of the ESA requires that, through consultation (or conferencing for proposed species) with the National Marine Fisheries Service (NMFS), federal actions do not jeopardize the continued existence of any threatened, endangered, or proposed species or result in the destruction or adverse modification of critical habitat. A second BA has been prepared for a Pile Installation Demonstration Project (PIDP), scheduled for spring 2012, which has among its objectives the testing of various sound attenuation technologies.

This BA evaluates the potential effects of the proposed transportation project on species that are federally listed or proposed for listing under the ESA. Specific project design elements are identified that avoid or minimize adverse effects of the proposed project on listed species and/or critical habitat.

The findings of the BA will be discussed in the Record of Decision (ROD), which will include an effects determination that presents conclusions, supported by information presented in the

BA, regarding potential effects on the local population of the species discussed. This BA will be submitted to NOAA Fisheries for review and a final determination of effect. The BA will be completed prior to construction, and the bridge design will reflect appropriate measures to protect these species that result from the consultation process. The BA addresses only the currently proposed construction activities. If NOAA Fisheries determine that the construction activities would adversely affect a federally listed species or a species proposed for listing, then the FHWA must enter into formal consultation and obtain a Biological Opinion concerning the potential for incidental "taking" of such species before conducting the project. "Take" is defined in the ESA as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct. Incidental take is understood to occur should the activities associated with implementing the ROD adversely affect the shortnose sturgeon or Atlantic sturgeon habitat and/or mating behavior. If it is determined that the construction activities are not likely to adversely affect the species, NOAA Fisheries will issue written concurrence that the remedial project is not likely to adversely affect the species.

In addition to FHWA's involvement with the project, several other federal agencies will be involved. The USACE and U.S. Environmental Protection Agency (EPA) will require an application for transport and ocean disposal of dredge material under Section 103 of the Marine Protection, Research and Sanctuaries Act, and a permit will be required from the United States Coast Guard under the General Bridge Act of 1946 for construction of bridges over navigable waters of the United States. Authorization will also be required from the USACE for certain in-water activities at the project site.

1.2. Project Description

The proposed Replacement Bridge Alternative (Project) would result in a new bridge crossing of the Hudson River between Rockland and Westchester Counties. A number of design parameters have been considered to develop the location and general configuration of the Replacement Bridge. However, to provide for flexibility in the final design of the Replacement Bridge, this assessment considers options for certain structural characteristics of the bridge.

The Project would be constructed north of the existing Tappan Zee Bridge. The planning for the Replacement Bridge considered a footprint that would maximize the use of existing NYSTA right-of-way while minimizing effects on existing highway infrastructure in Rockland and Westchester Counties. Replacement bridge alignments both north and south of the existing Tappan Zee Bridge were considered, and it has been determined that an alignment north of the existing bridge is more prudent for the following reasons:

- There is available NYSTA right-of-way to the north of the existing highway on both sides of the Hudson River to accommodate construction of a new crossing. Sufficient right-of-way is not available on the south side of the existing highway at the Rockland landing.

- A north alignment allows for a straight approach to the Westchester toll plaza. A south alignment would result in a conflict between the new crossing's horizontal curvature and the approach to the toll plaza, which would not meet design and safety standards.

- Construction storage and staging areas are available north of the existing bridge on both sides of the Hudson River. Staging for a southern alignment could require temporary or permanent acquisition of property.

Therefore, the Replacement Bridge would be located to the north of the existing Tappan Zee Bridge.

The following sections describe the features of the Project. To conform to highway design standards, including widths and grades, the Replacement Bridge Alternative would result in new bridge and modifications to Interstate 87/287 between approximately Interchange 10 (Route 9W) in Nyack and Interchange 9 (Route 9) in Tarrytown. The following sections describe the proposed salient features relative to this BA, including approach spans, main spans, and ancillary facilities of the Replacement Bridge (see **Figure 1**).

1.2.1. Landings and Approach Spans

In Rockland and Westchester Counties, Interstate 87/287 would be shifted northward to meet the new abutments of the Replacement Bridge. There are two options for the Replacement Bridge's approach spans (Short Span and Long Span Options), which would result in somewhat different configurations of the Rockland County landing.

1.2.1.1. Short Span Option

The Short Span Option would consist of two parallel bridges that would have a typical highway design with a road deck supported by girders and piers (see Figure 2). The parallel bridges would be separated by a gap that would vary in dimension across the approach spans. The following describes the general characteristics of the Rockland County and Westchester County approach spans for the Short Span Option:

- The Rockland County approach spans would extend 1,257 m (4,125 feet) between the abutments and the main spans, and each would consist of 43 sections. The average distance between the piers of Rockland County approach spans would be 70.1 m (230 feet). There would be no gap between the parallel bridges at the abutments. The gap between the highway decks would widen to 70 feet at the main spans.

- The Westchester County approach spans would extend 548.6 m (1,800 feet) between the main spans and the abutments, and each would consist of 16 sections with an average distance between the piers of approximately 70.1 m (230 feet). The gap between the parallel highway decks would range from 70 feet at the main spans to 40 feet at the abutments.

As the approach spans meet the main span, the road deck would be at an elevation of 53.3 m (175 feet) above the Hudson River's mean high-tide elevation.

1.2.1.2. Long Span Option

The Long Span Option would also consist of two parallel bridges. Each bridge would have a truss structure supported by piers (see **Figure 2**). The road deck would be located on top of the trusses. The parallel bridges would be separated by a gap that would vary in dimension across the approach spans. The following describes the general characteristics of the Rockland County and Westchester County approach spans for the Long Span Option:

- The Rockland County approach spans would extend 1,257 m (4,125 feet) between the abutments and the main spans, and each would consist of 23 sections. The average distance between the piers of the Rockland County approach spans would be about 131 m (430 feet). There would be no gap between the parallel bridges at the abutments. The gap between the highway decks would widen to 70 feet at the main spans.

- The Westchester County approach spans would extend 548.6 m (1,800 feet) between the main spans and the abutments, and each would consist of 10 sections with an average distance between the piers of 131 m (430 feet). The gap between the parallel highway decks would range from 70 feet at the main spans to 40 feet at the abutments.

As the approach spans meet the main span, the road deck would be at an elevation of 59.4 m (195 feet) above the Hudson River's mean high-tide level.

1.2.2. Main Span

The main spans, which are the portions of the bridge that cross the navigable channel of the Hudson River, must provide adequate vertical and horizontal clearance for marine transport.

- The horizontal clearance affects the width of the Hudson River's navigable channel for water craft and must be clear of bridge piers and other bridge infrastructure. The U.S. Coast Guard requires a minimum horizontal clearance of 183 m (600 feet) through the Tappan Zee crossing. However, a clearance of 305 m (1,000 feet) is preferred to provide a safety buffer for maritime navigation through the channel.

- The vertical clearance affects the height of the bridge as well as the hull-to-mast height of marine vessels that navigate under the bridge. The Replacement Bridge Alternative would provide for at least 42.4 m (139 feet) of vertical clearance at mean high tide to maintain the existing hull-to-mast height requirements of vessels that travel beneath the Tappan Zee crossing.

This BA considers two options for the bridge's main spans over the navigable channel—Cable-stayed and Arch (see **Figure 3**). Both options would result in a horizontal clearance of at least 305 m (1,000 feet) and a vertical clearance at least 42.4 m (139 feet) over the navigable channel.

1.2.2.1. Cable-stayed Option

The Cable-stayed Span Option would result in two spans supported by cables connected to towers. The four towers (two towers per span) would rise about 122 m (400 feet) above the road deck and would be set approximately 91.4 m (300 feet) outward from the limits of the navigable channel. Cables would extend from each of the towers to various points on the road deck, in effect holding it up from above. The cables would support the entirety of the main spans between the approach structures. The cables would extend both eastward and westward from each tower tying into the road deck as much as 91.4 m (300 feet) away from the towers. The cables would be anchored to the ground through the tower foundations. Each section of the road deck would be connected to the towers by multiple cables, resulting in a highly redundant structure.

1.2.2.2. Arch Option

This option would consist of a steel arch that would extend eastward and westward from the main spans' piers. The main spans' piers would be located about 152.4 m (500 feet) outward from the limits of the navigable channel. The supports would curve upward and support the road deck from below. On either side of the navigable channel, the curved supports would extend above the road deck and meet in the middle forming the arch. The top of the arch would be about 61 m (200 feet) above the road deck. Suspender cables would extend vertically from the arch structure to support the road deck.

1.3. Study Area and Setting

The Hudson River is one of the major rivers on the Atlantic coast, extending from its source at Lake Tear of the Clouds on Mount Marcy in the Adirondacks to the Battery in New York Harbor, a distance of approximately 507 km (315 miles) (Geyer and Chant, 2006). In the study area, the Hudson River is tidally influenced and is commonly referred to as the Hudson River estuary. The estuarine portion of the river begins at the Troy Dam about 247.8 km (154 miles) north of the Battery in southern Manhattan. Tides in the Hudson River estuary are semidiurnal, having two high waters and two low waters each day with an average range of 0.98 m (3.2 feet) (NOAA 2009). At approximately 4.8 km (3 miles) in width in the study area, the river is designated by New York State Department of Conservation (NYSDEC) as a Class SB (saline) waterbody, intended to be suitable for recreation, and fish survival and propagation. Water quality surveys by the Project Sponsors identified considerably variable concentrations of suspended sediments in the water column near the bridge depending on water depth, season, and weather conditions.

In the vicinity of the bridge, the river ranges in depth from less than 3.7 m (12 feet) along the western causeway to greater than 14.3 m (47 ft) in the shipping channel under the main span. The causeway and bridge piers cause river currents to locally scour the bottom sediments, resulting in depressions in the bottom of the river alongside the bridge.

The Hudson River and its tributaries are tidally influenced. The Hudson River in the vicinity of the TZB is referred to as an estuary due to the blending of freshwater and marine (saline) inputs. Bottom sediments are comprised of clayey silt. The river provides shallow as well as deep water habitat for a wide range of plants and animals, as described in subsequent sections of this chapter. The tidal action of the river, currents, and the seasonal variation in the amount of freshwater contributed by precipitation and runoff, make it a highly dynamic and unstable system. As a result, the ecosystem is generally dominated by a few well adapted species.

Bottom sediments throughout most of the estuary are generally soft and comprised of mud or sandy mud, but other bottom types such as sand or gravelly sand occur as well, and are more common in the upper portions of the estuary (AKRF 2010). The river provides shallow and deep water habitats for a wide range of aquatic and terrestrial plants and animals, as described in subsequent sections of this BA. The tidal action of the river, currents, and the seasonal variation in the amount of freshwater contributed to it by precipitation and runoff make it a highly dynamic and unstable system. As a result, the ecosystem is typically dominated by a few well adapted species.

In 1992, the Habitat Work Group of the New York-New Jersey Harbor Estuary Program, administered by the United States Environmental Protection Agency (USEPA), requested that USFWS identify significant coastal habitats warranting special protection. The Tappan Zee section of the Hudson River was included in an area described as follows (USFWS 2011):

“The significant habitat complex boundary for the lower Hudson River estuary follows the shores of the Hudson River from the tip of Battery Park, Manhattan, generally referred to as river kilometer 0 (river mile 0), north to the Stony Point area river kilometer 66 (river mile 41). The boundary of the complex includes all riverine and estuarine habitats, including open water and tidal wetlands in this stretch of the river. This section of the river is the major site of river water mixing with ocean water in the Hudson Estuary, and includes the moderate and high salinity zones (mesohaline and polyhaline salinity zones) of the river. This productive estuary area is a regionally significant nursery and wintering habitat for a number of anadromous, estuarine, and marine fish species, including the striped bass (*Morone saxatilis*), and is a migratory and feeding area for birds and fish that feed on the abundant fish and benthic invertebrate resources in this area” (http://library.fws.gov/pubs5/web_link/text/low_hud.htm).

In 1990, the New York State Department of State (NYSDOS) designated several Significant Coastal Fish and Wildlife Habitats (SCFWH) within the stretch of the Hudson River between River Miles 11 and 40. These SCFWWs include Haverstraw Bay and Croton River and Bay (9.7 m, or 6 miles, north of the bridge), the Lower Hudson Reach (6.4 m, or 4 miles, south of the bridge), and Piermont Marsh (3.2 m, or 2 miles, south of the bridge). The NOAA and NYSDEC have designated Piermont Marsh part of the Hudson River National Estuarine Research Reserve. No SCFWHs occur within the study area.

The study area in the immediate vicinity of the replacement bridge encompasses intertidal and subtidal habitats of varying depths, ranging from shallow intertidal shorelines to shallow subtidal shoals and deeper channel habitats. There are no vegetated tidal wetlands present in this area. Areas south of the existing bridge less than 1.8 m (6 feet) deep at mean low water (MLW) are mapped as littoral zone wetlands by the NYSDEC. No NYSDEC tidal wetlands are mapped north of the bridge.

On the west side of the river, the shoreline typically consists of unvegetated intertidal beaches composed of coarse sand with scattered boulders. Immediately north of the bridge the shoreline is bulkheaded. The eastern shoreline adjacent to the railroad tracks consists of riprap armoring in the vicinity of the replacement bridge.

Shallow water environments occur near the shorelines and along the western and eastern causeways, while deep water habitat occurs within and near the shipping channel and the main bridge span. Shallows attract aquatic organisms that prefer greater sunlight and less water depth for part or all of their life cycles, while deeper water areas attract organisms with deeper water column needs. The region under the existing bridge attracts certain organisms that use the pier structures as habitat, or that seek the organisms that adhere to the structures as food resources.

1.4. Consultation History

Informal consultations have been occurring with NMFS throughout the course of the project. Consultations have occurred with both the Habitat Conservation Division (HCD) in Milford, CT and the Protected Resources Division (PRD) in Gloucester, MA. The objective of the initial informal consultations was to develop and review the Hudson River ecological, hydrodynamic and sediment sampling program (Proposed Ecological Investigations within the Hudson River and along the I-287 Corridor, March 10, 2006), the results of which would support the DEIS and EIS impact analyses. Data were collected from April 2007 through May 2008 with additional sampling of oyster beds and submerged aquatic vegetation (SAV) during 2009. These data were reviewed with NMFS. Furthermore, design option concepts for the replacement bridge were presented to the agency at several meetings beginning in February 2008.

Detailed methodologies have been presented to NMFS related to the approaches that will be employed to assess ecological impacts of resuspended sediment and underwater noise, two of the more complex issues associated with bridge construction. A detailed, explanatory “read-ahead” document was submitted to the agency followed by a presentation in their offices for each of the two methodologies. The presentations were generally organized as follows:

- Discussion of ecological issues
- Relevant construction activities
- Proposed “on set of effects” criteria
- Use of sampling data
- Analytical procedures (i.e., mathematical models).

At each of the methodology meetings, comments were requested from NMFS with regard to the proposed “onset of effects” criteria and the analytical methods that would be employed in the DEIS analysis. General comments on the proposed acoustic “physiological effects” criteria have been received from NMFS-PRD (August 24, 2010; Julie Crocker to Melissa Toni).

A subsequent meeting was held with NMFS in Gloucester, MA on October 14, 2011 with members of the HCD and the PRD. The objective of the initial meeting was to develop and review the planned Pile Installation Demonstration Project (PIDP) for the proposed bridge replacement project. This meeting detailed the PIDP and the methodologies that will be employed to assess direct and indirect ecological effects associated with the PIDP.

Recently, NMFS provided commentary on the Project’s scoping document, and provided an extensive list of items to consider during the preparation of the EIS, the BA and Essential Fish Habitat (EFH) evaluation (NMFS 2011b). A second meeting was held in Gloucester, MA on

December 14, 2011 to continue the coordination of the PIDP and the Project's Biological Assessment and Essential Fish Habitat analyses. At this meeting NMFS provided comments on the Draft PIDP BA (NMFS 2011a), but raised issues that were also relevant to the Biological Assessment for the Replacement Bridge Alternative as well.

A draft BA for the Tappan Zee Hudson River Crossing Project was submitted as an attachment (Appendix F-4) to the Draft Environmental Impact Statement (DEIS) prepared for the project (FHWA 2012). Additional consultation with NMFS indicated that certain analyses needed to be expanded upon and additional information provided in order to provide a more complete assessment for agency review. This revised BA has been prepared to include among other items, an agency recommendation for the recalculation of potential effects to shortnose sturgeon based on gill net sampling, responses to specific comments made with respect to the DEIS and draft BA, and a more comprehensive analysis for estimating potential effects to the recently listed Atlantic sturgeon.

Chapter 2 Federally Proposed and Listed Species and Designated Critical Habitat

The USFWS lists of federally threatened, endangered, candidate, and proposed species for Westchester and Rockland Counties include only one endangered fish species, the shortnose sturgeon (*Acipenser brevirostrum*; endangered) occurring within the study area. Shortnose sturgeon are also currently listed for protection by the State of New York as an endangered species. Atlantic sturgeon (*Acipenser oxyrinchus*) whose Hudson River population will be listed as federally endangered with an effective date of April 6, 2012, are also known to occur in the study area.

Alewife and blueback herring were designated as candidate species on November 2, 2011. These species are being considered for listing as endangered or threatened under the ESA. Candidate status does not carry any procedural or substantive protections under the ESA.

According to sources cited in the most recent NMFS commentary, a November 15, 2011 letter from Patricia Kurkul to Michael Anderson (NMFS 2011b), seals and dolphins are present occasionally in the Hudson River and may migrate through the study area (DiGiovanni 2011 as cited in NMFS 2011b). Harbor porpoises (*Phocoena phocoena*) occasionally may also be present in the study area (Jackson et al. 2005 as cited in NMFS 2011b). However, the study area does not contain any marine mammal concentration areas or seal haul-out areas (NMFS 2011b). The NMFS letter also indicated that large whales and sea turtles, including those listed under the ESA, are similarly unlikely to occur in the study area.

2.1. Shortnose Sturgeon

The shortnose sturgeon is a member of the family Acipenseridae. The shortnose sturgeon is a long-lived, slow-maturing species. It is the smallest sturgeon species native to North America, achieving maximum lengths of up to 1,070 millimeters (“mm”) (42 inches) in the Hudson River (Bain 1997), and maximum lifespans of approximately 50 to 60 years (Kynard 1997).

Within North America, the shortnose sturgeon inhabits large coastal rivers along the Atlantic coast, ranging from New Brunswick, Canada, to the Saint Johns River in Florida. Nineteen distinct sub-stocks, ranging in size from less than 100 adults in the Merrimack River (Massachusetts) to greater than 60,000 adults in the Hudson River, have been recognized (NMFS 1998a). Shortnose sturgeon adults generally remain in their natal rivers or estuaries; there is little evidence of interbreeding or interchange of fish among stocks (Kynard 1997). McCleave et al. (1977) studied daily movements of shortnose sturgeon in a Maine estuary and did not find any conclusive evidence of a distinct or abrupt change in swimming pattern at the time of tidal change.

Hudson River shortnose sturgeon typically inhabit the deepest water available (Hastings et al. 1987; O'Herron et al. 1995) but often move into shallow areas to forage. In tidal reaches of the Hudson River, the deepest water typically is found within or adjacent to the navigation channel, away from river shores. Shortnose sturgeon prefer lower salinity waters, and although they rarely can be found in pure seawater (approximately 34 parts per thousand ("ppt"), they generally have a maximum salinity tolerance in the range of 30 to 31 ppt (Holland and Yelverton 1973; Dadswell et al. 1984). Their distribution and life history pattern in the Hudson River is summarized in **Figure 4**.

2.1.1. Adults (including spawning adults)

The shortnose sturgeon's age at sexual maturity varies by latitude. In mid-Atlantic estuaries, including the Hudson River, male shortnose sturgeon can reach sexual maturity at three to five years of age, and females at six to ten years (Dadswell et al. 1984). First spawning may follow sexual maturation in males by up to one to two years, whereas in females spawning may be delayed for up to five years (Dadswell 1979). Based on the percentage of sexually developing fish from August through March collections in New Brunswick, Canada, it appears that females spawn once every third year, and males every other year (Dadswell 1979). Other data (e.g., annuli formation in the pectoral rays) suggest a 5 to 11 year interval between individual spawning events (Dadswell 1979). NMFS (2011b) has indicated that, based on limited data, females spawn every three to five years, while males spawn approximately every two years.

Shortnose sturgeon fecundity can be quite variable. Estimates of number of eggs per gravid female range from 27,000 to over 200,000, with a mean of 11,568 eggs/kg body weight (see Dadswell et al. 1984 for review of reported fecundity values). This high fecundity likely evolved in the presence of highly variable environmental conditions of primary spawning grounds, as well as high natural early life stage mortality rates.

Shortnose sturgeons spawn well north of the Tappan Zee Bridge between the Troy dam and RM 131 (Dovel et al 1992). Shortnose sturgeon undertaking the spawning migration in the Hudson River travel upriver in deeper channel areas as far as accessible spawning habitat permits (**Figure 4**, adapted from Bain et al. 1998). Spawning usually occurs when River temperatures increase to about 8.8°C (47°F), and concludes when temperatures reach 12.2°C–15.0°C (54°F–59°F) (Kynard 1997). River channels with rock or gravel substrate and moderate bottom current velocities are the preferred spawning habitat of the shortnose sturgeon (NMFS 1998a).

2.1.2. Eggs

Shortnose sturgeon are broadcast spawners, with fertilization occurring externally (Gilbert 1989). Ripe and fertilized eggs have diameters of 3.0 to 3.2 mm and can be as large as 3.5 mm (0.12 to 0.13 inches and 0.14 inches), respectively (Dadswell et al. 1984; Buckley and Kynard 1981). Shortnose sturgeon eggs are demersal and adhere to objects on the river bottom within 20 minutes of fertilization. Eggs hatch approximately 13 days after fertilization at temperatures between 7.7°C and 12.2°C (46°F and 54°F) (Bain 1997).

Eggs are confined to freshwater reaches above the saline area and would not be expected to occur in Tappan Zee region.

2.1.3. Larvae

Upon hatching, larvae are 7.3 to 11.3 mm (0.29 to 0.44 inches) long (Taubert 1980; Buckley and Kynard 1981). Research on larval behavior indicates that hatchlings exhibit negative phototaxis (i.e. response to light), and seek cover under any available structure immediately after hatching (Richmond and Kynard 1995). Within the first one to two days of hatching, larvae denied access to, or physically dislocated from, cover will exhibit a temporary and short-lived "swim-up and drift" behavior. In the wild, this behavior allows the larvae to move short distances (with the assistance of currents) to locate available cover downstream. Yolk-sac larvae ("YSL") will continue to seek benthic cover for about a week, but after one to two days post-hatch their movements are predominantly parallel to the bottom (Richmond and Kynard 1995). At 9 to 12 days post-hatch, the yolk sac is absorbed and larvae have well-developed, functioning eyes, a mouth with teeth, and fins that enable them to swim normally (Kynard 1997).

In laboratory tests, larvae were nocturnally active, and preferred the deepest water available to them (Richmond and Kynard 1995). Even shortnose sturgeon embryos released near the surface of a test enclosure sought bottom cover. In other hatchery experiments, ten-day-old larvae attempted to remain on the bottom or placed themselves under available cover (Pottle and Dadswell 1979; Washburn and Gillis Associates 1980). After the yolk sac is completely absorbed, post yolk-sac larvae actively feed on zooplankton (Buckley and Kynard 1981; Washburn and Gillis Associates 1980). Snyder (1988) and Parker (2007) considered individuals to become juveniles at around 57 mm TL with the transformation occurring on about day 40 after hatching for fish from the Connecticut River (Parker 2007).

Larvae are predominately confined to freshwater reaches above the saline area and would not be expected to occur in Tappan Zee region.

2.1.4. Juveniles

The juvenile phase can be subdivided into young of the year (YOY) and immature sub-adults. YOY and sub-adult habitat use differs and is believed to be a function of salinity tolerance (NMFS 2011c). Little is known about YOY behavior and habitat use although it is believed that they are found in freshwater habitats above the saltwedge for about one year. Hence, YOY would not be expected to occur in the Tappan Zee study area. Sub-adults would be expected to occupy similar spatio-temporal patterns as adults and occupy a much wider portion of the estuary, including the Tappan Zee study area.

The early growth of shortnose sturgeon is relatively rapid compared to many species, and occurs during the first few months following hatching as YOY gradually migrate to downstream deep, brackish, waters from the spawning grounds. Upon reaching about 14 to 17 mm total length (0.5 to 0.7 inches TL), shortnose sturgeon generally resemble adults and may leave bottom cover briefly to swim in the water column (although they remain strongly bottom-oriented). In the wild, fish of this size probably disperse downstream using currents as conveyance (Richmond and Kynard 1995).

The juveniles (fish ranging from 2 to 8 years old) can be found in brackish areas of the Hudson River. The primary summer habitat for shortnose sturgeon in the middle section of the Hudson River above Newburgh is the deep river channel (13 to 42 m deep, or 43 to 138 feet). The river channel downstream of this middle estuary area is 18 to 48 m deep (59 to 157 feet; Peterson and Bain 2002).

2.1.5. Hudson River Population

In its 1979 NMFS Biological Opinion for the Indian Point Generating Station, NMFS used an assumption of a shortnose sturgeon population of 6,000 individuals, although other contemporary estimates placed the Hudson River shortnose sturgeon population at approximately 13,000 individual adults (Bain 1997). By the 1990s, the Hudson River adult population was estimated to be as high as 61,057, which represents the largest shortnose sturgeon population in the United States (Bain et al. 1998; 2007). Other researchers have suggested that some populations segments (including the Hudson River) have recovered to historic abundance levels (Wirgin et al. 2005; Woodland and Secor 2007). The increase in the shortnose sturgeon population in the Hudson River has been attributed to both managed population recovery and regional conservation measures, specifically the enactment and enforcement of fishing regulations (Bain et al. 2007).

According to Woodland and Secor (2007), twenty years of sustained annual recruitment has contributed to strong recovery of shortnose sturgeon in the Hudson River. During this period there were several particularly strong year classes that translated into substantial population growth. Size and body condition of the fish caught in these studies indicate the population is primarily healthy, long-lived adults. Hoff et al. (1988, in Bain 1997) reported most captures of adult shortnose sturgeon during river monitoring of fish distributions by the Hudson River electric utilities from 1969 to 1980 occurred between river miles (RM) 24 to 76 (from near the New York/New Jersey border up to near Poughkeepsie).

Dovel et al. (1992) concluded that most of all adults form an overwintering concentration near Kingston. Bain (1997), however, described a second late fall and overwintering area near Haverstraw Bay between km 54 and 61 (RM 33-37).

From 2000-2009, the Fall Shoals Monitoring Program sponsored by a coalition of Hudson River Utilities collected 289 juvenile and adult shortnose sturgeon using a beam trawl. The majority of these fish were collected north of West Point (RM 47) and were adults. Only eight shortnose sturgeon were collected in the Utilities designated Tappan Zee region (RM 24-33). Greater than 90% of all shortnose sturgeon were collected from bottom habitats in waters greater than 6.1 m (20 ft) in depth. A review of commercial catch data provided by NYSDEC (NYSDEC 2011 unpublished data) indicated that from the years 1980-2002 shortnose sturgeon were collected in the Tappan Zee vicinity (RM 25-27) in 14 of 23 years. The Utilities also report the number and size of shortnose sturgeon collected as part of their Striped Bass and Atlantic tomcod sampling program.

A year-long, project-specific fish survey was conducted between April 2007 and May 2008 to further characterize the fish community and examine seasonal differences in abundance near the

Tappan Zee Bridge. These surveys combined hydroacoustics, gill nets, and trap nets to characterize the species composition, relative abundances, and distributions of fish populations within the study area. A total of 25 species and just over 2,000 individual fishes and hundreds of blue crabs were collected during 679 hours of gill-net sampling within the study area between April 2007 and May 2008. A total of 12 shortnose sturgeon were captured in gill nets during the bi-monthly fish-sampling effort within the Tappan Zee study area. The sturgeon were captured in the warmer months of the year—between May and October—at both the bridge and reference locations in water depths between 1.8 and 9.1 m (6 and 30 feet). Although no individuals were captured during the December, February, and April sampling events, it is possible that the species is present within the study area but that the cold waters slowed its movements enough so fish would not be captured by the gill net, a stationary and passive gear type.

The shortnose sturgeon that were collected in the 2007-2008 sampling program ranged in size from an estimated 450 mm (1.5 ft) to 990 mm (3.2 ft) in total length. Eleven of the 12 fish collected were 650 cm (2.1 ft) or larger, and based on their sizes, are presumed to have been adult shortnose sturgeon.

2.2. Atlantic Sturgeon

Atlantic sturgeon, which has recently been designated as endangered for the New York Bight DPS, is also known to occur in the Hudson River. By contrast with shortnose sturgeon, which spend a great deal of their lives in the Hudson River, Atlantic sturgeon spend most of their lives in marine waters along the Atlantic coast. It is a large anadromous, bottom-feeding species that spawns in the Hudson River and matures in marine waters; females return to spawn at age 15 or older and males return earlier at 12 years or older (Bain 1997, citing other authors). Young et al. (1988) reported that in the Hudson River, maturity of females Atlantic sturgeon begins at age 11 and increases gradually for the next ten years until all females are mature. In the Hudson River, Atlantic sturgeon are found in the deeper portions and do not occur farther upstream than Hudson, New York.

Like shortnose sturgeon, the Atlantic sturgeon is a member of the family Acipenseridae, and ranges from the Hamilton River, Labrador to northeastern Florida (Gruchy and Parker 1980). Atlantic sturgeon is one of the largest fish species in North America with a maximum recorded length of about 4.2 meters (14 feet) (Bain 1997). The oldest recorded Atlantic sturgeon was a 60-year-old individual from the St. Lawrence River (Gilbert 1989). Male Atlantic sturgeon generally do not reach maturity until at least 12 years and females as late as 19 years (Dovel and Berggren 1983). Their inter-annual spawning period can range from three to five years, and adults usually inhabit marine waters either all year during non-spawning years or seasonally during spawning years (Bain 1997). Atlantic sturgeon are anadromous; they spawn in freshwater, but spend most of their lives in ocean waters often undertaking long distance migrations along the Atlantic Coast (Bain 1997).

Wrege et al. (2011) studied activity patterns of Gulf of Mexico sturgeon, a subspecies of Atlantic sturgeon, in Pensacola Bay. These authors found that Gulf sturgeon were more active at night in all seasons except summer. Gulf sturgeon migrate out of the estuary to the Gulf of Mexico in fall and up through the bay system to summering habitats in rivers in spring.

Several genetic studies have attempted to characterize the population structure and the homing fidelity of Atlantic sturgeon. DNA studies among different Atlantic sturgeon populations suggest that they are reproductively separate and exhibit high fidelity to natal spawning grounds (Wirgin et al. 2002; Waldman et al. 2002). In 2007, NMFS proposed five distinct population segments (DPS) for the U.S. Atlantic sturgeon based largely on DNA results, while another study estimated at least nine population segments (ASSRT 2007; Grunwald et al. 2008).

2.2.1. Adults (including spawning adults)

In the Hudson River population, spawning and early development occurs in the freshwater portion of the River from late May through mid-July, while adult and large juvenile Atlantic sturgeon occupy marine waters. Primary spawning sites for Atlantic sturgeon have been identified in Hyde Park, New York at RM 83 (Bain et al. 2000) and Catskill (RM 113), and spawning appears to be associated with rock islands, irregular bedrock, and substrate of silt and clay (Bain et al. 2000; Bain 1997). Spawning is unlikely to occur near brackish water because sturgeon eggs, embryos, and larvae are intolerant of saline conditions, and some significant length of river habitat is required downstream of the spawning area to accommodate successful dispersal of egs and larvae (Van Eenennaam et al. 1996). The spawning area is freshwater throughout the year and water temperatures in habitats used for spawning have been documented between 19 to 28°C (66 to 82°F) (Bain et al. 2000).

2.2.2. Eggs and Larvae

Like the eggs of shortnose sturgeon, the eggs of Atlantic sturgeon are adhesive, and after fertilization and hydration are approximately 2.2 mm (0.09 inches) (Hardy and Litvak 2004). After hatching, the larvae remain closely associated with the bottom in deep channel habitats (Bain et al. 2000). Atlantic sturgeon larvae are about 7 mm (0.28 inches) TL upon hatching. The transition from the larval to the juvenile stage is estimated to occur at about 30 mm (1.18 inches) TL, based on Hudson River specimens (Bath et al. 1981). In the Hudson River, the larvae have been recorded from around RM 37 to RM 92 (Dovel and Berggren 1983). This range includes some brackish waters; however, larval Atlantic sturgeon have limited tolerance to salt and the most favorable larval habitat must occur well upstream of the salt front (Van Eenennaam et al. 1996). It is believed that the preferred habitat for larval Atlantic sturgeon is close to the spawning habitat between RM 37 to RM 92, with larvae gradually moving downstream as they grow and develop the salt tolerance that is characteristic of juveniles and adults (Bain et al. 2000). Neither eggs nor larvae would be expected to occur in the vicinity of the project.

2.2.3. Juveniles and Winter Habitat

Juvenile Atlantic sturgeon smaller than about 70 cm TL tend to occupy summer rearing and over-wintering habitats in the freshwater reaches of the Hudson River (Bain et al. 2000). From April through October, early Hudson River juvenile Atlantic sturgeon are primarily found between RM 42 and 66 and at water temperatures between 24 and 28°C (75 and 82°F) (Bain et al. 2000). This region comprises the highland gorge and wide estuarine portion of the Hudson River, where the transition from freshwater to brackish water typically occurs. Juvenile Atlantic sturgeon are most often found in salinities ranging from 0 to 5 ppt (Bain et al. 2000). Water depths associated with most juvenile captures ranged from 10 to 25 meters (33 to 82 feet), and the substrates were primarily silt and sand (Bain et al. 2000). Later studies have pointed to Haverstraw Bay as a primary habitat for juvenile Atlantic sturgeon (Sweka et al. 2007). These studies suggest that while soft bottoms in deep habitat comprised only 25% of the available habitat in Haverstraw Bay, these habitats yielded the greatest frequency of catches, the highest catch per unit effort ("CPUE"), and lowest variance of CPUE (Sweka et al. 2007).

Hudson River winter habitat of Atlantic sturgeon has been described using data from trawl and gill-net sampling that was conducted between 1975 through 1978 (Dovel and Berggren 1983). When water temperature in the river reaches approximately 9°C (48°F), most juvenile Atlantic sturgeon that have not migrated to the ocean appear to congregate in a deep-water habitat between RM 12 and 46 (Bain et al. 2000). Water temperatures during winter can reach 0°C (32°F) in this segment of the Hudson River, salinity typically ranges from 3 to 18 ppt, and water depths in the channel commonly range from 20 to 40 meters (66 to 131 feet) (Bain et al. 2000). It appears that most juvenile sturgeon habitats prefer clay, sand, and/or silt substrates.

By the time juvenile Atlantic sturgeon reach 70 cm they begin to migrate to marine waters. These fish occupy marine habitats during the winter and may move back into riverine systems, or remain in coastal marine habitats during the summer (Bain et al. 2000).

Late juvenile and adult Atlantic sturgeon in the Hudson River also are known to occupy similar habitats in other rivers. Tagged Hudson River Atlantic sturgeon have been recaptured in tributaries of the Chesapeake Bay and in the Delaware River (Dovel and Berggren 1983). There also are accounts of concentrations of late juvenile and adults in coastal marine waters during the summer, including the deep waters of Long Island Sound off the Connecticut coast, with at least one fish collected that was originally tagged in the Hudson River (Bain et al. 2000; Eyler 2006). The Long Island Sound habitat was approximately 30 to 40 meters (98 to 131 feet) deep with mud substrate.

Adult Atlantic sturgeons do not appear to occupy the freshwater reaches of the Hudson River during the winter. Autumn collections of fish leaving the coastal waters and estuaries have been reported by fishermen in Chesapeake Bay, New York, and New Jersey, and some scientific researchers also have documented this out-migration (Bain et al. 2000; Kieffer and Kynard 1993). A study by NYSDEC has indicated that tagged Atlantic sturgeon left the Hudson River by late July (NYSDEC unpublished data).

2.2.4. Hudson River Population and Other Distinct Population Segments (DPS)

No data on abundance of juvenile Atlantic sturgeon in the Hudson River are available prior to the 1970s; however, catch depletion analyses conservatively estimated that 6,000 to 6,800 females comprised the spawning stock during the late 1800s (Secor 2002; Kahnle et al. 2005). Two population estimates of age-1 Atlantic sturgeon have been developed for the Hudson River. In 1977, the 1976 cohort was estimated at 25,647 individuals (95% confidence interval of 13,206–53,039) (Dovel and Berggren 1983). In 1994, the cohort size was estimated at 4,314 (95% confidence interval of 1,916–10,473) individuals (Peterson et al. 2000). The large confidence intervals from the latter study point to the difficulty in obtaining a precise population estimate for Atlantic sturgeon for a small population in a large river system such as the Hudson River (Sweka et al. 2007). An estimate of 863 spawning adult fish per year, consisting of 596 males and 267 females, was calculated based on fishery dependent data collected from 1985-1995 (Kahnle et al. 2007).

Current abundance trends for Atlantic sturgeon in the Hudson River are also available from a number of ancillary surveys. From July to November during 1982-1990 and 1993, NYSDEC sampled the abundance of juvenile fish in Haverstraw Bay and the Tappan Zee Bay. The CPUE of immature Atlantic sturgeon was 0.269 in 1982 and declined to zero by 1990 (ASSRT 2007). The American shad (*Alosa sapidissima*) gill net fishery in the Hudson River estuary, conducted annually from early April to late May, incidentally captures young Atlantic sturgeon (< 100 cm) and has been monitored by fisheries observers since 1980. The CPUE of Atlantic sturgeon as shad bycatch was greatest in the early 1980s and decreased until the mid 1990s, but has gradually begun to increase slightly since then (ASSRT 2007).

The Utilities' Long River Sampling Program samples ichthyoplankton river-wide from the George Washington Bridge (RM 12) to Troy (RM 153) using a stratified random design (Con Edison 1997; ASSRT 2007). These data, which are collected from May to July, have provided an annual abundance index of juvenile Atlantic sturgeon in the Hudson River estuary since 1974. In addition, data from the Utilities' Fall Shoals Sampling Program, conducted from July through October/November, is used to calculate an annual index of the number of fish captured per haul. Indices from utility surveys conducted from 1974 through 2007 (LRS and FSS) indicate that the annual abundance of juvenile Atlantic sturgeon has been in decline over the monitoring period, with the CPUE peaking at 12.29 in 1986 (the highest of the survey period) and then declining to 0.47 in 1990 (Con Edison 1997; ASSRT 2007). Since 1990, the CPUE has ranged from 0.47-3.17, and has increased somewhat in recent years to 3.85 (in 2003). Taken together, these population estimates and annual abundance indices suggest a generally decreasing population trend for the Hudson River. NMFS (2012) has indicated that despite CPUEs from 2000-2007 being generally higher than those from 1990-1999, they are low compared to the late 1980s. Furthermore, NMFS indicated that there is currently not enough information regarding any life stage to establish a trend for the Hudson River population.

Between 2000-2009, the Hudson River Utilities Fall Shoals Sampling Program has collected 241 juvenile and sub-adult Atlantic sturgeon using a beam trawl. The majority of these fish were collected north of West Point (RM 47). Only five Atlantic sturgeon were collected in the Utilities defined Tappan Zee region (RM 24-33). Greater than 95% of all Atlantic sturgeon were collected from bottom habitats in waters greater than 6.1 m (20 ft) in depth. Between 2000-2009, the Utilities' Long River Program also collected 16 yolk and post yolk-sac larvae, all upstream of Cornwall (RM 58). The Utilities also report the number and size of Atlantic sturgeon collected as part of their Striped Bass and Atlantic tomcod sampling program.

No Atlantic sturgeon were captured in project-specific gill nets during the bi-monthly fish-sampling effort within the study area between 2007-2008. However, the carcass of an Atlantic sturgeon was observed floating approximately 152.4 m (500 feet) north of the bridge in May of 2008.

Commercial catch data provided by NYSDEC from observed fishing trips for the American shad gill net fishery (NYSDEC 2011 unpublished data) indicated that from the years 1980-2002 Atlantic sturgeon were collected in the study area between RM 25 and 27 in 14 of 23 years. However, Atlantic sturgeon were collected in only one year after 1992, which coincided with a marked reduction in commercial fishing effort. A separate adult Atlantic sturgeon tracking program was developed by NYSDEC which began tagging fish in 2007 with digital sonic tags. The study results confirm that the study area serves as a migration corridor for adult Atlantic sturgeon. Most of the fish that were tagged arrived in the Hudson from early April to late June and left the river by late July.

In 2007, a Status Review Team ("SRT") consisting of biologists from NMFS, the U.S. Geological Survey ("USGS"), and USFWS completed a status review report on Atlantic sturgeon in the United States. The SRT recommended that Atlantic sturgeon in the United States be divided into the following five distinct population segments ("DPS"): Gulf of Maine; New York Bight; Chesapeake Bay; Carolina; and South Atlantic.

The Atlantic Sturgeon Status Review Team identified 15 stressors that appear to be impacting the United States populations of Atlantic sturgeon (ASSRT 2007). Of the stressors evaluated, fishing bycatch mortality, degraded water quality, lack of adequate state and/or Federal regulatory mechanisms, and dredging activities were identified as the most significant threats to the viability of Atlantic sturgeon populations. In addition, some populations were impacted by unique stressors, including habitat impediments (e.g., Cape Fear and Santee-Cooper rivers) and apparent ship/propeller strikes (e.g., Delaware and James Rivers) (ASSRT 2007). NMFS cites locks and dams, overfishing and the more recent impact of bycatch and habitat degradation as causes for the Atlantic sturgeon decline in the Northeast (NMFS, Species of Concern Atlantic sturgeon www.nmfs.noaa.gov/_)

In October 2010, NMFS published two proposed rules to list five distinct population segments (DPS) of Atlantic sturgeon (75 FR 61872; 75 FR 61904). The Hudson River is contained within the New York Bight, which is one of the DPS identified in the proposed rule. Within the northeast region NMFS has determined that for the New York Bight and Chesapeake Bay DPS, an endangered listing is warranted, while a listing of threatened is warranted for the Gulf of Maine DPS. On February 6, 2012, NMFS promulgated regulations to list the New York Bight DPS as endangered with an effective date of April 6, 2012.

As part of the ongoing Endangered Species Act listing for Atlantic sturgeon, the National Marine Fisheries Service (NMFS) is considering each of the five Distinct Population Segments (DPS) as an individual species. Because Atlantic sturgeon are thought to range widely along the Atlantic coast and have been shown to move among DPS (Erickson et al. 2011), there is a possibility that individuals from all five DPS could occur in the New York Bight DPS and may potentially pass through the Tappan Zee study area. As a result, Atlantic sturgeon from any of the five DPS could be affected by project activities associated with construction of the new Tappan Zee Bridge. For this reason, it is necessary to evaluate the potential for project effects on each of the five DPS.

Despite the fact that some individuals may migrate over large distances, their movement, in general, appears to be more localized to the coastal waters of the DPS of their origin (Erickson et al. 2011). For example, movement of Hudson River sturgeon has been shown to be largely limited to coastal waters from Long Island and somewhat northward, to the Chesapeake Bay, suggesting that the potential impact of bridge construction on Atlantic sturgeon may be greatest for individuals from the New York Bight DPS and possibly individuals from the adjacent Gulf of Maine and Chesapeake DPSs, and much less for sturgeon from non-contiguous DPS.

The study area is located centrally within the New York Bight DPS, which is bounded to the north by the Gulf of Maine DPS and to the south by the Chesapeake DPS. Further south are the Carolina and South Atlantic DPS. Atlantic sturgeon from each of the DPS are unique in terms of their biological and genetic attributes, which provides the basis for their consideration as separate “species” (ASSRT 2007, Grunwald et al. 2008). While some mixing of individuals between the New York Bight and more southern DPS has been shown to occur in the southern portion of the New York Bight DPS (i.e., Delaware Bay; Waldman et al. 1996), nearly all Atlantic sturgeon (up to 99%) from further north in the New York Bight DPS are considered to be endemic to this DPS based on genetic analyses (Waldman et al. 1996). Fewer than 4% of Atlantic sturgeon in the coastal waters of the New York Bight likely originate from more southern DPS, while very few sturgeon (0% based on genetic analysis by Waldman et al. 1996) from the Gulf of Maine DPS move south into the New York Bight DPS. Earlier tag-recapture studies from the Carolina DPS suggests that Atlantic sturgeon from the two southern DPS have more restricted geographic distributions and move shorter distances than sturgeon from northern DPS, with all the recaptures in those areas coming from the Carolina or South Atlantic DPS (NMFS 1998b). These studies suggest that the majority of Atlantic sturgeon remain in coastal waters within their DPS or in adjacent DPS.

Although Atlantic sturgeon are capable of ranging widely along the Atlantic coast and of movement throughout DPS (Erickson et al. 2011), tagging and genetic studies indicate high site fidelity in natal rivers and very low gene flow among populations (Dovel and Berggren 1983, Savoy and Pacileo 2003, Grunwald et al. 2008). The fact that adult sturgeon return to their natal river to spawn (Collins et al. 2000, Grunwald et al. 2008), reduces the likelihood of impacting individuals from the four other DPS. Furthermore, the infrequency with which Atlantic sturgeon spawn (1-5 years for males and 2-5 years for females) further reduces the potential effects of bridge construction on Atlantic sturgeon from the New York Bight DPS. That is, since only a subset of adult sturgeon migrate to spawning grounds in the Hudson River during a given year, the remainder of the adult sturgeon should be unaffected. Use of the Hudson River by sturgeon from DPS outside of the New York is a possibility (ASSRT 2007), however, the abundance of these individuals in the Hudson River relative to sturgeon from the New York Bight DPS is likely to be low.

Based on the best available information, the potential impacts of bridge construction on Atlantic sturgeon are greatest for individuals from the New York Bight DPS and much less likely for individuals from the four other DPS, despite the potential for Atlantic sturgeon to disperse widely among Atlantic coastal habitats and throughout DPS. Support for this conclusion comes primarily from recent tagging studies demonstrating that the majority of Atlantic sturgeon from the Hudson River remain within the New York Bight and from genetic studies that have shown distinct populations among DPS, low gene flow among populations and high site fidelity for natal rivers. Finally, NMFS (2012) has recently determined that Atlantic sturgeon in the action area are likely to originate from three DPSs at the following frequencies: Gulf of Maine 6%; New York Bight 92%; and Chesapeake Bay 2%.

At this time, no critical habitat has been proposed for Atlantic sturgeon.

2.3. Marine Mammals

NMFS indicated that dolphins, harbor porpoises, and seals make occasional use of the Tappan Zee region of the Hudson River (NMFS 2011b). These species are marine, and only occur in the tidal Hudson River as transients. Rigorous scientific surveys of these species within the Hudson River are not known; however, anecdotal sightings of dolphins and other species have been published by the NYSDEC in the Hudson River Almanac. Both alleged and confirmed sightings of bottlenose dolphin (*Tursiops truncatus*) have been mentioned for Tappan Zee, Kingston Point, Tivoli Bay, Rhinecliff, and Peekskill in 1997 and 2008 (NYSDEC 2008). In addition, at least one confirmed death of an observed bottlenose dolphin occurred during the same reporting period. A follow-up necropsy was conducted by the Aquarium of Wildlife Conservation at Coney Island, Brooklyn, New York. The reported cause of death was stress related to an entanglement with monofilament fishing line resulting in septicemia (NYSDEC 2008). The Hudson River Almanac has also reported observation of harbor seals (*Phoca vitulina*), harp seal (*Phoca groenlandica*) in 1996, hooded seal (*Cystophora cristata*) in 1996, gray seal (*Halichoerus grypus*) in 2004, and harbor porpoise (*Phocoena phocoena*) in 1995, 1997, 1999, and 2005. Due to the anecdotal (and often unconfirmed) nature of these reports, it is difficult to determine the frequency of occurrence for any of these species in the Tappan Zee Reach. The NYSDEC considers the harbor seal "relatively common" in the Hudson River Estuary, although not necessarily in the Tappan Zee Reach. Based on the few anecdotal observations reported, the presence of these species in the vicinity of the project is rare and is likely attributable to either previously stressed / injured animals or healthy, but transient, individuals.

The Project Sponsors have submitted a permit application to transport and dispose the project's dredged material at the Historic Area Remediation Site (HARS). Historically, consultations pursuant to Section 7 of the Endangered Species Act (ESA) have taken place for the area of the HARS during preparation of the SEIS for the closure of the Mud Dump Site and opening of the HARS. The USEPA prepared a biological assessment that concluded that the closure of the Mud Dump Site and designation of the HARS would not be likely to adversely affect loggerhead and kemps ridley sea turtles and humpback and fin whales (USEPA 1997). Special conditions are included in USACE Section 103 permits for placement of Remediation Material at HARS that requires the presence of NMFS approved Endangered Species Observer(s) on disposal scows during their trips to the HARS. The role of these observers is to prevent adverse impacts to endangered or threatened species transiting the area between the proposed dredge site and the HARS. With the implementation of these conditions placement of Remediation Material at the HARS would not result in adverse effects to threatened or endangered species, also including marine mammals.

Chapter 3 Environmental Baseline

The focus of this BA is confined to the habitats and biota that are directly relevant to shortnose and Atlantic sturgeon and marine mammals – namely the aquatic habitats that occur below the mean high tide line. The following narratives describe the physical aquatic habitat and biota within the study area.

3.1. Physical Habitat

The study area encompasses intertidal and subtidal habitats of varying depths, ranging from shallow intertidal shorelines to shallow subtidal shoals and deeper channel habitats. Along the shorelines, coarse woody and rocky debris provide structural refuge and foraging substrates for fishes. Benthic habitat includes submerged aquatic vegetation and oyster beds, as well as unvegetated areas of coarse sandy to fine silty sediments. The navigation channel provides deeper open-water and deep-water benthic habitats.

3.1.1. Water Quality

The water quality classification in the vicinity of the TZB is a driving factor in assessing the effects of the Tappan Zee Replacement Bridge. The Hudson River near the TZB is classified by NYSDEC as a Class SB water. There are no numeric water quality standards for the parameters typically associated with suspended sediments, such as turbidity or total suspended sediment (TSS), colloidal, and settleable solids (6 NYCRR § 703.2). However, the narrative standards state that an action should not increase turbidity sufficiently to result in a substantial visible contrast to natural conditions, or any suspended, colloidal or settleable solids from sewage, industrial or other wastes that would cause deposition or impair the waters for their best use.

The Hudson River is tidally influenced from the Battery to the Federal Dam at Troy, NY. Tides at the Battery have an average range of 1.37 m (4.5 ft), with the mean range decreasing to 0.98 m (3.2 ft) at the TZB and gradually increasing again to 1.43 m (4.7 ft) at the Federal Dam (NOAA, 2009). The majority of freshwater flow enters the Hudson River north of the Federal Dam, with the remaining freshwater flow entering from various tributaries downstream of the dam. The variation between freshwater flows at the mouth of the river and in the vicinity of the TZB is a few percent (DiLorenzo et al. 1999).

The Hudson River estuary is well studied and a large number of other data sources exist. These include permanent monitoring stations, such as the USGS gauge at Hastings on Hudson (8 km, or 5 miles, downstream from the TZB), the Hudson River Environmental Conditions Observing System gauge at Piermont Pier (3.2 km, or 2 miles, downstream), and the US Geological Survey (USGS) gauge at West Point (38.6 km, or 24 miles, upstream). Other monitoring stations include the NOAA gauge at The Battery and the USGS gauge south of Poughkeepsie which continuously monitors SSC.

The USGS gauge south of Poughkeepsie uses backscatter information from an Acoustic Doppler Current Profiler (ADCP) to estimate suspended solids concentration (SSC) (Wall et al. 2006). Using the SSC estimates combined with the current data measured by the device, an estimate of total sediment discharge is also calculated. This gauge has been operating almost continuously since 2002.

Available guidance and precedent suggest that the suspended solids concentrations (SSC) in the vicinity of the TZB do not need to be rigorously defined, as (1) water quality standards for suspended solids are typically defined in relative rather than absolute terms, and (2) existing background conditions do not materially alter the behavior of sediments resuspended by construction activities.

3.1.2. Sediment Characteristics

The physical properties of river sediments (particularly grain-size distribution, which is an input to dispersion and settling models) and the presence or absence of contamination in the sediment are key parameters in determining potential effects from suspended sediments. The predominant sediment texture in the vicinity of the TZB is clayey silt. As shown in **Figure 5**, accumulations of sand, silt and clay material are observed along the causeway section of the existing bridge. Gravelly sediments are also found extensively in the navigation channel south of the TZB near the eastern shore of the Hudson River and across a large swath roughly 1,000 ft north of the existing causeway section of the TZB.

3.1.3. Sediment Chemistry

Because of anthropogenic influences, sediments deposited during the industrial era are considered more likely to be “contaminated.” Mapping of suspected industrial-era sediment deposits in the vicinity of the TZB was developed by Lamont-Doherty Earth Observatory (LDEO) through the integration of acoustic mapping and lead concentration data, as shown in **Figure 6**. This mapping indicates industrial-era sediments in the project study area are generally less than 1 ft in depth. Some thicker deposits are likely to be found south of the existing bridge and near the eastern shore, with depths approaching 1.8 m (6 ft) in certain areas.

In order to identify the sediment chemistry of the study area, sediment samples were collected in 2006 and 2008 using vibracore methods. Up to 1.5 m (5 ft) of sediment was collected at 38 locations; sediment chemistry analyses were conducted for SVOCs-base/neutral (BN) fractions, pesticides, PCBs, and metals. A subset consisting of 17 samples from 10 cores was analyzed for dioxins analysis.

As compared to the 48.3-km (30-mile) segment of the Hudson River centered around the TZB, the results of the 2006 and 2008 sediment sampling programs indicate that sediments in the immediate vicinity of the bridge are not markedly different from the river as a whole in terms of bulk chemistry, as shown by comparison to local river average data in Tables 7 through 9. In the case of metals, for the 10 analytes for which Hudson River average results are available, average concentrations are generally of the same order of magnitude as that found in project-specific samples. While organic contaminants were generally found to be of higher concentrations in the project-specific samples than in the previous samples, this relationship was also generally true when comparing only to the subset of previous Hudson River samples within one mile of the TZB. Comparing only previous samples from within one mile of the bridge to the larger 48.3-km

(30-mile) area, sediment characteristics near the TZB were generally comparable to those further away. Furthermore, in all cases, the data indicated very few exceedances of the benthic aquatic chronic or acute criteria. In that respect, the project-specific and historic Hudson River data are consistent in that they indicate that Hudson River sediments are affected by low-level organic contaminants on a widespread basis.

3.2. Aquatic Biota

3.2.1. Phytoplankton

Phytoplankton are microscopic plants whose movements within the system are largely governed by prevailing tides and currents. Several species can obtain larger sizes as chains or in colonial forms. Light penetration, turbidity and nutrient concentrations are important factors in determining phytoplankton productivity and biomass.

In one 1998 study focusing on the Hudson River, investigators collected 161 phytoplankton species. Diatoms are generally the most widely represented class of phytoplankton, accounting for 78 percent of the different taxa collected, with green algae (15 percent), blue-green algae (cyanobacteria) (3 percent), golden algae (Chrysophyceae) (2.5 percent), dinoflagellates (1 percent), and Cryptophyceae (a type of flagellate algae) (0.6 percent) comprising the remainder of the phytoplankton community. High turbidity and rapid mixing of the Hudson River (which decrease light availability) limit primary production by phytoplankton (Smith et al. 1998).

3.2.2. Submerged Aquatic Vegetation and Benthic Algae

Submerged aquatic vegetation (SAV) are rooted aquatic plants that are often found in shallow areas of estuaries, at water depths of up to six feet at low water (New York's Sea Grant Extension Program undated). These communities exhibit high rates of primary productivity and are known to support abundant and diverse epifaunal and benthic communities. These organisms are important because they provide nursery and refuge habitat for fish. Light penetration, turbidity and nutrient concentrations are all important factors in determining SAV and benthic algae productivity and biomass.

NYSDEC has mapped the distribution of SAV in the Hudson River from Hastings-on-Hudson to Troy using 1997, 2002, and 2007 data. No SAV is mapped in the study area, although SAV is mapped within the ½ mile study area. SAV surveys were conducted as part of the project in 2009 to confirm the locations of SAV identified on the NYSDEC maps. The dominant species of SAV collected as part of the surveys is the native water celery (*Vallisneria americana*); two other species were collected in the vicinity of the study area, including Eurasian water-milfoil (*Myriophyllum spicatum*) and sago palmweed (*Potamogeton pectinatus*). SAV beds were found along the western bank of the river; on the east bank, SAV was only found north of the bridge.

3.2.3. Zooplankton

Zooplankton are an integral component of aquatic food webs—they are primary grazers on phytoplankton and detritus material, and are themselves used by organisms of higher trophic levels as food. Copepods, cladocerans, and rotifers are the primary representatives of zooplankton species in the Hudson River. Zooplankton also include life stages of other organisms such as fish eggs and larvae (i.e., ichthyoplankton) that spend only part of their life cycle as plankton. Analysis of long-term data from the Hudson River Utilities Long River Sampling Monitoring Program indicates larval Atlantic tomcod (*Microgadus tomcod*), bay anchovy (*Anchoa mitchilli*), striped bass, and white perch (*Morone americana*) as the dominant ichthyoplankton species. The higher-level consumers of zooplankton typically include forage fish, such as bay anchovy, as well as commercially and recreationally important species, such as striped bass and white perch during their early life stages.

3.2.4. Benthic Invertebrates

Invertebrate organisms that inhabit river bottom sediments as well as surfaces of submerged objects (such as bridge piers, riprap, and debris) are commonly referred to as benthic invertebrates. These organisms are important to an ecosystem's energy flow because they convert detrital and suspended organic material into carbon (or living material); moreover, they are also integral components of the diets of ecologically and commercially important fish and waterfowl species.

Some of these animals live on top of the substratum (epifauna) and some within the substratum (infauna). Substrate type (rocks, pilings, sediment grain size, etc.), salinity, and DO levels are the primary factors influencing benthic invertebrate communities; secondary factors include currents, wave action, predation, succession, and disturbance.

Versar (Llanso et al. 2003) collected benthic samples from the lower Hudson River estuary (RM 11 to 40) in 2000 and 2001 which included the vicinity of the study area. In general, they found greatest numbers of species per sample in the lower portions of the study area (south of the Tappan Zee Bridge) and lowest numbers north of the bridge. Greatest benthic biomass occurred in shallow regions of Croton Bay and north of Piermont Pier on the western side of the river. Taxa which showed the greatest densities included the oligochaete worm *Tubificoides* spp., the clam *Rangia cuneata*, and the amphipod *Leptocheirus plumulosus*. They also found the barnacle *Balanus improvisus* and the pollution tolerant polychaete worms *Marenzelleria viridis* and *Heteromastus filiformis* to be present in relatively high abundances.

Bimonthly sampling of benthic resources in the bridge vicinity was conducted between March 2007 and January 2008 on behalf of the Project Sponsors in order to better characterize the fauna in the immediate vicinity of the existing bridge and the Bridge Replacement Alternative. Samples were taken in the vicinity of the footprint of the existing and proposed bridges as well as the locations of the proposed temporary causeways along the southeast and southwest portions of the existing bridge. Forty one bottom benthic locations and six bridge pier locations were sampled for this phase of the project.

A total of 48 species were collected during the bottom sediment sampling program. Total numbers, species richness, and species diversity which consider both number of species and the evenness of distribution were calculated. Greatest diversity was observed in July and lowest in January. The barnacle *Balanus* spp. and the amphipod *Leptocheirus plumulosus* were two of the dominant taxa collected in each of the six sampled months. A one way analysis of variance (ANOVA) indicated that, for the most part, there was no statistically significant difference in benthic diversity, total numbers of individuals, or species richness between the current and proposed bridge alignments. There was often a statistical difference for the benthic metrics between the approach areas for the causeways and the other locations. These locations, south of the bridge, are thought to accumulate thick sediment deposits which may account for the different benthic community characteristics.

Benthic invertebrate sampling of the existing bridge piers conducted for the project in 2007 identified a total of 8 taxa and two taxa of benthic algae. The polychaete worm *Nereis* spp., amphipods, barnacles, grass shrimp, mud crabs, isopods, oysters, and ribbed mussels were collected from the piers, as well as red and green algae. These organisms were collected in similar densities on three types of pier structure, namely, steel, concrete and timber.

3.2.5. Fish

The Hudson River estuary’s fish community is species-rich. The estuary's species diversity is enhanced by its mid-latitude location on the Atlantic Coast. Southern tropical marine species can enter the Hudson River during the summer, and a number of northern fishes are near their southern limit in the New York Harbor Estuary. A report by Smith and Lake (1990) noted that 201 species have been documented in the Hudson River. These species were classified by their probable origin, which demonstrated that the Hudson River fish community, particularly in the estuarine reach, is a mixture of both temperate and tropical marine forms, freshwater forms, and intentional and accidental introductions (ASA 2006). Over the period from 1974 to 2006, the total number of species collected annually in the utilities' monitoring program has varied from 64 to 104. Despite the large number of species that are occasionally found in the estuary, the majority of the fish represent only a limited number of species. More than 99% of the total fish community is comprised of only 10-15% of the species documented to be present in the river. In stable ecosystems, low species diversity may be an indicator of environmental stress. However, in highly dynamic and unstable ecosystems such as the Hudson River estuary, the biological community may be dominated by only a few species that are well adapted to such naturally dynamic conditions (ASA 2006).

Each of the fish species that occurs in the River can be classified by its salinity tolerance. Marine species live in the open Atlantic Ocean and nearshore waters and venture into the estuary during the warmer months of the year when salinity is relatively high. These species typically occupy the lower reaches of the estuary. Estuarine species occupy a large portion of the brackish estuary year-round and may be occasionally found in freshwater and marine reaches. Freshwater species live in the Hudson River and rarely, if ever, venture into low-salinity areas of the estuary such as the region in the vicinity of the Tappan Zee Bridge. Several fish species that occur in the Hudson River migrate from the Atlantic Ocean into freshwater habitats of the River, typically for spawning (anadromous), or leave the river to spawn in the open ocean (catadromous).

The dominant marine species in the Tappan Zee region is the bay anchovy (*Anchoa mitchilli*). An analysis of the Fall Shoals data from 1998-2007 indicated that numerically, bay anchovy comprised about 82% of the total fish standing stock. Bay anchovy are found in salinities ranging from fresh to seawater and may be the most abundant species in the western north Atlantic (Newberger and Houde 1995). Other marine species which were at times abundant in the Utilities sampling program included weakfish (*Cynoscion regalis*), Atlantic menhaden (*Brevoortia tyrannus*), Atlantic croaker (*Micropogonias undulatus*), butterfish (*Peprilus triacanthus*), and bluefish (*Pomatomis saltatrix*).

Estuarine species are generally euryhaline (i.e. tolerant of wide salinity ranges), and are year-round residents of the saline portions of the Hudson River. Abundant estuarine species collected by the utilities' monitoring program included white perch, banded killifish (*Fundulus diaphanus*), Atlantic silverside (*Menidia menidia*), and hogchoker (*Trinectes maculatus*).

Anadromous species that use the estuary as spawning and nursery grounds include alewife (*Alosa pseudoharengus*), American shad (*Alosa sapidissima*), Atlantic sturgeon, Atlantic tomcod, blueback herring (*Alosa aestivalis*), and striped bass. Adults typically enter the estuary in the spring and migrate upstream to low-salinity brackish and freshwater areas to spawn. The young fish then use the near-shore shoal areas for food and habitat as they make their way downstream, and generally leave the estuary in the fall. American eel (*Anguilla rostrata*) is the only catadromous species that occur in the Hudson. Although the Utilities data indicate that there are wide variations in the annual totals of collected eels, overall there has been a sharp decline in the number of individuals captured during these surveys since the mid 1980s. The U.S. Fish and Wildlife Service and NMFS are currently reviewing the status of American eel, blueback herring, and alewife to determine whether any or all of these three species should be proposed for listing as a protected species.

Chapter 4 Project Details

4.1. Construction

As shown in **Figure 7**, construction of the Short Span Option would take approximately 5½ years. The schedule shows both preliminary activities used to support the construction of the project (i.e., dredging and temporary platforms) as well as individual elements of bridge construction (i.e., main span and approaches). Throughout the construction period roadway work would be required at various times. During that time, the approach roadways would be shifted and remain in the new location for an extended period before being shifted again. The dredging would occur in three stages over the 5 ½ year period during a three-month window between August 1 and November 1 and construction of the main span would consist of approximately 3½ years of construction. Completion of the short span approaches would involve approximately 3½ to 4 years of construction. Demolition of the existing Tappan Zee Bridge would be expected to span approximately 1 year.

Construction of the Long Span Option would last approximately 4½ years (see **Figure 7**). The construction sequence and schedule would be similar to that of the Short-Span Option with the exception of the construction of the approaches, which would be expected to take approximately 2½ to 3 years.

4.1.1. Landings

Landings would employ typical highway construction techniques and would be completed on both the Westchester and Rockland sides of the Hudson River upland from the bridge abutment to the tie in with the existing roadway. Construction of the landings would occur throughout the duration of the construction. The construction activity for the landings, however, would be gradual, as the roadways on both sides would be altered and then maintained for lengthy spans of time before being altered again. The alterations to the landings would consist of changes in roadway grade, elevation, direction, and general configuration.

4.1.2. Approaches

Beginning at the abutments, the approaches carry traffic from the land to the main span of the bridge. Construction of the approaches would last for approximately three and a half to four years for the short-span alternative, and two and a half to three years for the long-span alternative. The piles, pile caps, piers, and deck that compose this segment of the bridge would be built sequentially so that as a new pile is being constructed, a completed pile would be undergoing further transformation with, for example, the addition of a pile cap.

4.1.3. Main Span

The main span would stretch between the Westchester and Rockland approaches. It is the segment of the bridge that would be defined largely by its superstructure design as an arch or cable stayed bridge. Within its substructure, the piers would be more substantial than those of the approaches. All main span work would be done sequentially and in a similar manner as that of the approaches. The piles, pile caps, pylons, and deck construction would last approximately three and a half years.

4.2. Construction Of Key Elements

Construction of either option of the Replacement Bridge Alternative would require a wide range of activities on both sides of the river as well as from within the waterway itself. In addition, due to the lack of available land along the waterfront in the vicinity of the bridge, staging areas at some distance from the construction site would be required. Furthermore, it is likely that some bridge components would be pre-fabricated well outside the study area and transported to the site via barge.

To support construction of the main span and bridge approaches, materials, equipment, and crews would be transported from upland staging areas in Westchester and Rockland counties to temporary platforms that would be constructed on the shoreline of the river, as shown in **Figure 8**. Dredged channels would provide access to the two work areas in the shallow portion of the river crossing: the Rockland and Westchester approaches. Substructure construction would establish the foundation of the bridge through the processes of pile driving, construction of pile caps, and construction of columns. Superstructure construction would then take place either with a gantry that would move from pier to pier lifting segments from barges below (as in the case of the short-span design option) or a short pier-head truss segment would be lifted atop the next open pier column and secured (as in the case of the long-span option).

4.2.1. Waterfront Construction Staging

The shoreline areas near the proposed bridge site are limited by adjacent development. In order to provide space for the docking of vessels, the transfer of materials and personnel, and the preparation of construction elements, temporary platforms and a permanent platform along the Rockland County side would be extended out from the shoreline over the Hudson River (see **Figures 9** and **10**). The Rockland platforms would protect the shoreline and also enable the continued maintenance of the original Tappan Zee Bridge as well as providing continued support for the New York State Thruway Authority (NYSTA) Dockside Maintenance facility operation. These platforms would provide access to the replacement bridge site via temporary trestles. Their main purposes would be to facilitate delivery of heavy duty bridge elements from an offsite fabrication facility, receive deliveries from the concrete batch plant, receive deliveries (i.e., construction equipment and light duty bridge elements) from the staging areas, and allow for barge-mounted cranes to erect heavy duty bridge elements. Upon completion of construction, the temporary platforms and the piles that support them would be removed. The permanent platform would remain and its potential effects on sturgeon are discussed in greater detail in Chapter 6 (Effects Analysis)

As the construction of the temporary platforms and access trestles would begin at the shoreline, an access road and work area near the shore would also be constructed. A channel would be dredged specifically to provide barge access to the temporary platforms from in-river work sites.

4.2.2. Dredged Access Channel

Since the proposed bridge alignment spans extensive shallows, it would be necessary to dredge an access channel for tugboats and barges to utilize during construction of the approach spans. These vessels would be instrumental in the installation of cofferdams, pile driving, the construction of pile caps and bridge piers, and the erection of bridge decks and other superstructure components. As noted earlier, temporary, trestle-type access platforms would be constructed near the shoreline to provide access for construction vehicles that would operate on the trestles. This would avoid the need to dredge the near-shoreline area.

Two alternate construction methods were evaluated in an effort to avoid the need to dredge an access channel. One method involved the use of overhead gantries for the construction of foundations and the other consisted of the implementation of a full-length temporary trestle for access. Both of these alternatives were found to be impractical: the former because it is not practicable for the heavy-duty pile-driving requirements of the replacement bridge and the latter because the deep soft soils in the shallow waters of the construction zone would require foundations that would be expensive and time-consuming to construct.

As shown in **Figure 11**, dredging would be conducted in three stages over a 4-year period for a duration of 3 months in the fall of the year. The purpose of the first two dredging stages (Years 1 and 2) would be to provide access for bridge construction, while the final dredging stage (Year 4) would provide access for demolition of portions of the existing bridge allowing for completion of the remaining portions of the new structure. Each of these three-month spans would occur during the limited fall window (between August 1 and November 1) when dredging is typically allowed in the New York Harbor/Hudson River Estuary area; this is the period when dredging activities would have the minimum effect on aquatic resources.

Based on an analysis of the types, number, size and operation of vessels that would operate in the access channel during construction, it was determined that a clear draft of at least 3.6 m (12 feet) would be required within the access channel. To avoid the potential for grounding of vessels, an additional two feet would be added to provide a working channel depth of 4.3 m (14 feet) at the lowest observed water level, which occurs during the Spring Neap Tide. The lowest observed water level is referred to as Mean Low Low Water (MLLW).

In addition, to minimize any adverse effects from the re-suspension of the fine sediment material due to movement of vessels, particularly tugboats, within the dredged channel, a layer of sand and gravel (referred to as "armor") would be placed at the bottom of the channel following dredging. As discussed below in Section 18-4-12 (Water Resources) the sediments in the vicinity of the area to be dredged are highly susceptible to resuspension into the water column. Without "armoring," prop scour from working tugboats in the channel would result in the generation of suspended sediment at rates several orders of magnitude greater than what would occur from the dredging operation itself. Therefore, it was concluded that this level of sediment resuspension and ultimate transport into the river would pose an unnecessary and potentially substantive adverse effect to the environment.

The installation of the sand and gravel would take place as soon as the dredging for that section of the channel was successfully completed, forming a protective layer to keep sediment from further disturbance. Without this protective layer, additional dredging would be required to create a deeper work zone. The sand and gravel materials would be delivered by barges or scows, and would be placed within the channel by barge-mounted cranes. The materials would not be removed after the project completion, since they would become fully buried by the gradual deposition of river sediments over time once construction was completed. The dredging depth required assumes that two feet of sand and gravel armor is placed on the bottom. In total, the channel would be dredged to a depth corresponding to 4.9 m (16 feet) below MLLW.

Table 1 shows the amount of material to be dredged during each stage for the two bridge design options. For either design option, the channel width would measure approximately 145 to 161 m (475 to 530 feet), and it would extend approximately 2,133 m (7,000 feet) from the Rockland County side into deeper waters and 610 m (2,000) feet from the Tarrytown access trestle into deeper waters. Because the long span alternative would occupy a wider footprint, a slightly larger area must be dredged for that alternative. It is estimated that approximately 1.28 and 1.33 million cubic meters (1.68 and 1.74 million cubic yards) of sediment would be dredged for the short and long span options, respectively.

Table 1
Dredging Quantities for the Replacement Bridge Alternatives

Construction Stage	Short Span		Long Span	
	Quantity (million CY)	Percent of Total	Quantity (million CY)	Percent of Total
Stage 1	1.08	64%	1.12	64%
Stage 2	0.42	25%	0.43	25%
Stage 3	0.18	11%	0.19	11%
Total	1.68	100%	1.74	100%

Notes:
CY = cubic yards
Dredging for bridge demolition (Stage 3) includes that portion of the bridge which must be removed to complete the Replacement Bridge Alternative tie-in.

Environmental Performance Commitments (EPCs) to be used during dredging operations include:

- Adherence to a 3-month fall window when dredging between August 1 and November 1 would be allowed;
- Use of an environmental bucket with no barge overflow; and
- Armoring of the channel to prevent re-suspension of sediment during the movement of construction vessels, installation and removal of cofferdams, and pile driving.

4.2.3. Transport and Disposal of Dredged Material

During each three-month period when dredging is occurring, dredged materials would be collected from the bottom of the river by barge-mounted cranes placed into hopper scows, which are boats with a capacity of approximately 1,911 cubic meters (2,500 cubic yards). To ensure that the scows do not exceed the maximum allowable draft of the river work zone, they would be limited to 80 percent of their maximum load, or 1,529 cubic meters (2,000 cubic yards) per load.

Each dredging stage would occur during a 90-day period. During that period, it is estimated that dredging would occur up to 75 of the 90 days, with two dredge operations occurring at a time. During the busiest dredging stage, Stage 1, up to 11,468 cubic meters (15,000 cubic yards) of materials would be dredged each day. **Table 2** presents the estimated daily volumes of materials removed for each dredging stage for the two replacement bridge alternatives.

Table 2
Daily Materials Removal by Construction Stage

Construction Stage	Short Span Daily Volume (cubic yards)	Long Span Daily Volume (cubic yards)
Stage 1	14,600	15,000
Stage 2	5,700	5,800
Stage 3	2,400	2,600

After placement in the hopper scows, the next step in the dredge materials handling would depend on the dredge placement option selected.

As discussed above in the introduction of this chapter, certain activities related to project construction are left to the discretion of the contractor. One of these specific activities would be the ultimate transport and disposal of dredge spoils from construction of the access channel. Transport by ocean scow and placement in the Historic Area Remediation Site (HARS) in the New York Bight would offer a number of benefits to the project including cost, schedule, logistics and the avoidance of impacts to the surrounding residential communities on the Rockland and/or Westchester shorelines.

In this option, the dredged materials would be transported to HARS, 5.6 km (3.5 miles) east of Sandy Hook, NJ. The HARS is overseen by the U.S. Army Corps of Engineers (USACE) and the U.S. Environmental Protection Agency (USEPA). This site was historically used for ocean disposal of dredged material and a variety of waste products, including some contaminated materials. Today, the site is being remediated through a program to cap those historic sediments with cleaner sediments dredged from New York Harbor that meet certain criteria established by the Ocean Dumping Act.

A permit is required for dredged material to be placed at the HARS from the USACE for that placement. To receive the permit, the materials must be suitable for remediation, in that they meet certain criteria related to contaminants based on sediment toxicity and bioaccumulation tests. In addition, in accordance with 40 CFR §227.16, the USEPA must evaluate alternative disposal options before permitting placement of dredged material at the HARS, and must find that there are no practicable alternative locations and methods of disposal or recycling available. In support of this required finding, an alternatives analysis can be found in Appendix H to Draft Environmental Impact Statement documenting that there are no practicable alternatives locations for the placement of the dredged material at the HARS site.

In recognition of the many benefits offered by the HARS site, the project is proceeding with sampling and analysis of the dredged material in support of a permit under Section 103 of the Marine, Protection, Research, and Sanctuaries Act of 1972 from the USACE. If approved, the dredged materials from the Tappan Zee Hudson River Crossing Project placed at the HARS would be transferred from the hopper scows to larger capacity [up to 3,440 cubic meters (4,500 cubic yards)] ocean scows. These vessels have large drafts, typically up to 5.5 m (18 feet), that would be too large to be accommodated in the dredged construction channel. Therefore, materials would be transferred from the hopper scows to the ocean scows in deeper water areas of the Hudson River. The ocean scows would then travel to the HARS, where materials would be placed at the site in accordance with the permit conditions for that placement.

If the permit application for the use of HARS is denied in whole or part, the contractor would be required to dispose of the dredged material at an approved facility in accordance with all applicable laws and regulations. However, due to the estimated number of truck trips that would be required (nearly 800 round trips daily) and the potential for adverse traffic, air quality and noise impacts on the local community the contractor would not be allowed to transport the dredged material by truck from the waterfront staging areas in Rockland or Westchester Counties. The contract documents would specify that alternate means of transport of the dredged material such as barge or barge to rail would be required for disposal.

4.2.4. Substructure Construction

Substructure construction would vary as a function of water depth and sediment conditions at each location. Work on the foundations can be categorized into three segments referred to as Zone A, Zone B, and Zone C (see **Figures 12** and **13**). Pile installation would typically be performed one row of piles at a time. The actual pile driving is done one pile at a time. As shown in **Table 3**, a total of 1,326 piles for Piers 1 to 57 would be required for the Short Span Option. **Table 4** includes similar information for the Long Span Option at Piers 1 thru 32. The Long Span Option would require 836 piles. In terms of the largest piles, the number of the 3-m (10-foot) piles would be the same (50) for either option. The greatest difference between the two options would be the number of smaller 1.2-m (4-foot) piles with the Sport Span Option requiring approximately 346 more piles than the Long Span Option. The Long Span Option would also require 104 less 1.8-m (6-foot) piles and 40 less 2.4-m (8-foot) piles for a total difference of 490 piles. Under either option, the driving of the largest piles [2.4- and 3-m) (8- and 10-foot)] would only occur for a few months in the first year of construction.

Table 3
Pile Driving, Short Span Option

Pier No.	Substructure Zone	Pile Size (diameter ft)	No. of Piles Within each Pier	Total No. of Piles
1-3	A1	6	4	24
4-8	B1	6	6	60
9 - 14	B1	4	20	240
15-32	B1	4	20	720
33-35	B1	8	4	24
36-43	C	8	4	64
44-45	C	10	25	50
46-50	C	6	6	60
51-57	B2	6	6	84
Total				**1,326**

Table 4
Pile Driving, Long Span Option

Pier No.	Substructure Zone	Pile Size (diameter ft)	No. of Piles Within each Pier	Total No. of Piles
1-2	A1	6	4	16
3	A1	6	6	12
4	B1	6	6	12
5-17	B1	4	25	614
18-21	B1	8	4	32
22-23	C	8	4	16
24-25	C	10	25	50
26-28	C	6	6	36
29-30	B2	6	6	24
31-32	A2	6	6	24
Total				**836**

Environmental Performance Commitments (EPCs) to be employed during construction of the substructure include:

- Driving the largest [3 and 2.4 m (10 and 8 ft)] diameter piles within the first few months of the project thereby limiting the time period of greatest potential impact.
- Using cofferdams and silt curtains, where feasible, to minimize discharge of sediment into the river.
- Using a vibratory pile driver to the extent feasible (i.e., all piles will be vibrated at least to 36.6 m (120ft) depth or to vibration refusal) particularly for the initial pile segment.
- Using bubble curtain, cofferdams, isolation casings, Gunderboom, or other technologies to achieve a reduction of at least 10 dB of noise attenuation.
- Using the results of the Hudson River site specific Pile Installation Demonstration Project (PIDP) which includes the testing of various sound attenuation devices to inform the project on the effectiveness of BMP technologies for reducing sound levels, and implementing BMPs to achieve maximum sound reduction.
- Limiting the periods of pile driving to no more than 12-hours/day.
- Limiting driving of 8 and 10 ft piles with an impact hammer within Zone C [water depths 5.5-13.7 m (18-45 feet)] to 5 hours per day during the period of spawning migration for shortnose and Atlantic sturgeon (April 1 to August 1).
- Maintaining a corridor where the sound level is below the West Coast threshold for onset of behavioral effects to fish totaling at least 5000-ft at all times during impact hammer pile driving. This corridor shall be continuous to the maximum extent possible but at no point shall any contributing section be smaller than 1500 ft.

- Pile tapping (i.e. a series of minimal energy strikes) for an initial period to cause fish to move from the immediate area.

- Development of a comprehensive monitoring plan. Elements would include:

  - Monitoring water quality parameters such as temperature, salinity, and suspended sediment concentrations in the vicinity of the pile driving.
  - Monitoring fish mortality and inspection of fish for types of injury, as well as a program for determining contaminant levels in dead sturgeon through tissue analysis methods.
  - Monitoring the rate of recovery of the benthic community within the dredged area and armored bottom and also providing site specific information on sedimentation processes and time of recovery of sturgeon foraging soft bottom habitat following construction and temporary modification of bottom habitat.
  - Supporting the Atlantic and shortnose sturgeon sonic tagging program through coordination with NMFS and NYSDEC. This may include placement of telemetry receivers in the project area.
  - Monitoring predation levels by gulls and other piscivorous birds, which would indicate an increased number of dead or dying fish at the surface.
  - Preparing a Standard Operating Procedures Manual outlining the monitoring and reporting methods to be implemented during the program.

- In addition, dredging (using a clamshell dredge with an environmental bucket) would only be conducted during a three-month period from August 1 to November 1 for the three years of the construction period in which dredging would occur, which would minimize the potential for interaction with the dredge and migration effects to sturgeon and other fish species.

4.2.4.1. Foundation Zone A

The two areas of shallowest water depth extend from the shorelines on the Rockland and Westchester sides of the Hudson. These areas, where the water measures less than 2.1 m (7 feet) in depth, are labeled as Zone A. The area adjacent to the Rockland shoreline is labeled Zone A1, while the area adjacent to the Westchester shoreline is Zone A2. Zone A substructure elements would be constructed within cofferdams from adjacent temporary trestle platforms. These cofferdams would be constructed prior to pile driving the bridge foundation piles. The cofferdam would remain flooded during pile installation.

4.2.4.1.1. Cofferdams

A cofferdam is a watertight chamber designed to facilitate construction in an area that would otherwise be underwater. In this case, the cofferdams would be composed of interlocking sheet piles extending into the riverbed a distance of up to 6.1 m (20 feet). Upon completion of the cofferdam, foundation piles would be driven into the riverbed.

4.2.4.1.2. Pile installation

Prior to pile driving, a template to guide piles would be placed within the cofferdam to ensure that they are in position and to hold them when pile driving is not taking place. A quick, low-noise, moderate-energy vibratory hammer would be used to install much of the length of the pile, after which a high efficiency hydraulic impact hammer suspended from cranes operating on the two temporary shoreline access trestles would be used to apply force to the tops of the piles so as to deliver the piles more deeply into the riverbed. It should be noted that the use of vibratory hammers for the entire driving operation is not possible due to the excessive depths to bedrock. The feasibility of using vibratory hammers to drive piles deeper than originally proposed in order to reduce the duration of impact hammering will be tested in the PIDP. Using the vibratory hammer rather than the impact hammer to accomplish the majority of the pile driving would require the addition of substantially more pilings than originally proposed in order to achieve the desired weight-bearing capacity and settlement of pilings into the substrate. However, because vibratory hammers have considerably less potential noise impact than do impact hammers, they will be used to the maximum extent feasible. The extent of vibratory piling use will be reconsidered after the results from the PIDP are available. Once all piles are driven, the template and its supports would be transitioned to the next cofferdam.

4.2.4.1.3. Pile caps

A 300-ton crawler crane would suspend the 45.7-m (150-foot) pile sections and support the pile driving hammer during operation. Upon completion of pile installation, the soil within each pile would be excavated and transported to an off-site disposal facility. Finally, a tremie concrete plug, which braces the bottom of the sheet pile cofferdam and provides a seal at the base of the cofferdam to allow for dewatering of the cofferdam, would be poured inside the pile and a steel reinforcing cage would be inserted into the pile. River water recovered during dewatering of the cofferdams would be routed to tanks to settle out any suspended sediments (or a water filtration system as necessary) and discharged back to the Hudson River in accordance with conditions issued by the NYSDEC under the Section 401 water quality certification for the project, and would not result in adverse impacts to water quality of the Hudson River.

As previously mentioned, a tremie concrete plug would be poured into the hollowed pile. The pile itself would be dewatered down to the plug. Prior to the installation of the pile cap, pier reinforcement, post tensioning ducts, and pile reinforcement would be secured. A pile cap, which is a reinforced concrete slab constructed atop a cluster of foundations piles, would then be constructed to form a single structural element that would allow for even distribution of the weight that the piles bear, avoiding over stressing any individual component. These slabs would also provide a larger area for the construction of the columns that they will support.

4.2.4.2. Foundation Zone B

The water depths in Zone B range from 1.5 to 5.5 m (5 to 18 feet), and the zone is characterized by a relatively deep soft-soil profile. Zones B1 (close to the Rockland shoreline) and B2 (close to the Westchester shoreline) are located adjacent to Zones A1 and A2 and are closer to the centerline of the river. The functions performed in Zone B substructure construction would take place in cofferdams, as in Zone A, but the tasks would be completed from barges and support vessels.

4.2.4.2.1. Pile Installation

Piles, which would be transported in two pieces to Zone B by barge, would measure between 76.2 and 91.4 m (250 and 300 feet) due to the relatively deep soft-soil profile within the zone. Pile driving would begin immediately upon completion of the cofferdam construction. As in Zone A, a 300 ton crawler crane would lift the pile sections. A pile-driving rig would supply a hammer suspended from the barge mounted crane. The template would be positioned to guide the lower pile section into proper position before the pile would be allowed to delve into the soft stratum under its own weight. The depth achieved in this manner would be considerable, and should the application of further pressure be called for, a vibratory hammer would be used to drive the remainder of the pile into place. Upon the placement of the lower segment of the pile, preparations to begin welding the two segments together will commence. In order for the two segments to be joined, the upper segment would be hovered over the lower until the automated welding process was complete. Upon the completion and inspection of the welding, the remaining length of the conjoined pile would be driven to required depth or specified penetration resistance with a hydraulic hammer. As in Zone A, the soil within the pile would be excavated and transported to an off-site disposal facility in order to create space for the tremie plug and steel reinforcing cage.

4.2.4.2.2. Pile caps

The construction process of pile caps in Zone B would be similar to that of Zone A. One difference would be that a granular fill material would be distributed inside of the cofferdam to enable the tremie seal to be poured to its planned elevation. This granular material would remain after the removal of the cofferdam.

4.2.4.3. Foundation Zone C

Foundation Zone C lies between Zones B1 and B2, connecting the two sides of the river. This zone is defined by the greatest water depths, which range from 5.5 to 13.7 m (18 to 45 feet). Construction in this zone would encompass the construction of the main span as well as that of both approaches.

The first substructure construction activity in Zone C would be the installation of the foundation piles. In this zone, due to the greater depths than Zones A or B, cofferdam construction would follow the pile installation, thus requiring that the cofferdam be constructed around the installed pile to create a dry environment in which to construct the tremie seal. The cofferdam in Zone C would be constructed using a different method than that utilized in Zones A and B. This alternative method, the “hanging cofferdam method”, would begin with the installation of a temporary support structure above the foundation piles on which the cofferdam would be assembled. The cofferdam components would then be pieced together from pulleys secured to the top beams of the support structure. After the placement of the cofferdam, the tremie slab would be poured onto a steel deck acting as the cofferdam floor. Divers would seal the gaps between the piles and the cofferdam deck before the dewatering process. The tremie slab would then be poured, and the unreinforced slab would bond the piles to the cofferdam pending the construction of the reinforced pile cap.

4.2.5. Construction of Bridge Superstructure

Completion of the bridge superstructure would include piers, columns, pylons (for a cable-stayed option), bridge deck, roadway finishes, lighting, and the shared use path. Much of the material would be pre-fabricated at various locations and delivered to the project site via barge. At the construction site, these elements would be lifted into place by gantries and cranes operating on barges, the temporary work platforms, or completed portions of the structure.

4.2.6. Existing Bridge Demolition

The existing Tappan Zee Bridge contains five segments: causeway, east trestle, east deck truss, west deck truss, and main spans. The demolition of the existing bridge will be performed in two stages. The first stage will include partial demolition to allow for construction of the new bridge, and the second stage will occur after the completion of the new bridge. No blasting of the existing structure would occur.

4.2.6.1. Causeway and East Trestle Spans

The causeway is a simple span construction composed of 166 spans measuring 15.2 m (50 feet), with the exception of one 30.5-m (100-foot) span. The east trestle is comprised of 6 spans. Within its simple span construction, the causeway contains a stringer and deck superstructure and a substructure of concrete columns and footings on timber piles. Initially, the deck and stringers would be lifted out and placed onto awaiting barges. Then, the protective dolphins would be cut so as to offer unrestricted access for pier removal. Columns and footings would either be cut with diamond wire or broken by pneumatic hammers. Finally, the timber piles forming the causeway foundation would be cut to just below the mud line. All materials would be transported to an appropriate permitted off-site disposal facility, and a turbidity curtain would be utilized to ensure that demolition debris would not be dispersed. Side-scan sonar surveys would be performed in order to verify that all generated debris would be removed from the river.

4.2.6.2. Deck Truss Spans

The deck truss spans, including 13 east deck, 7 west deck, and all approach truss spans, each contain a deck slab, steel trusses, and concrete piers supported on buoyant foundations or caissons. The deck slabs would be removed and transported off-site by an awaiting barge. A channel would then be dredged in Stage 3 to provide access to the trusses near the Westchester shoreline, and steelwork would either be removed by barge-mounted crane or a crane mounted on an adjacent in-tact span. Caisson-supported piers would be demolished using the same process as in the causeway and east trestle spans, and would then be removed to the mud line using diamond cutting wire devices or pneumatic hammers. Steel H piles would remain below the mud line. Turbidity curtains and netting would also be used in this stage.

4.2.6.3. Main Span

The main span stretches 735.2 m (2,412 feet) and is structurally formed by a through truss above a deck supported by four latticework piers on buoyant foundations, ice deflectors around the two central piers, and pre-stressed concrete beams on 76 cm (30-inch) diameter steel piles. Initially, the main span deck slab would be lifted and removed off-site by barge. Then, the entire suspended span would be lowered onto a barge via a strand jack or winch system. Conventional barge-mounted cranes would then deconstruct the anchor span steelwork piece by piece and the ice-breaker and fender structures protecting the main span piers would be demolished by divers and barge-mounted cranes. The pier steelwork would also be removed piece by piece, and the buoyant caissons would be cut and flooded. Following main span demolition, a barge-mounted crane operated clam shell bucket would clear the river bottom of debris. Side-scan sonar surveys would verify that all debris and concrete were removed from the river.

Chapter 5 Project Action Area

5.1. Limits of Action Area

The Hudson River is one of the major rivers on the Atlantic Coast, extending from its source at Lake Tear of the Clouds on Mount Marcy in the Adirondacks to the Battery in New York Harbor, a distance of approximately 507 km (315 miles) (Geyer and Chant, 2006). In the study area, the Hudson River is tidally influenced and commonly referred to as the Hudson River estuary. The estuarine portion of the river begins at the Troy Dam about 248 km (154 miles) north of the Battery in southern Manhattan. Tides in the Hudson River estuary are semidiurnal, having two high waters and two low waters each day with an average range of 0.98 m (3.2 feet) (NOAA 2009). At approximately 4.8 km (3 miles) in width in the study area, the river is designated by NYSDEC as a Class SB (saline) waterbody, intended to be suitable for recreation, and fish survival and propagation. Water quality surveys by the Project Sponsors identified considerably variable concentrations of suspended sediments in the water column near the bridge depending on water depth, season and weather conditions.

In the vicinity of the bridge, the river ranges in depth from less than 3.6 m (12 feet) along the western causeway to greater than 14.3 m (47 feet) in the shipping channel under the main span. The causeway and bridge piers cause river currents to locally scour the bottom sediments, resulting in depressions in the bottom of the river alongside the bridge.

The study area in the immediate vicinity of the replacement bridge encompasses intertidal and subtidal habitats of varying depths, ranging from shallow intertidal shorelines to shallow subtidal shoals and deeper channel habitats. Areas south of the existing bridge less than 1.8 m (6 feet) deep at mean low water (MLW) are mapped as littoral zone wetlands by the NYSDEC. No NYSDEC tidal wetlands are mapped north of the bridge.

On the west side of the river, the shoreline typically consists of unvegetated intertidal beaches composed of coarse sand with scattered boulders. Immediately north of the bridge the shoreline is bulkheaded. The eastern shoreline adjacent to the railroad tracks consists of riprap armoring in the vicinity of the replacement bridge.

Shallow water environments occur near the shorelines and along the western and eastern causeways, while deep water habitat occurs within and near the shipping channel and the main bridge span. The habitat of the Tappan Zee Reach is dominated by a large shallow western shoal with soft sediments, deep channel in the middle of the river with coarse-grained sediments, and narrow shallow shoal on the east side of the river denominated by soft sediments. Within the Tappan Zee Reach, the benthic habitat also has a patchy distribution of oyster beds. All of the benthic habitats in the reach (e.g., soft and coarse-grained sediments, oyster beds, and bridge piers), provide foraging opportunities for species in the Tappan Zee Reach.

Shallows attract aquatic organisms that prefer greater sunlight and less water depth for part or all of their life cycles, while deeper water areas attract organisms with deeper water column needs. The region under the existing bridge attracts organisms that use the pier structures as habitat, or that seek the organisms that adhere to the structures as food resources.

The entire east bank of the Hudson River within the study area has been developed as rail beds (rip rap), piers, or bulkheads. Several vegetated tidal wetland areas or tidally-influenced areas were observed along tributaries to the Hudson River, as well as between the rail beds. The rip rap and beach areas may provide food and shelter values for fish, shellfish, and other wildlife.

The limits of the study area considered in this BA have been determined by the potential project effects for dredging and re-deposition of suspended sediment, acoustic impacts from pile driving, and loss of habitat. The potential geographic boundaries extend across the entire width of the Tappan Zee Reach, and based on modeled sound isopleths extend a maximum of 2,210 m (7,250 feet) or less in both up and downriver directions. For sediment resuspension, which is a measure for assessing impacts to water quality, project incremental concentrations above 10 mg/L above ambient conditions may extend in a relatively thin band approximately 305 to 610 m (1,000 to 2,000 ft) from the dredges. Concentrations of 5 mg/L above ambient may extend a greater distance in either an upstream or downstream direction, depending upon the tidal stage. Because of the recent listing of the Atlantic sturgeon, the study area has been expanded to also include the HARS, where dredged material is expected to be transported to and placed. The HARS is located approximately 4 miles east of Highlands, New Jersey and about 9 miles south of Rockaway, Long Island. It comprises about 20 square miles.

Chapter 6 Effects Analysis

The assessment of impacts focuses on potential direct and indirect effects on the shortnose and Atlantic sturgeon populations in the study area. The following were determined to be indicators of direct and indirect effects:

- Direct effects. Direct effects are considered to be any adverse effects arising from project activities that could result in immediate impacts on shortnose and Atlantic sturgeon individuals or changes to their habitat. These effects are defined as onset of physiological effects, recoverable physical injury or death, disruption of migration or spawning behaviors, and direct alteration of existing habitat. For this BA direct effects were evaluated for pile driving, increased vessel traffic, dredging activities, and shading from the new structures.

- Indirect effects. Indirect effects are defined as any effects that are caused by or will result from the proposed action later in time, but which are still reasonably certain to occur (50 CFR § 402.02). These effects are defined as water/sediment quality impairment and indirect alteration of habitat, inclusive of burial of spawning substrates by resuspension of material during vessel movements, dredging or backfill/capping, and associated effects.

6.1. Direct Effects

The primary potential direct effects from the project resulting in an incidental take of shortnose and Atlantic sturgeon are associated with the physical disturbance to adults and juveniles as a result of pile driving and increased vessel traffic. In addition, the dredging required to facilitate construction barge access to the site could also directly interact with shortnose or Atlantic sturgeon, or affect the foraging ability of these sturgeon species. Finally, the BA considers the potential for direct effects from shading.

6.1.1. Acoustic Effects from Pile Driving

In order to understand the potential impacts of the sounds produced by pile driving, as well as other anthropogenic sources, on the listed shortnose and candidate Atlantic sturgeon, it is necessary to have a basic understanding of sound, and, in particular, underwater sound. In this BA the potential effects from pile driving are evaluated based on the interim West Coast criteria for onset of physiological effects agreed to in a Memorandum of Agreement (MOA) by FHWA, USFWS, NMFS, CalTrans, and the Washington Department of Transportation on June 12, 2008.

6.1.1.1. Current Interim Criteria for the Onset of Physiological and Behavioral Effects

6.1.1.1.1. Physiological effects

As a result of the aforementioned MOA, a set of interim criteria was established for the acoustic levels at which there could be a potential onset of physiological effects to fish. The criteria were established in June 12, 2008 and are referred to as the interim West Coast criteria (reviewed in Woodbury and Stadler 2008; Stadler and Woodbury 2009). These criteria are intended to reflect the onset of physiological effects (Stadler and Woodbury 2009), and not levels at which fish are mortally damaged. Indeed, the onset of physiological effects may be minimal changes in fish tissues that have no biological consequence (Halvorsen et al. 2011). The interim criteria are:

Peak SPL: 206 decibels relative to 1 micro-Pascal (dB re 1 μPa).
SEL_{cum}: 187 decibels relative to 1 micro-Pascal-squared second (dB re 1 $\mu Pa^2\cdot s$) for fishes above 2 grams (0.07 ounces).
SEL_{cum}: 183 dB re 1 $\mu Pa^2\cdot s$ for fishes below 2 grams (0.07 ounces).

6.1.1.1.2. Behavioral Effects

For purposes of assessing behavioral effects of pile driving at several West Coast projects, NMFS employs a 150 dB re 1μPa rms SPL criterion, although it is pointed out in Caltrans (2009) that, at least on the West Coast, "…NOAA Fisheries staff informally indicated … that they do not expect exceedance of the 150 dB RMS behavior threshold to trigger any mitigation." This BA evaluates the potential for the project to result in onset of temporary behavioral changes to sturgeon.

6.1.1.2. Recent Results Relevant to the Interim Criteria for Onset of Physiological Effects

A recent peer-reviewed study from the Transportation Research Board (TRB) of the National Research Council of the National Academies of Science describes the first carefully controlled experimental study of the effects of pile driving sounds on fish (Halvorsen et al. 2011). This investigation was funded by the National Cooperative Highway Research Program (NCHRP) of the TRB, Caltrans, and the Bureau of Ocean Energy Management (BOEM), as well as by the Canadian Department of Fisheries and Oceans (DFO), and was developed and overseen by individuals from highway programs and federal agencies throughout the United States as well as leading experts in underwater acoustics and hearing from the U.S. and abroad. The study was the first to document effects of pile driving sounds (recorded at actual pile driving operations) under simulated free-field acoustic conditions where fish could be exposed to signals that were precisely controlled in terms of number of strikes, strike intensity, and other parameters. The acoustic field simulated one that would take place beyond about 10 m (33 ft) from a source. Sufficient number of animals exposed to the source, as well as controls (treated identically to experimental other than for their being exposed to sound), were used to provide a strong statistical base. Subsequent to treatment, animals were subject to extensive necropsy (autopsy) to determine the types of physiological effects and the sound exposure levels at which these would show up.

The study was conducted on Chinook salmon (*Oncorhynchus tshawytscha*), an endangered species on the US West Coast. The study considered the onset of a wide variety of potential physiological effects that ranged from small amounts of hemorrhage at the base of fins to severe hemorrhage or rupture of the swim bladder and surrounding body tissues (kidney, liver, spleen, etc.). It was determined that very small effects, such as small hemorrhages at the base of fins, are not life threatening nor would they have any short or long-term effect on fish fitness, unlike damage such as swim bladder rupture which would potentially result in mortality. Based on a thorough statistical analysis of results, with extensive controls, it was determined that onset of physiological effects that have the potential of reduced fitness, and thus a potential effect on survival, started at above 210 dB re 1 $\mu Pa^2\cdot s$ SEL_{cum}, a level that is about 23 dB above the current West Coast interim onset criteria. The peak level for effects is about the same as the current West Coast level.

Subsequent work, using the identical methodology has demonstrated that there is recovery from effects on Chinook salmon exposed to sounds as high as 216 dB re 1 $\mu Pa^2\cdot s$ SEL_{cum} when fish were kept in the laboratory (higher cumulative sound levels could not be used in that particular study). In addition, other studies from the same research group have shown that similar results to those reported for Chinook salmon were also found in several other species, including lake sturgeon (*Acipenser fulvescens*). There was small variation in the onset level for physiological effects, but all were well above 203 dB re 1 µPa^2·s SEL_{cum} or levels well above the West Coast interim criteria.

6.1.1.3. Basic Background on Acoustics and Fish Bioacoustics

Sound in water follows the same physical principles as sound in air. The major difference is that due to the density of water, sound in water travels about 4.5 times faster than in air [(approx. 1,493.5 m/s vs. 335.3 m/s (4,900 ft/s vs. 1,100 ft/s)], and attenuates much less rapidly over distance from the source than in air. As a result of the greater speed, the wavelength of a particular sound frequency is about 4.5 times longer in water than in air (Rogers and Cox 1988; Bass and Clarke 2003).

The most commonly considered aspects of sound are frequency (i.e., number of cycles per unit of time, with hertz (Hz) as the unit of measurement) and amplitude (loudness, measured in decibels, or dB). The frequencies of primary relevance to humans are those in their hearing range, which is from about 20 Hz to 20,000 Hz in a child and perhaps 20 Hz to 10,000 Hz in an older adult. In considering fish, the hearing range to be considered may extend from below 20 Hz to, in most species, perhaps 800 to 1,000 Hz. Most fish in the Hudson River fit into this hearing range, although catfish may hear to about 3,000 or 4,000 Hz and some of the herring-like fishes in the genus *Alosa* (including the American shad) can hear to over 100,000 Hz (Popper et al. 2003; Bass and Ladich 2008; Popper and Schilt 2008).

A sound wave consists of both pressure and particle motion components that propagate from the source. All fishes have sensory systems to detect the particle motion component of a sound field, while fishes with a swim bladder (a chamber of air in the abdominal cavity) may also be able to detect the pressure component. Pressure detection is primarily found in fishes where the swim bladder (or other air chamber) lies very close to the ear, whereas fishes in which there is no air chamber near the ear primarily detect particle motion (Popper et al. 2003; Popper and Schilt 2009; Fay and Popper 2000).

6.1.1.4. Measuring the Energy in a Signal

The level of a sound in water can be expressed in several different ways, but always in terms of dB relative to 1 micro-Pascal (µPa). Decibels, a log scale, is used to “compress” very large differences of sound level (e.g., from a whisper to cracking of thunder) into more manageable numbers. As a consequence, a doubling of sound pressure level (whether in air or water) is seen as a change of just a few dB. Thus, each 10 dB increase is a ten-fold increase in sound pressure. Accordingly, a 10 dB increase is a 10x increase in sound pressure, and a 20 dB increase is a 100x increase in sound pressure.

For the purposes of this BA, the following measures are defined:

- Peak sound pressure level (SPL) is the maximum sound pressure level in a signal measured in dB re 1 µPa.

- Sound exposure level (SEL) is the integral of the squared sound pressure over the duration of the pulse – in this case a full pile driving strike. Measured in dB re 1 µPa^2·s.

- SEL_{cum} is the energy accumulated over multiple strikes. The rapidity with which the SEL_{cum} accumulates depends on the level of the single strike SEL (SEL_{ss}). The actual level of accumulated energy (SEL_{cum}) is the logarithmic sum of the total number of single strike SELs. Thus, SEL_{cum} (dB) = $SEL_{ss} + 10\log_{10}(N)$; where N is the number of strikes. A demonstration of how $SEL_{cum,}$ changes with an increasing number of strikes of a particular SEL_{ss} is depicted in **Figure 14.**

Sound levels are analyzed in several different ways. The most common approach is "root mean square" (rms) pressure level, which is the average level of a sound signal over a specific period of time, such as the average level 90% of the time of the whole signal as shown in **Figure 15**. Alternatively, one may measure "Peak" sound level, which is the highest level of sound within a signal (e.g., the highest point in Figure 15). Peak is most often used to give an indication of the maximum level of a sound, but it does not give a good picture of the overall sound energy in a signal.

Figure 15 shows an impulsive signal that is typical of a single strike from a pile driving operation. The frequencies in this sound are primarily below about 500 Hz. In order to attempt to better characterize the full extent of energy in the signal, acousticians developed the concept of Sound Exposure Level (SEL), which is simply the integration over time of the square of the acoustic pressure in the signal. Thus the SEL is an indication of the total acoustic energy received by an organism from a particular source (such as pile strikes).

SEL is generally expressed as the total energy in a signal over one second. There are two ways of looking at SEL that are relevant to the issue of pile driving. First is what is referred to as "single strike" SEL – the amount of energy in one strike of a pile (SEL_{ss}). The second is "cumulative SEL" (or SEL_{cum}), which represents the summed energy in all strikes over some period of time or, perhaps, during the driving of a single pile. SEL_{cum} is particularly useful since it is indicative of the total amount of energy to which an animal is exposed during any kind of signal (assuming the animal remains in the same place for the duration of the signal – such as for all strikes to embed a single pile). Consequently, SEL can be used compare total sound exposure between two signals with waveforms that are very different than one another, such as between a pile driving strike and the sound of a seismic air gun used in geologic exploration.

6.1.1.5. Sound and Effects on Fish

Sound is a critical source of environmental information for most vertebrates (e.g., Fay and Popper 2000). While we most often think in terms of sound for communication (e.g., speech), perhaps the most important use of sound is to learn about one's environment. Indeed, humans and all other vertebrates have auditory systems that listen to the "auditory scene" and can, from this, learn a great deal about the environment, and the things in it (Fay and Popper 2000; Bass and Ladich 2008). Although the comparable "visual scene" is restricted by the field of view of the eyes and light level, the auditory scene provides a three-dimensional, long distance sense that works under most all environmental conditions. It has, therefore, been proposed that hearing evolved for detection of the auditory scene (Fay and Popper 2000), and that fishes use sound to learn about their general environment, the presence of predators and prey, and, in many species, for acoustic communication. As a consequence, sound is important for fish survival, and anything that impedes the ability of fish to detect a biologically relevant sound could affect individual fish as well as survival of the population or species.

6.1.1.6. Potential Effects of Anthropogenic Sound on Fish

Richardson et al. (1995) defined different zones around a sound source that could result in different types of effects on fishes. As shown in **Figure 16**, there are a variety of different potential effects from any sound, with a decreasing range of effects at greater distances from the source. Thus, very close to the source, effects may range from mortality to behavioral changes. Somewhat further from the source, mortality is no longer an issue, and the effects range from physiological to behavioral. As one gets even further, the potential effects decline. The actual nature of effects, and the distance from the source will vary and depend on a large number of factors, such as fish hearing sensitivity, source level, how the sounds propagate away from the source, the sound level at the fish, whether the fish stays in the vicinity of the source, the motivation level of the fish, etc.

6.1.1.7. Sound Sources from Which Different Effects Might Occur

There are limited data from other projects to demonstrate the circumstances under which immediate mortality occurs as a result of pile driving: mortality appears to occur when fish are close [(within a meter to 9 m (a few ft to 30 ft)] to driving of relatively large diameter piles. Studies conducted by California Department of Transportation (e.g., Caltrans, 2001) showed some mortality for several different species of wild fish exposed to driving of steel pipe piles 2.4 m (8 ft) in diameter, whereas Ruggerone et al. (2008) found no mortality to caged yearling coho salmon (*Oncorhynchus kisutch*) placed as close as 0.6 m (2 ft) from a 0.45 m (1.5 ft) diameter pile and exposed to over 1,600 strikes. Thus, in the overall range of effects on fish in ecosystems such as the Tappan Zee, only a very small fraction of a fish population likely will be close enough to a pile to be subject to immediate mortality.

Of greater relevance than immediate mortality to aquatic organisms caused by pile driving and other intense sound sources is the potential for onset of physiological effects that could potentially result in delayed mortality. At the same time, many of the physiological effects of exposure to pile driving sound are highly unlikely to have any effect on fish survival. Indeed, the potential physiological effects are highly diverse, and range from very small ruptures of capillaries in fins (which are not likely to have any effect on fitness or survival) to severe hemorrhaging of major organ systems such as the liver, kidney, or brain (Stephenson et al. 2010). Other potential effects include rupture of the swim bladder (the bubble of air in the abdominal cavity of most fish species that is involved in maintenance of buoyancy). (See Halvorsen et al. 2011 for a review of potential injuries from pile driving.)

Effects on body tissues may result from barotrauma or result from rapid oscillations of air bubbles. Barotrauma occurs when there is a rapid change in pressure that directly affects the body gasses. Gas in the swim bladder, blood, and tissue of fish can experience a change in state, expand and contract during rapid pressure changes, which can lead to tissue damage and organ failure (Stephenson et al. 2010).

Related to this are changes that result from very rapid and substantial excursions (oscillations) of the walls of air-filled chambers, such as the swim bladder, striking near-by structures. By way of example, under normal circumstances the walls of the swim bladder do not move very far during changes in depth or when impinged upon by normal sounds. However, very intense sounds, and particularly those with very sharp onsets (referred to as “rise time”), will cause the swim bladder walls to move greater distances and thereby strike near-by tissues such as the kidney or liver. Rapid and frequent striking (as during one or more sound exposures) can result in bruising, and ultimately in damage, to the nearby tissues.

At the same time, there are data showing that very intense signals may not necessarily have substantial physiological effects and that the extent of effect will vary depending on a number of factors including sound level, rise time of the signal, duration of the signal, signal intensity, etc. For example, investigations on the effects of very high intensity low and mid-frequency sonars showed no damage whatsoever to ears and other tissues of several different fish species (Kane et al. 2010). Moreover, studies involving exposure of fish to sounds from seismic air guns, signal sources that have very sharp onset times, as found in pile driving, also did not result in any tissue damage (Popper et al. 2007; Song et al. 2008; although see McCauley et al. 2000, 2003 for an instance of inner ear hair cell damage to seismic air guns). Finally, recent studies of the effects of pile driving sounds on fish showed that there is a clear relationship between onset of physiological effects and single strike and cumulative sound exposure level, and that the initial effects are very small and would not harm an animal (and from which there is rapid and complete recovery), whereas the most intense signals (e.g., >210 dB SEL_{cum}) may result in tissue damage that could have long-term mortal effects (Halvorsen et al. 2011).

6.1.1.8. Results of Empirical Studies on Effects of Sound on Behavior

Results of empirical studies of hearing of fishes, amphibians, birds, and mammals (including humans), in general, show that behavioral responses vary substantially, even within a single species, depending on a wide range of factors, such as the motivation of an animal at a particular time, the nature of other activities that the animal is engaged in when it detects a new stimulus, the hearing capabilities of an animal or species, and numerous other factors (Brumm and Slabbekoorn 2005). Thus, it is difficult to assign a single criterion above which behavioral responses to noise would occur.

It is also critical to note that animals (and humans) generally do not respond to sounds that are minimally perceivable (whether there is background sound or not). Sounds generally have to be well above the minimal detectable level in order to elicit behavioral changes (Dooling et al. 2009). At the lowest sound levels, the animal may just ignore the sound since it is deemed to be unimportant or too distant to be of immediate relevance. It is only at larger sound levels where the animal becomes “aware” of the sound and may make a decision whether or not to behaviorally respond to the sound. In some cases, sounds may be “masked” by background noise of the same or similar frequencies (Bee and Swanson 2007). In this case, the masked sound could either be undetectable or less detectable than it would otherwise be under quieter conditions. In a natural setting, it is possible that the sound has to be sufficiently above the masked threshold of detection for the animal to be able to resolve the signal within the surrounding ambient noise and recognize the signal as being of biological relevance.

By way of example, in an experiment on responses of American shad to sounds produced by their predators (dolphins), it was found that if the predator sound is detectable, but not very loud, the shad will not respond (Plachta and Popper 2003). But, if the sound level is raised an additional 8 or 10 dB, the fish will turn and move away from the sound source. Finally, if the sound is made even louder, as if a predator were nearby, the American shad go into a frenzied series of motions that probably helps them avoid being caught. It was speculated by the researchers that the lowest sound levels were those recognized by the American shad as being from very distant predators, and thus, not worth a response. At somewhat higher levels, the shad recognized that the predator was closer and then started to swim away. Finally, the loudest sound was thought to indicate a very near-by predator, eliciting maximum response to avoid predation.

At the same time, there is evidence from a recent study in Norway (Doksaeter et al. 2009) that fishes will only respond to sounds that are of biological relevance to them. Doksaeter et al. (2009) showed no responses by free-swimming herring (*Clupea* spp.) when exposed to sonars produced by naval vessels. Similarly, sounds at the same received level produced by major predators of the herring (killer whales) elicited strong flight responses. These results were further substantiated in a more recent study from the same group using captive animals (Doksaeter et al., 2012).

Significantly, the sound levels at the fishes from the sonar in this experiment were from 197 dB to 209 dB re 1 µPa (rms) at 1,000 to 2,000Hz. The hearing threshold for herring that are most closely related to those used in the Doksaeter et al. (2009) study in this frequency range is about 125 to 135 dB re 1 µPa (also see Mann et al. 2005). This means that the fish showed no reactions to a sound that was up to 84 dB above the fish's hearing threshold (209 dB re 1 µPa sonar vs. 120 dB re 1 µPa threshold), but not biologically relevant to this species. More recently, Doksaeter et al. (2012) showed that caged herring showed no response to sonar (as in the earlier paper) or to the sounds of a frigate, but did show some responses to sounds from a motor boat.

There is not an extensive body of literature on effects of anthropogenic sounds on fish behavior, and even fewer studies on effects of pile driving (see Section 6.1.1.6 below), and many of these were conducted under conditions that make the interpretation of the results for this project uncertain. Of the studies available, the most useful in assessing the potential effects on behavior of pile driving on fish are those that use seismic air guns, since the air gun sound spectrum is reasonably similar to that of pile driving (Section 6.1.1.10). The results of the studies, summarized below, suggest that there is a potential for underwater sound of certain levels and frequencies to affect behavior of fish, but that it varies with fish species and the existing hydroacoustic environment. In addition, behavioral response may change over time as fish individuals habituate. Behavioral responses to other noise sources, such as noise associated with vessel traffic, and the results of noise deterrent studies, are also summarized below.

The vast majority of the (albeit limited) behavioral studies to date, discussed below, suggest that there is not likely to be any adverse behavioral response from sturgeons, or any fish species, at sound levels as low as 150 dB re 1 µPa. However, in order to ensure that there is limited effect at this level, or even at higher sound levels, the project will maintain a corridor where ensonification due to pile driving is below the 150dB rms SPL behavioral guidance level suggested by NMFS (Figs 16-19). Therefore, the project would minimize the potential for the project to impede movement of fish in the Hudson River. Moreover, and perhaps of even greater significance in ensuring minimal or no behavioral impacts on sturgeon is the fact that the duration of pile driving will be only be during about 7% of the total duration of bridge construction. Combining this with the efforts to ensure a corridor where sounds will be below 150 dB re 1 µPa (rms) during pile driving should minimize any chance of behavioral impacts on sturgeons.

6.1.1.9. Behavioral Studies Using Pile Driving (or Pile Driving-Like) Sounds

There have been very few studies that have examined behavioral effects, including avoidance behavior, of pile driving on fish. Most of these studies, as reviewed by Popper and Hastings (2009), were in small cages where behavior is severely constrained and so would not be representative of a natural setting. In order for the results of an empirical study to be relevant to an assessment of the potential for pile driving, or other anthropogenic stimuli, to affect fish and other aquatic biota, such study must examine free-swimming wild animals.

While not done on free-swimming animals, Mueller-Blenke et al. (2010), in an unpublished report that has not been peer reviewed, attempted to evaluate response of Atlantic cod (*Gadus morhua*) and Dover sole (*Solea solea*) in large pens to playbacks of pile driving sounds recorded during construction of Danish wind farms. The investigators reported that a few representatives of both species exhibited some movement response, which they claim to have represented increased swimming speed or freezing to the pile-driving stimulus at peak sound pressure levels ranging from 144 to 156 dB re 1 µPa for sole and 140 to 161 dB re 1 µPa for cod. However, with the methodology used it was impossible to determine fish position more frequently than once every 80 seconds, and so, despite the suggestions of behavioral responses by the investigators, it was scientifically impossible to know if, and how, fish were moving or otherwise responding to the sound. Moreover, even in the few times that the investigators could glean information that suggested that fish moved from one place in the pen to another during sound presentation, this was only for very few fish, and it is not even clear that the authors interpretation of these results were correct since several alternative interpretations are possible from the very limited data. Finally, the statistical analysis of the results was very limited, and could not be used to document any behavioral responses by any animals.

Feist (1991) examined the responses of juvenile pink (*Oncorhyncus gorbuscha*) and chum (*O. keta*) salmon behavior during pile driving operations. Feist had observers watching fish schools in less than 1.5 m water depth and within 2 m of the shore over the course of a pile driving operation. The report (Feist's MS thesis) did not give pile size, other than to say that one was hollow steel and the other solid. While sound measurements were attempted, data were not available for this publication according to the author, thus none of the limited results can be correlated with sound levels from the pile driving operation. Feist did report that there were changes in distribution of schools at up to 300 m from the pile driving operation, but that of the 973 schools observed, only one showed any overt startle or escape reaction to the onset of a pile strike. Moreover, there was no statistical difference in the number of schools in the area on days with and without pile driving, although other behaviors changed somewhat. However, without data on sound levels, it is impossible to use the Feist data to help understand how fish would respond to pile driving and whether such sounds could result in avoidance or other behaviors. Indeed, one interesting observation, though in need of quantification and correlation with sound levels, is that the size of the stocks of salmon never changed, but appeared to be transient, suggesting that normal fish behavior of moving through the study area used was taking place no differently during pile driving operations and in quiet periods. These results, albeit very limited, suggest that at least these species of salmon are not avoiding pile driving operations.

6.1.1.10. Field Studies of Effects of Seismic Air Guns on Behavior

Aside from the few studies that have examined the effects of pile-driving noise on fishes, a number of additional studies have examined the effects of other anthropogenic impulsive sounds on fish with sound spectrums and rise time similar to those generated by pile driving, such as seismic air guns and have generally shown that there is no onset of behavioral responses, including startle responses until the sounds are well above 150 dB re 1 µPa (rms).

The seismic studies are of some use in helping understand potential effects on fish since the sound produced by seismic air guns is similar to that produced by a pile-driving strike in terms of the length of time to reach peak amplitude and the component of the sound most likely to elicit a startle response. Because the rise time of the signal for seismic air guns is even sharper for seismic air guns than for pile driving, noise generated by seismic air guns has the potential to be more behaviorally and physiologically disturbing to fish than pile driving.

In an evaluation of the behavior of free-swimming fishes to noise from seismic air guns, fish movement (e.g., swimming direction or speed) was observed in the Mackenzie River (Northwest Territories, Canada) using sonar. Fishes did not exhibit a noticeable response even when sound exposure levels (single discharge) were on the order of 175 dB re 1 $\mu Pa^2 \cdot s$ and peak levels over 200 dB re 1 µPa (Jorgenson and Gyselman, 2009).

Wardle et al. (2001) observed very minor behavioral responses to the air gun emissions (most often very brief startle responses) and no permanent changes in the behavior throughout the course of the study in response to peak sound levels of 210 dB re 1 µPa at 16 meters (52.5 ft) and 195 dB re 1 µPa at 109 meters (358 ft) from the source. Moreover, no animals appeared to leave the reef during noise production. Temporary changes in fish catch, and thus presumably in behavior, in response to exposure to seismic air guns were reported in Engås et al. (1996), Engås and Løkkeborg (2002), Slotte et al. (2004), and Løkkeborg et al. (2012) although the level of sound received by fish was not reported. In other studies that looked at catch rate, Skalski et al. (1992) showed a 52 percent decrease in rockfish (*Sebastes* sp.) catch when the area of catch was exposed to a emissions of a seismic air gun at 186-191 dB re 1 µPa (mean peak level). The results also suggested that rockfish would show a startle response to sounds as low as 160 dB (re 1 µPa), but this sound level did not appear to elicit a decline in catch.

McCauley et al. (2000) examined the effects of seismic air guns on caged pink snapper (*Pagrus auratus* Forster) (this work has recently been published in Fewtrell and McCauley, 2012). Fish were caged and exposed to hundreds of emissions from an air gun as it approached and moved over and beyond the cage for approximately 1.5 hours. Received SEL exceeded 180 dB re 1 $\mu Pa^2 \cdot s$ for several of the shots. Startle responses, when they occurred, were elicited by sound levels greater than 156-161 dB re 1 µPa. In addition to the startle response, some individuals moved from the bottom of the cage, possibly to areas of lower sound levels. Behavior of individuals that did respond to the seismic sounds returned to normal within 14 to 30 minutes of cessation of seismic exposure and those individuals exhibited no long-term physiological or behavioral effects. (McCauley et al. 2003). Fish were also reported to habituate to the seismic air gun (McCauley et al. 2000), which means that after some amount of exposure, fish will no longer pay attention to the sound and the sound will have no further affect on behavior.

In an evaluation of the effects of a seismic survey on wild and caged fish of various species inside of Scotts Reef Lagoon in Western Australia, McCauley et al. (2008) observed some startle responses and small levels of movement in fishes exposed to sound exposure levels (single sound) of about 145-155 dB re $1uPa^2$-s.

6.1.1.11. Behavioral Responses to Other Sound Sources

Noise from construction vessels also has the potential to affect fish behavior. Using divers to observe behavioral responses of bluefin tuna (*Thunnus thynnus*) in large in-ocean cages (approximately 70 meters square opening and 30 meters deep) to passing boats, Sarà et al. (2007) documented changes in the depth, location and swimming patterns of the tuna school in the presence of sounds from approaching ferries and hydrofoils. However, the authors did not provide sound levels received by the fish.

Two recent studies suggest that fish will show behavioral responses to sounds far below 150 dB re 1 µPa (rms). However, both studies were conducted on fish within small tanks with the underwater sound source located close by, an experimental setup which would have exposed the test subjects to both sound pressure and particle motion components of the sound field, although only the sound pressure was measured. Since all of the fish in both studies are very likely to be most responsive to particle motion and not pressure, and since particle motion was not measured, it is impossible to know to which aspect of the signal the fish were responding. Indeed, due to tank acoustics it is very highly likely that there the fish were exposed to very large particle motion signals (Parvulescu, 1967), and any behavioral responses were associated with that component of the sound.

In one study, signals recorded from the operation of wind farms were found to temporarily alter the behavior of roach (*Rutilus rutilus*) and three-spined sticklebacks (*Gasterosteus aculeatus*) (Andersson et al. 2007). The reported sound pressure levels eliciting responses were from 80 to 120 dB re 1 µPa (rms), although, as indicated above, particle motion, the actual stimulus that the fish could detect, was not measured. Similarly, Purser and Radford (2011) also examined the behavioral response (e.g., startle response and foraging behavior) of three-spined sticklebacks to short (10-sec) and long (300-sec) sounds. Fish showed an increased level of startle response and poorer foraging behavior at sound levels of about 150 dB re 1 µPa. Again, however, particle motion, the likely stimulus for both species in this small tank, was not measured or reported.

A nine-month long study by Wysocki et al. (2007) demonstrated that continuous exposure to sounds at 150 dB re 1 µPa produced no behavioral responses in rainbow trout, and no indications whatsoever of effects on stress levels, growth, or feeding. Turnpenny et al. (1994), in an unpublished report, examined the behavior of three species of fish in a pool in response to different sounds and reported avoidance behavior at certain levels of pure-tone test frequencies. However, due to poor experimental design and substantial errors in acoustics, the results of this study are impossible to interpret because of lack of calibration of the sound field at different frequencies and depths of the tanks, and due to other problems with experimental design (see comments on this study by Popper and Hastings 2009).

Studies that examined the effectiveness of underwater sound to deter fish from entering an area (e.g., dam spillways, or irrigation ditches, power plant intakes) suggest that fish will not change movement or show avoidance when sound is used as a potential fish deterrence (reviewed in VanDerwalker 1967; Popper and Carlson 1998). The exception was a study by Maes et al. (2004), who used a sound deterrent system from 20 to 600 Hz to control the movement of some clupeid fishes (*Alosa* spp.) in an attempt to deter fish from the water intake of a nuclear power plant. Fishes without swim bladders, and others that are thought to have poor hearing (e.g., sticklebacks) were not deterred by the sound. In contrast, fish with presumably better hearing capabilities (clupeids) were deterred to some degree by the sound, although there are no data on received sound levels. Moreover, this work has not been replicated. In contrast, Ploskey et al. (2000), in a very well designed study, investigated the responses of a number of schools of different juvenile salmonid species near the Bonneville Dam on the Columbia River to sounds that ramped up and down in intensity from silent to 160 dB re 1 µPa every two seconds. Only one of over 100 schools of fish exhibited a short startle response, but no individuals were deterred from the vicinity of the dam or altered their behaviors in a way that differed from the control fish, thereby indicating no avoidance of the sound.

6.1.1.12. Behavioral Responses of Sturgeon to Pile Driving

The question remains as to how sturgeon will respond behaviorally to pile driving sounds generated during bridge construction. It has been demonstrated that sturgeons have small swim bladders (Beregi et al. 2001). This finding, along with studies of hearing in sturgeon, suggests the idea that these fish are likely to primarily detect particle motion (see Lovell et al. 2005; Meyer et al. 2010, 2012, discussed below). Accordingly, the low particle motion component of signals likely to arise from pile driving suggest that these species, like flatfish and other fishes with swim bladders far removed from the ear, are less likely to hear such sounds unless they are very close to the sound source.

While there are no data for hearing by either species of sturgeon in the Hudson River, there are data for the closely related lake sturgeon (*Acipenser fulvescens*), both in terms of hearing sensitivity and structure of the auditory system (Lovell et al. 2005; Meyer et al. 2010, 2012). The data suggest that lake sturgeon can hear sounds from below 100 Hz to about 500 Hz (Lovell et al. 2005); while Meyer et al. (2010) reported evidence to suggest that the same species may hear up to 800 Hz. These data also demonstrate that sturgeon are not sensitive to sound pressure, but, instead, that they primarily detect the particle motion component of a sound field (Lovell et al. 2005; Meyer et al. 2010).

Based on the known hearing capabilities of sturgeon and the findings that they are primarily detectors of particle motion rather than changes in pressure, it is difficult to use pressure as a measure for potential behavioral impacts on sturgeon (e.g., 150 dB re 1 µPa rms). Indeed, as pointed out by Lovell et al. (2005), since sturgeon are primarily (and perhaps only) sensitive to particle motion, it will take a much higher level of signal (with much higher sound pressures) to elicit behavioral responses from sturgeon than from fish that are primarily pressure sensitive.

6.1.1.12.1. Sturgeon Behavior at 150 dB re 1 µPa rms

There are no data to indicate how sturgeon will behave in response to sound pressure at the NMFS criterion level. However, even if one makes the assumption that sturgeon do detect pressure signals, the likelihood of a behavioral response, such as avoidance or startle, at 150 dB re 1 µPa rms is very low when one takes into consideration the data presented above regarding known behavioral responses of fish. In all cases, other than in the acoustically flawed studies by Purser and Radford (2011) and Andersson et al. (2007) (discussed above), fish show no responses to sounds at 150 dB re 1 µPa rms. Other studies show small responses at substantially higher sound levels to which fish either habituate or from which they recover shortly after the end of exposure (e.g., McCauley et al. 2000, 2008; Fewtrell and McCauley, 2012; Wardle et al. 2001). In some cases, no response has been observed even at sound levels substantially higher than 150 dB re 1 µPa (e.g., Jorgensen and Gyselman (2009)). The rms (root mean square) which is being used to evaluate behavioral effects represents an average pressure over time and is different than the interim West Coast criterion of 206 dB re 1 µPa for peak SPL, which is indicative of the highest sound level in a signal (Figure 15).

It is also worth noting that, in using the modeled isopleths of areas in which 150 dB re 1 µPa rms would result from pile driving (**Figures 17-20**), these sounds may not be detectable to fish if there is any masking from other ambient noises, such as those produced by the river, boats, and other non-project related sources (e.g., traffic on the current bridge, the railway along the shore of the Hudson River). As a consequence, even though the 150 dB re 1 µPa isopleth from driving a 3-m (10-ft) pile (assuming a 10 dB reduction from noise attenuation measures) is considerable in the east-west direction, masking would mean that the sound is not perceived by the fish as being 150 dB re 1 µPa until the actual sound level (without the presence of a masker) is approximately 5-10 dB higher.

It is likely that sturgeon will not show any adverse behavioral response to sounds at 150 dB re 1 µPa, which enlarges the potential migration corridors available to them during the construction. It is conceivable that sound levels well above the 150 dB re 1 µPa could potentially cause sturgeons to change behaviors, ranging from just halting movement to their turning away from the source. In many cases the changes in movement are likely to result in sturgeon quickly moving to a region of lower sound levels in the river, at which time they will continue with their original migratory movement through the corridor. In other cases, it is possible that the sturgeon will stop migratory movements, as if the sounds were a physical barrier and then resume movement once the sound stops.

There is no pile-driving produced by impact hammering over approximately 93% of the project duration. Thus, few fish would ever encounter an acoustic “barrier” and, even then, they would only be “delayed” for the very small amount of time that the sound is present. Once the sound ceases, the fish will continue in their normal pathway since the “drive” to reach spawning or feeding grounds is generally very high in animals. (e.g., salmon and American shad are very well known to overcome considerable barriers to get to spawning sites, and it is likely that the same applies for other anadromous species in the Hudson River, such as Atlantic and shortnose sturgeon).

6.1.1.13. Affected Area and Potential Physiological Effects based on Modeled Pile Driving

In order to analyze the potential impacts of the project’s pile driving on Hudson River aquatic resources, the likely hydroacoustic scale of pile driving was modeled (JASCO 2011a). The extent of the sound pattern generated by pile driving for the Project was determined by application of three different sound propagation modeling approaches (i.e., MONM, VSTACK, and FWRAM). The models account for the frequency composition of the source signal and the physics of acoustic propagation in the Hudson River and underlying geological substrate. This type of modeling differs from generalized and empirical acoustic models, such as “practical spreading loss” models (Caltrans, 2009), that do not take into full account the source characteristics or the many site-specific factors that could influence the rate of noise transmission such as water depth and substrate transmission characteristics.

Various pile driving scenarios were used to generate the cumulative sound exposure level (SEL_{cum}) for each day over the construction period. Maximum and typical pile driving scenarios were analyzed. In addition, the application of Best Management Practices (BMPs) that provided a 10 dB reduction in sound was incorporated into the acoustic modeling effort. These practices represent various methods to reduce the extent to which a waterbody would be ensonified by pile driving operations. Various BMPs have been employed on pile driving operations around the country, including air bubble curtains of various forms, isolation casings, Gunderbooms, and dewatered cofferdams. The Project Sponsors have committed to the use of BMPs to attenuate the potential impacts of sound associated with pile driving.

Figure 21 presents the peak SPL, with BMPs, for 4-, 6-, 8-, and 10-ft piles being driven at representative locations along the alignment of the replacement bridge. The figure illustrates the transmission loss that would occur as distance from the pile driving site increases. Transmission loss is not uniform across the different size piles since the piles would be driven at locations where water depth and other environmental factors vary. For the 4-ft piles, sound above the interim 206 dB peak threshold encompasses a distance of about 30 ft; for the 10-ft piles the 206 dB peak SPL the distance increases to approximately 300 ft.

The following figures present accumulated energy (SEL_{cum}) for driving a pile over the time for driving the pile and should be understood that way. Thus, the information in these figures does *not* represent the energy from a single strike or the instantaneous level of sound at any one moment in time (as represented for peak levels in Figure 21). Instead, it represents the final energy, accumulated over time, of a large number of strikes with a particular SEL_{ss}. Moreover, the accumulated energy in the following figures represents the received energy for an animal *only* if the animal stays in the same location for the duration of the pile driving activity. Since sturgeon are likely to move out of the ensonified zone during the duration of the pile driving, the accumulated energy received by the fish is likely to be considerably less than indicated by an analysis based on the modeled isopleths.

It should also be understood that the expression SEL_{cum} represents the total energy at a particular location in the river for a discrete duration associated with a particular pile driving operation. Often, this represents the duration for the full driving of a single pile, or even for multiple piles if driven in a single day (if a pile is driven over two days, there is a "resetting" of the SEL_{cum} after 12 hours and accumulation starts again (Carlson et al. 2007; Stadler and Woodbury 2009). It is important to note that it is highly unlikely that a fish would be exposed to the full SEL_{cum} of a pile driving operation since that could only occur if the fish stays in place and exhibits no swimming behaviors (including behavioral response to the pile driving sounds) for the duration of the pile driving operation. Thus, the scenario with fish receiving a full accumulated exposure to any pile driving is highly unlikely and conservative for sturgeon in the Hudson River. This limitation of exposure to the full SEL_{cum} and the likely avoidance of fish was acknowledged by NMFS (2012) in their assessment of potential effects of the pile driving associating with the Pile Demonstration Installation Project (PIDP).

Figure 22 presents the SEL_{cum} that results for simultaneously installing two 10-ft piles at the replacement bridge main span over the number of strikes that are predicted to be needed to fully seat the piles. The proposed schedule for concurrent placement of two 10-ft piles would be the same for both the Short and Long Span Options. The concentric "circles" (or isopleths) of different colors represent distances from the pile driving activity at which various accumulated sound energy levels (SEL_{cum}) would be reached over the duration of driving of the two piles. For example, the 187 dB isopleths extends over a mile in each direction north and south of the point of pile driving and 49% of the cross sectional width of the river. This can be contrasted with the 187 dB re 1 $\mu Pa^2 \cdot s$ isopleth profile for installing four 4-ft piles at the replacement bridge main span in one day, which does not extend substantial distances in any direction (see **Figure 23**).

Figure 24 indicates the cross sectional area of the river that would be reach an accumulated sound level of 187 dB re 1 $\mu Pa^2 \cdot s$ over the duration of the construction period for the Short Span Option, and assumes a BMP reduction of 10 dB. During the period of driving the 10 foot piles, 49% of the river cross sectional width would be within the SEL_{cum} 187 dB re 1 $\mu Pa^2 \cdot s$ isopleth. Similarly, the ensonified area would be between 43 and 61% during the four-month period when 4, 6, and 8 ft piles are all being driven, sometimes simultaneously. The figure indicates that driving of the 10 and 8 ft piles would take place in the first few months of the first year of construction, limiting the period of time of greatest potential effects, During the remaining years of the construction period, the affected cross section of the river is considerably less, on the order of 14 to 38%. Given that the river is approximately 3 miles wide, there would always be a considerable portion that remains below the threshold noise criteria, thereby insuring adequate corridors for migration and movement of sturgeon and other fish species through the region. Moreover, even within the construction periods, there will only be sounds during daily construction activity and not at night or on weekends, thereby bringing the actual time of ensonificiation to only a small portion of each day or week. **Figure 25** indicates the cross sectional area of the river that would be ensonified to the SEL_{cum} 187 dB re 1 µPa^2·s isopleths over the duration of the construction period for the Long Span Option.

For all of the pile driving scenarios modeled, including those in which the maximum numbers of simultaneous piles are being driven and/or for the largest piles, a substantial portion of the Hudson River's width never reaches the SEL_{cum} criterion established for onset of physiological effects. Furthermore, even within a single day of operations (assuming up to a 12 hour day), there will be no pile driving activity for a most of the day, due to activities such as placing and welding of piles, or relocation of pile driving machinery. Thus, fish in much of the river will not be exposed to pile driving sounds of sufficient magnitude or for significant periods, and the likelihood of accumulating sufficient energy (SEL_{cum}) to result in onset of physiological effects is low. Finally, as stated above, fish are not likely to remain in an area at which noise (from pile driving or other source) would cause discomfort and so they are likely to move away from areas that could have higher accumulated sound exposure levels.

Finally, it is worth repeating that caution must be used when interpreting the model's results that present SEL_{cum} at different locations relative to the pile driving because the model strictly is in terms of sound levels and does not take into consideration any behavioral responses of fish that would result in their leaving the site of maximum ensonification and thereby not being exposed to SEL_{cum} levels that would result in onset of physiological effects. Furthermore, data from Halvorsen et al. (2011) demonstrate that SEL_{cum} has to be substantially above the minimum level that would result in onset of low levels of physiological effects to start to potentially impact fitness, and even more above the minimal level to potentially result in mortality. Thus, for example, Chinook salmon exhibit some minor effects that are not considered to impact fitness at a SEL_{cum} at about 210 dB re 1 µPa^2·s, but it is not until the levels reach 216 – 219 dB re 1 µPa^2·s that injuries become potentially fatal (Halvorsen et al. 2011).

6.1.1.14. Measures for Minimizing Potential Effects of Pile Driving and Estimating Numbers of Shortnose Sturgeon Potentially Affected

Shortnose and Atlantic sturgeon are likely to be present in the Tappan Zee Reach throughout the construction period. If an individual fish occurs within an area(s) ensonified over Peak 206 dB re 1 µPa for a single strike or 187 dB re 1 µPa^2·s for accumulated energy (SEL_{cum},) there is the potential for the onset of physiological effects, though at these levels the likelihood would be that there would be no loss of fitness. While the areas that may be ensonified by the pile driving are not spawning grounds for any either sturgeon species, they are used for foraging and transit during migrations up and down the river. Thus, pile driving represents a potential risk to juvenile and adult life stages of shortnose and Atlantic sturgeon.

Fish that may be close to the piles during a pile driving operation are going to be exposed to single strike sound levels that are above the interim criteria defined above (e.g., 206 dB re 1 µPa peak), and there is a possibility of injury to these individual animals. However, methods have been tested that suggest, albeit with limited data, that fish move from the vicinity of pile driving prior to the onset of maximum strikes. For example, during the construction of the Woodrow Wilson Bridge over the Potomac River, there is evidence that tapping the pile with lower energy for the first few strikes may cause fish to move away from the piles before full operations begin (FHWA 2003). Reports from the Woodrow Wilson Bridge construction indicated that in some cases this kind of ramp-up procedure substantially decreased mortality; however, it is appropriate to acknowledge that these findings were anecdotal and were not part of scientifically controlled studies.

Pile driving in the warmer months of the year could expose sturgeon to potential effects as they use the project vicinity as a foraging area, but sturgeon would likely leave an area ensonified above the above Peak 206 dB or 187 dB SEL_{cum} from pile driving operations if such sounds caused discomfort or "frightened" the fish. On days when pile driving occurs during migration periods, a substantial portion of the cross section of the Hudson River would not be ensonified with sound energy of greater than 187 dB (**Figures 24** and **25**). Importantly, for a period of 12 hours or more each day there would be no pile driving activities and pile driving is anticipated to occur for no more than five days a week. Thus, the majority of time each week the river would experience no sound energy above normal ambient levels, and pile driving activities would not represent a barrier to upriver or downriver movement of sturgeon, or to foraging.

To the extent possible, a vibratory hammer, which produces 10 to 20 dB lower noise levels than an impact hammer (Caltrans 2009), would be used to drive the piles. Moreover, a number of Environmental Protection commitments (EPCs) are being implemented by the Project to reduce the potential for pile driving associated injury to shortnose and Atlantic sturgeon and other aquatic species. These measures were enumerated in Section 4.2.4 Substructure Construction:

6.1.1.15. Methods for Estimating the Potential Number of Shortnose Sturgeon Affected by the Pile Driving

Using fish abundance estimates from a 1-year comprehensive gill-net sampling study, the encounter rate of shortnose sturgeon in the study area was estimated as the number of shortnose sturgeon collected per gill net per hour. From June 2007 – May 2008, 476 gill nets were deployed just upstream of the existing Tappan Zee Bridge (and within the study area) for a total sampling time of 679 hours. Sampling was conducted approximately bimonthly from April 2007 to May 2008. During this time, 12 shortnose sturgeon were collected: 7 in September and October, 4 in May and June and 1 in August, and none in December or February. Based on the observed number of sturgeon collected over 679 gill-net hours, the encounter rate for shortnose sturgeon in the proposed bridge replacement area is 0.033 sturgeon encountered per hour of sampling. This encounter rate was calculated assuming that two of the five panels of the gill net (i.e. the one and two inch mesh sizes) were too small to effectively collect shortnose sturgeon.

To estimate the potential number of shortnose sturgeon affected by pile driving activities, it was necessary to scale gill-net encounter rates from a single gill-net sample (the gill net is 125 ft in length) to the area encompassed by the isopleth bounding the SEL_{cum} of 187 dB re 1 $\mu Pa^2 \cdot s$ (e.g. **Figures 22** to **23**; JASCO 2011a). The SEL_{cum} of 187 dB re 1 $\mu Pa^2 \cdot s$, which is the NMFS interim threshold measure for onset of physiological effects to fish was used to determine the number of shortnose sturgeon that would have been collected if multiple gill nets were deployed side-by-side across the width of the 187 dB re 1 $\mu Pa^2 \cdot s$ isopleth. For the Short Span Option the width of the 187 dB isopleth for the pile sizes ranges from 310.9 m to 2,841.9 m (1,020 ft to 9,324 ft), depending on the size of the pile, or combination of pile sizes being driven (see **Table 5**). However, for about 80% of the weeks that construction will be ongoing, the width of the isopleths will be 1,066.8 m (3,500 ft) or less. For the Long Span Option the width of the 187 dB isopleth for the pile sizes ranges from 359 m to 2,427.7 m (1,178 ft to 7,965 ft), depending on the size of the pile, or combination of pile sizes being driven (see **Table 6**). For 80% of the weeks that construction will be ongoing for the Long Span Option, the width of the isopleths will be 1,191.8 m (3,910 ft) or less.

Movement by shortnose sturgeon has been shown to be strongly oriented directly with or against the river currents (McCleave et al. 1977; Richmond and Kynard 1995). This is supported by data collected during the 2007-2008 gill net study, in which shortnose sturgeon were collected with greater frequency in gill nets deployed across the river current vs. with the current. Based on these results, it can be assumed that sturgeon move in an upstream or downstream direction through the study area and at a constant rate and would thus be intercepted by gill nets spanning the width of the noise isopleth. It was also assumed that catch rates are proportional to shortnose sturgeon abundance, since this is a central assumption of most fish-sampling gears, and that sturgeon were uniformly distributed throughout the Tappan Zee region. Under these assumptions, each gill net would encounter shortnose sturgeon at the same rate allowing the estimates of sturgeon number to be scaled to the width of the isopleth.

6.1.1.16. Approach to Estimating Effects on Sturgeon

The current NMFS west coast criteria stipulates that the onset of physiological effects occurs at an SEL_{cum} of 187 dB re 1μPa^2•s. Furthermore, in the recent PIDP BO, NMFS stated this level as being one at which there are no impacts on sturgeon that impact fitness. Moreover, recent studies on Chinook salmon (Halvorsen et al. 2011) show that there are no effects at all on fish at an SEL_{cum} of well over 203 dB re 1μPa^2•s.[1] These data also show that onset of physiological effects in Chinook salmon occurs at about 210 dB re 1μPa^2•s, but the effects at this level are not likely to affect fitness. It is only until SEL_{cum} gets close to 216 dB re 1μPa^2•s that potentially harmful effects start to be encountered.

Based on the recent pile driving studies and discussions with NMFS, it is proposed that there are three hierarchical SEL_{cums} in determining numbers of animals potentially taken as a result of pile driving. These three levels are highly conservative, even in light of the Halvorsen et al. (2011) data. Each level is associated with an increasing effect level. (1) Level for potential onset of physiological effects without any impact on fitness - 187 dB re 1μPa^2•s, (2) potential onset of recoverable physical injury such as external tissue effects, e.g., minor hemorrhage - 197 dB re 1μPa^2•s, and (3) potential onset of mortal injuries - 207 dB re 1μPa^2•s.

The rationale for these levels is as follows. The selection of an SEL_{cum} of 187 dB re 1μPa^2•s is based on current West Coast criteria. This value is, as discussed above, used in determination of the areas around pile driving at which fish have the potential to have the start of physiological effects, but without any changes in fitness. The SEL_{cum} of 197 dB re 1μPa^2•s, is 10 times the lower level and still 13 dB lower than the level that Halvorsen et al. (2011) showed to be the onset of minor physiological effects that are likely not to result in changes in fitness. Finally, the SEL_{cum} of 207 dB re 1μPa^2•s, is 100 times greater energy than the current criteria and yet still well below the actual results from Halvorsen et al. (2011) and others for the onset of mortality.

[1] The value for Chinook salmon is actually an SEL_{cum} of 210 dB, but the level for other species varies by a few dB and so the 203 dB value is used here to be very conservative and consider the potential "worst case" for onset of physiological effects until even more data are available.

6.1.1.17. Estimated Number of Shortnose Sturgeon Potentially Affected by the Replacement Bridge Alternative

Tables 5 and 6 provide a summary of the number of shortnose sturgeon potentially exposed to the pile driving at various locations with BMPs providing a reduction of 10 dB. Based on this approach, 796 shortnose sturgeon have the potential to be exposed to an SEL_{cum} of 187 dB re 1 µPa^2·s over the project duration for the Short Span Option (see **Table 5**). Similarly, 603 sturgeon have the potential to be exposed to an SEL_{cum} of 187 dB over the project duration for the Long Span Option (**Table 6**). Assuming 61,057 as a population estimate for shortnose sturgeon in the Hudson River and assuming that this number remains static for the duration of the pile-driving activities, the Short Span Option has the potential to expose 325 fish (0.5% of the shortnose sturgeon population) and the Long Span Option has the potential to expose 245 fish (0.4% of the shortnose surgeon population) to SEL_{cum} of 187 dB re 1 µPa^2·s (potential onset of physiological effects) in the year of maximum impact. Potential effects to shortnose sturgeon would be considerably less during the remaining years of construction (**Tables 5 and 6**). At higher noise levels, a total of 298 shortnose sturgeon would be subject to the 197 dB re 1µPa^2•s SEL_{cum} ensonified area (potential onset of recoverable injury) for the Short Span and 218 shortnose sturgeon for the Long Span Option. The number of shortnose sturgeon that would encounter the 207 dB re 1µPa^2•s SELcum ensonified area (potential onset of mortality) during the course of the construction period was 89 sturgeon for the Short Span Option and 67 sturgeon for the Long Span Option (**Table 7**).

For the entire construction period, 1.3% and 1.0% of the population estimate of shortnose sturgeon would potentially be exposed to pile-driving signals that exceed 187 dB re 1 µPa^2·s (**Tables 5 and 6**). These estimates of population exposure represent a conservative maximum because they indicate the encounter rate within the isopleths over several years, and some fraction of that total number of sturgeon would be encountered more than once (e.g., they would be double counted) without having experienced the necessary sound for the onset of physiological effects or recoverable injury.

6.1.1.18. Estimated Number of Atlantic Sturgeon Potentially Affected by the Replacement Bridge Alternative

Since the gill-net sampling program that was conducted between 2007 and 2008 did not catch any Atlantic sturgeon, an alternative analysis approach which relied on the Utilities Fall Shoals monitoring data and published estimates of spawning adults in the Hudson River was conducted to assess the potential risk of pile driving to this species. In order to determine the number of Atlantic sturgeon potentially affected, it was first necessary to estimate the number of juvenile and spawning adult Atlantic sturgeon in the Hudson River. The analysis consisted of the following steps:

- Determine the efficiency of the gear used in the Fall Shoals Program for catching juvenile Atlantic sturgeon,
- Develop a population estimate for juvenile Atlantic sturgeon,
- Estimate abundance of juvenile Atlantic sturgeon in the ensonified area,
- Estimate abundance of adult Atlantic sturgeon in the ensonified area.

6.1.1.18.1. Gear Efficiency

In referring to the Utilities Fall Shoals Program, NMFS (2012) on page 64 of the Biological Opinion for the PIDP stated,

> "If we had information on the differential gear selectivity for shortnose vs. Atlantic sturgeon we may able to use the ratio of shortnose to Atlantic captured in these studies to determine how many fewer Atlantic sturgeon than shortnose sturgeon we anticipate in the action area."

The first step of the analysis to accomplish this goal was to compare the size distribution of shortnose and Atlantic sturgeon collected by the Fall Shoals sampling gear (3-m beam trawl) in an extended data set. Based on the similar size distribution of Atlantic (51 – 952-mm total length (TL)) and shortnose sturgeon (75 – 928-mm TL) collected in the Fall Shoals Program between 1998-2007, it was assumed that gear efficiency is similar for both species within the size range collected (i.e., <1,000 mm TL). Because of the lack of population-size estimates for Atlantic sturgeon and the similarities in body size and overlapping habitat use between both sturgeon species during the riverine occupancy (Bain 1997), the population estimate developed by Bain et al. (1998, 2007) for shortnose sturgeon was used to develop a gear-efficiency correction factor for the 3-m beam trawl used to sample sturgeon abundance as part of the Utilities fish sampling program. The population estimate of 61,057 from Bain et al. (1998, 2007) is considered an accurate estimate for shortnose sturgeon as it is based on mark-recapture studies in which the size of the sample population (i.e., tagged fish) is known. The standing crop estimate for shortnose sturgeon using Fall Shoals data (unadjusted for gear efficiency) from the same time period (1994-1997) as the Bain studies were performed was 27,534 fish. The percentage of adult shortnose sturgeon (≥550-mm TL) represented by Bain et al.'s (1998, 2007) estimate was 93%, with the remaining 7% represented by juveniles (<550-mm TL). Similarly, 90% of the shortnose sturgeon collected during the Fall Shoals survey between 1994-1997 were adults, with the remaining 10% in the size range of juveniles (<550 mm TL).

Gear efficiency was then estimated for both size classes of shortnose sturgeon (<550-mm TL and ≥550-mm TL) by dividing the juvenile and adult proportions of the Fall Shoals standing crop estimate (2,753 and 24,781, respectively) by the same proportions of the Bain et al. (1997) population estimate (4,274 and 56,783, respectively). The resulting gear-efficiency correction factors were 64% for sturgeon <550-mm TL and 44% for sturgeon between 550-1,000-mm TL.

6.1.1.18.2. Estimated Population Size for Juvenile Atlantic Sturgeon (1998-2007)

The standing crop estimate (unadjusted for gear efficiency) for riverine juvenile Atlantic sturgeon (<1,000-mm TL) was calculated using volume-corrected Atlantic sturgeon abundances from 1998-2007 Fall Shoals data stratified by sampling week, habitat (shoal, channel, bottom) and Utilities-survey river segment (e.g., Tappan Zee, Battery, Hyde Park, etc.). Abundances were interpolated for weeks that were not sampled. Weekly average standing crop was then calculated for each of the 52 calendar weeks and the maximum weekly average of 12,142 juvenile Atlantic sturgeon was calculated as the standing crop estimate for this time period and size range.

An examination of the Fall Shoals dataset revealed that 30% of the 233 Atlantic sturgeon collected in the Hudson River between 1998 and 2007 were ≥550-mm TL and the remaining 70% were <550-mm TL. These percentages were used to parse the standing crop estimate of 12,142 sturgeon into size classes which were then corrected for gear efficiency to yield an estimate of 13,708 juvenile Atlantic sturgeon (<550-mm TL) and 8,280 juvenile Atlantic sturgeon (≥550-mm TL) in the river. Based on the size of Atlantic sturgeon in this dataset (51 – 952-mm TL), this population of 21,988 Atlantic sturgeon was considered to consist of a number of age classes, including young of year, 1 and 2 year old fish, and fish 3 years old and possibly older (Bain 1997; Peterson et al. 2000).

6.1.1.18.3. Estimating Abundance of Juvenile Atlantic Sturgeon and Ensonified Volumes

During bridge construction, pile-driving activities create ensonified areas within which sturgeon may experience a range of potential effects. The size of these ensonified areas was modeled (JASCO 2011a) and used along with bathymetric data to estimate water volumes for assessing cumulative sound exposure levels (SEL_{cum}) for riverine juvenile Atlantic sturgeon. Although each of the noise isopleths (i.e., 187, 197 and 207 dB re 1µPa^2•s SEL_{cum}) representing cumulative sound exposure can be visualized by defining its length, width and depth (i.e., volume) within the river, the biological effects associated with each isopleths are time-dependent and assume that sturgeon remain within the isopleth for the duration of time required to drive the pile. Sturgeon that move from the area (as a behavioral response to avoid the stimulus, to continue migration, etc.) during the installation of a pile will only be exposed to a fraction of the defined sound level and may not experience the predicted biological effects associated with a given noise level.

Mean weekly Atlantic sturgeon densities were then applied to the water volumes ensonified by the 187 dB, 197 dB and 207 dB re 1µPa^2•s SEL_{cum} isopleths during each week of the proposed construction schedule to estimate the total number of fish expected to be potentially affected by pile-driving activities on a weekly basis over the course of bridge construction. The approach followed the proposed construction schedule and accounted for the various combinations of pile sizes that will be driven simultaneously, their location along the span, and their depth within the River. Fish numbers were expressed in terms of the Hudson River juvenile population of Atlantic sturgeon.

Upper and lower bounds for the number of fish exposed to the ensonified area were estimated by first assuming that the Hudson River population exists in a closed system (i.e., there is no immigration or emigration). Under this assumption, the same individual fish can be observed multiple times and the number of fish vulnerable to noise impacts can not exceed the maximum weekly average number of fish observed.

Therefore, the lower bounds were calculated as:

$$\text{Sturgeon}_{max} / \text{SC}_{max} \times 100$$

where,

Sturgeon_{max} = the maximum weekly number of sturgeon within the isopleths, and
SC_{max} = the maximum weekly average standing crop of the Hudson River.

To estimate the upper bounds, it was assumed that the Hudson River population exists in an open system with juvenile Atlantic sturgeon moving throughout the River. In this case, sturgeon are never observed more than once and every sturgeon observed within the project area is counted as a different individual. Under these assumptions, the number of juvenile sturgeon within the ensonified area each week was summed across all weeks and divided by the number of weeks of pile driving. This average weekly number of sturgeon was then multiplied by 52 weeks in a year to determine the number of affected fish during an average construction year.

Therefore, the upper bounds were calculated as:

$$(\sum \text{Sturgeon}_{\text{weekly}} / \text{n}_{\text{weeks}}) * 52 / \text{SC}_{\text{max}} \text{ X } 100$$

where,

Sturgeon $_{weekly}$ = the weekly number of sturgeon within the isopleths, and
n $_{weeks}$ = the number of weeks of pile driving during construction.

6.1.1.18.4. Number of Juvenile Atlantic Sturgeon Potentially Affected by Pile-Driving Activities

The analysis indicated that 35-46 juvenile Atlantic sturgeon have the potential to be exposed to an SEL_{cum} of 187 dB re 1μPa^2•s isopleths during a given year of construction for the Short Span Option and 35-67 juvenile Atlantic sturgeon for the Long Span Option; this represents 0.16 - 0.21% and 0.16 – 0.31% of the riverine juvenile population, respectively. These sturgeon would be susceptible to the physiological effects associated with exposure to this level of accumulated sound but would be expected to recover fully from any stress. Because of the smaller volume occupied by the 197 dB re 1μPa^2•s isopleths, fewer juveniles (21 sturgeon in a given year for the Short Span Option and 21-31 sturgeon for the Long Span Option; 0.09% and 0.09-0.14% of the riverine juvenile population, respectively) would be exposed to accumulated sound levels that may cause the onset of recoverable physical injury (e.g., auditory tissue damage, hemorrhaging). Even fewer juvenile Atlantic sturgeon (9 sturgeon per year for the Short Span Option and 9-13 sturgeon for the Long Span Option; 0.06% and 0.04-0.06% of the population, respectively) would be susceptible to cumulative sound exposure levels considered to be a very conservative level for the onset of mortality (i.e., 207 dB re 1μPa^2•s). At these sound levels, it is expected that avoidance behavior by sturgeon prior to the accumulation of 207 dB re 1μPa^2•s would minimize the number of fish subject to mortality.

Over the period of construction for either the Short Span or Long Span Options, less than 1.5% of the riverine juvenile population of Atlantic sturgeon would be expected to experience SEL_{cums} great enough to cause physiological effects (i.e., 187 dB re 1μPa^2•s). Less than 1% might experience recoverable physical injury (0.6%) or mortal injury (0.3%).

Based on these calculations, it is estimated that approximately 193 – 252 juvenile Atlantic sturgeon (<1,000-mm TL) could be exposed to noise levels high enough to cause physiological effects during the course of bridge construction of the Short Span Option (**Table 7**). An estimate of 113 – 116 juveniles might experience recoverable physical injury over the same time period, while 49 – 50 juvenile Atlantic sturgeon could potentially experience mortal injury if they were to remain in proximity to pile-driving for the time required to cause these effects.

Based on these calculations, it is estimated that approximately 158 – 303 juvenile Atlantic sturgeon (<1,000mm TL) could be exposed to noise levels high enough to cause physiological effects during the course of bridge construction of the Long Span Option (**Table 7**). An estimate of 93 – 141 juveniles might experience recoverable physical injury over the same time period, while 40 – 57 juvenile Atlantic sturgeon could potentially experience mortality if they were to remain in proximity to pile-driving for the time required to cause these effects.

The estimates provided here an approximation of the number of juvenile Atlantic sturgeon less than 800-mm TL that would potentially encounter ensonified areas in the Tappan Zee region. Juvenile Atlantic sturgeon collected throughout the Hudson River in the Fall Shoals survey ranged in size from 51 – 952-mm TL. The most commonly collected juveniles (92%) were between 100-700 mm TL and were bimodally distributed suggesting Age-0 (<400-mm TL) and Age-1 (400-700-mm TL) fish. Age-2 (> 600 mm TL) and possibly older age classes are also represented in the trawl collections. These size distributions are consistent with other studies reporting size-at-age information for juvenile Atlantic sturgeon in the Hudson River (Dovel et al. 1992, Peterson et al. 2000, Bain 2007). Juveniles reach Age-2 at approximately 600-700 mm TL (Peterson et al. 2000) at which point growth slows considerably (Dovel and Berggren 1983, Stevenson and Secor 1999). Congruence between the juvenile size distribution in the Fall Shoals dataset and the size range of riverine juveniles reported in the literature indicates that the early life stages are adequately represented by the Fall Shoals dataset.

The low abundance of juveniles collected in trawls in the Tappan Zee region, their absence in gill-net samples collected in this region and their high abundance upstream of Tappan Zee further support the hypothesis that the probability of ensonification of riverine juveniles is low and that the juvenile stage is adequately sampled by the beam trawl. The center of distribution for juvenile Atlantic sturgeon in the River is well upstream of the Tappan Zee region between West Point and Poughkeepsie at RMs 47-76 (Fall Shoals 1998-2007 data, Bain 1997). Sweka et al. (2007) reported concentrations of juveniles in Newburgh and Haverstraw Bays. During Fall Shoals sampling from 1998-2007, only 1% of all juvenile Atlantic sturgeon were collected within the Tappan Zee region. Of those juveniles, most were found within 10 feet of the bottom in waters deeper than 20 feet during late summer and fall months, with the remainder collected in shallow-water shoal habitat during summer months.

Juveniles remain in the River year-round until approximately Age-3 at which point they begin to migrate to offshore habitats along the Atlantic Coast of the US, where they mature at approximately 12-15 years and 1,500-2,000-mm TL before returning to the Hudson River to spawn in spring (Bain 1997). For this reason, oceanic juveniles are not susceptible to noise in the River. Similarly, non-spawning adults, which may represent 65% of the adult population each year based on an inter-spawning interval of 3 years (Bain 1997), are not exposed to noise in the River. Only a proportion of the adult population is expected to be susceptible to noise exposure during spawning migrations between April and August. The likelihood of exposure and an estimate of the number of spawning adult Atlantic sturgeon are examined in the following section.

6.1.1.18.5. Estimating Abundance of Adult Atlantic Sturgeon and Probability of Exposure to Ensonified Areas During Spawning Migrations

Adult population estimates for Atlantic sturgeon have been reported to be 863 spawning sturgeon (ASSRT 2007). Adults (>1,500-mm TL) migrate into the Hudson River from coastal waters to spawn beginning in April and most leave the river by August (Bain 1997, NYSDEC personal communication). Males, representing 69% of the spawning population (ASSRT 2007), enter the river during April and migrate to the spawning grounds near Hyde Park (RM 81) and Catskill (RM 113). Female Atlantic sturgeon (31% of the spawning population) follow the migration during May and move directly to the spawning grounds. The inter-spawning interval is thought to be 3-5 years depending on the sex (Bain 1997) meaning that the estimate of 863 adult Atlantic sturgeon is likely three times the spawning population during a given year (i.e., 288 per year). The non-spawning adult population remains outside of the Hudson River in nearshore coastal habitats and would therefore not be exposed to pile-driving noise within the River.

Because of their large size, spawning adult sturgeon are able to avoid collection by the beam trawl during Fall Shoals sampling. Therefore, the number of spawning adults potentially affected by pile-driving noise was estimated as a function of the probability of their exposure to noise. The probability of a migrating adult Atlantic sturgeon encountering the ensonified area becomes greater as the size and duration of the ensonifed area increases. To calculate this probability, time-weighted ensonified river widths were determined by multiplying the percentage of the river width occupied by the 187, 197 and 207 dB re 1μPa^2•s SEL_{cum} isopleths by the number of pile-driving hours during which the isopleths would occur in the river. For example, driving two 10-ft piles would create a 187 dB isopleth that is approximately 50% of the river width. The time required to drive all 50 of the 10-ft piles would be approximately 39 hours or 1.1% of the time in which spawning adults occupy the river (i.e., April 1- August 31). The product of the driving time and river width metrics equals the time-weighted ensonified river width, which accounts for both the spatial and temporal aspects of construction-related noise and thus the likelihood that adult Atlantic sturgeon would encounter the ensonifed areas. Ensonified river widths were binned into 5% width classes (from 0-100%) to calculate the total number of hours each width is expected to occur, based on the proposed construction schedule. The sum of these weighted river widths divided by the total number of hours in the spawning seasons for the construction period was used as the probability that a migrating adult Atlantic sturgeon would encounter the ensonified areas. This probability was calculated for both the Short Span (5.5 years) and Long Span (4.5 years) bridge designs and considered two different construction start-dates: one coinciding with the beginning of migration (April) which represented a worst-case scenario, and a second following emigration from the river (October). It was assumed that migrating adult Atlantic sturgeon could potentially encounter the ensonified area twice (i.e., once during immigration to the spawning grounds and again during emigration from the river).

6.1.1.18.6. Number of Spawning Adult Atlantic Sturgeon Potentially Affected by Pile-Driving Activities

Tables 7 and 8 indicate that for the Short Span Option 10-27 adult Atlantic sturgeon could encounter the 187 dB re 1μPa^2•s SEL_{cum} ensonified area during the course of the construction period. A total of 4-13 adult Atlantic sturgeon would be subject to the 197 dB re 1μPa^2•s SEL_{cum} ensonified area and 0-5 fish would encounter the 207 dB re 1μPa^2•s SEL_{cum} ensonified area during the course of the construction period. Depending upon whether the pile driving begins in April (worst case) or October, the fish located in the 187 dB re 1μPa^2•s SEL_{cum} ensonified area during the course of the construction period, would be equivalent to 3.1 and 1.1% of the adult population, respectively (**Table 8**).

Tables 7 and 8 indicate that for the Long Span Option 4-10 adult Atlantic sturgeon could encounter the 187 dB re 1μPa^2•s SEL_{cum} ensonified area during the course of the construction period. A total of 2-5 adult Atlantic sturgeon would be subject to the 197 dB re 1μPa^2•s SEL_{cum} ensonified area and 0-3 fish would encounter the 207 dB re 1μPa^2•s SEL_{cum} ensonified area during the course of the construction period. Depending upon whether the pile driving begins in April (worst case) or October, the fish located in the 187 dB re 1μPa^2•s SEL_{cum} ensonified area during the course of the construction period, would be equivalent to 1.2 and 0.5% of the adult population, respectively (**Table 8**).

When pile driving is ongoing, the probability of a migrating adult experiencing the equivalent of 187 dB re 1μPa^2•s SEL$_{cum}$ is low for several reasons: 1) during the majority of the time between April and August when spawning adults occupy the Hudson River there will be no pile-driving noise, 2) during those times when pile-driving is underway, the majority of the hours (~80%) will occur in shallow water (<20-ft deep) outside of the deeper water through which spawning adult Atlantic sturgeon migrate, and 3) migrating sturgeon are thought to move directly from coastal habitats to spawning grounds upstream of the Tappan Zee region spending little time in areas between these locations, particularly Atlantic female sturgeon. Thus it is less likely that they would accumulate the noise exposure required to cause physiological, injurious or lethal effects. For these reasons, the estimated number of migrating adult Atlantic sturgeon potentially exposed to the 187 dB re 1μPa^2•s SEL$_{cum}$ ensonified area is considered a conservative estimate.

These predictions are also likely to overestimate the number of shortnose and Atlantic sturgeon potentially affected for the following reasons:

- Since the calculations do not take into consideration the normal behaviors of sturgeon in response to a noxious stimulus, it is reasonable to assume that sturgeon, on hearing the pile driving sound, would either not approach the source or move around it. Since the pile driving sounds are very loud, it is also very likely that many of the fish will hear the sound, and respond behaviorally, by moving away, to a quieter location, well before they reached a point at which the sound levels exceeded the behavioral criterion of 150 dB re 1 µPa or the interim SEL$_{cum}$ criterion of 187 dB re 1 µPa^2·s. The likely behavioral response would be to alter the path through which the fish were traveling to avoid the sounds that were too loud and then resume their regular path once the highest sound levels were skirted. Moreover, the SEL$_{cum}$ assumes the fish are resident for the entire duration of the time to drive the pile, and this is not likely to occur since fish tend to move around and avoid areas of high sound levels.

- The analysis assumed that impact hammers would be used to drive the entire length of all of the piles. In reality, vibratory hammers will be used whenever feasible, which in many cases will be for at least 50% of the pile length. Caltrans (2009) reported that vibratory hammers produce sound energy that is spread out over time and is generally 10 to 20 dB lower than impact hammer driving. Moreover, vibratory piles are continuous sounds and do not have the sharp rise times associated with impact hammering. In fact, vibratory hammers more resemble continuous sounds. Since the major physiological effects on fish is from the rapid rise time of a signal (at onset), and since vibratory hammers do not have successive sharp rise times, the likelihood is that these sounds will have no more impact on fish than do the more comparable sounds used in studies of effects of high intensity sonars on fish (Popper et al. 2007; Halvorsen et al. 2012).

- The criteria used for potential onset of physiological effects that do not reduce fitness (>187 dB re 1 µPa^2·s), potential onset of recoverable injury (>197 dB re 1 µPa^2·s) and potential onset of mortal injuries (>207 dB re 1 µPa^2·s) are still very conservative, particularly based on new studies from the Transportation Research Board (Halvorsen et al. 2011). Based on this scientific study, the onset of fully recoverable injury to fish that does not lessen fitness would not occur until cumulative levels of 203 dB re 1 µPa^2·s or higher, and onset of mild injuries that could produce some decrease in fitness would not occur until cumulative sound levels are higher than 210 dB re 1 µPa^2·s. Onset of potential mortal injuries would be even higher, depending upon the species of concern. Measured by these higher values, the size of the ensonified area that could potentially cause onset of injury would be considerably reduced, as would the number of potentially affected fish.

- The analysis was conducted using a 10 dB reduction in sound energy generated by pile driving associated with implementation of BMPs. This level of attenuation may well underestimate the level of noise attenuation that can be achieved by bubble curtains or other technologies (i.e., 20 dB; Caltrans 2009)

- Carlson et al. (2007) indicated that as fish get larger there is less of an impact on them from sounds, and that the threshold for onset to injury to larger fish, such as sturgeon, is substantially higher (i.e. 213 dB re 1 $\mu Pa^2 \cdot s$) for fish above 200 grams, than the West Coast criterion for fish > 2 gm (i.e. 187 dB re 1 $\mu Pa^2 \cdot s$).

Table 5
Number of Shortnose Sturgeon Potentially Affected by Pile Driving Using cSEL Criterion – Short Span Bridge Option

Year	Week	Pile Diameter (feet)	Number of piles	Number of piles driven/day	Pile driving time (hours/pile)	Number of concurrently driven piles	Estimated pile driving time (hours)	With 10 dB BMPs: Width of isopleth for 187-db SEL_{cum} (ft)	With 10 dB BMPs: Number of gill nets (125-ft) to span width of isopleth	With 10 dB BMPs: Sturgeon encounter rate per gill net (fish/hr)	With 10 dB BMPs: Number of shortnose sturgeon potentially exposed to pile driving	With 10 dB BMPs: Percent of shortnose sturgeon population (61,057 fish)
	40-44	10	50	4	1.55	2	38.75	7186	57	0.033	72.89	
	45-48	6,8	20	7	1.11	2	11.1	5807	46	0.033	16.85	
	49	6,8	8	7	1.11	2	4.44	6336	51	0.033	7.47	0.21%
	50-51	4,8	20	6	1.14	2	11.4	7170	57	0.033	21.44	
1	52	4,8	10	6	1.14	2	5.7	6952	56	0.033	10.53	
	1	4,8	10	6	1.14	2	5.7	6952	56	0.033	10.53	
	2	4,8	10	6	1.14	2	5.7	6735	54	0.033	10.16	
	3-4	4,6,8	30	10	1.14	3	11.4	8418	67	0.033	25.21	
	5	4,6,8	15	10	1.14	3	5.7	9324	75	0.033	14.11	
	6	4,6,8	15	10	1.14	3	5.7	9253	74	0.033	13.92	
	7	4,6,8	15	10	1.14	3	5.7	8312	66	0.033	12.41	
	8-12	4,6,8	75	10	1.14	3	28.5	7732	62	0.033	58.31	0.53%
	13	6,8	12	7	1.14	2	6.84	7732	62	0.033	13.99	
	14-28	4,4	160	6	1.14	2	91.2	3490	28	0.033	84.27	
	29-49	4	95	3	1.14	1	108.3	2024	16	0.033	57.18	
	50-51	4,4,6	30	10	1.14	3	11.4	5581	45	0.033	16.93	
2	52	4,4,6	15	10	1.14	3	5.7	5036	40	0.033	7.52	
	1	4,4,6	15	10	1.14	3	5.7	5036	40	0.033	7.52	
	2	4,4	10	6	1.14	2	5.7	3490	28	0.033	5.27	
	3	4,4,6	15	10	1.14	3	5.7	4836	39	0.033	7.34	
	4	4,4,6	16	10	1.14	3	6.08	4217	34	0.033	6.82	
	5-10	4,4	65	6	1.14	2	37.05	3461	28	0.033	34.23	
	11-12	4,4	22	6	1.14	2	12.54	3197	26	0.033	10.76	
	13-17	4,4	53	6	1.14	2	30.21	3461	28	0.033	27.91	0.43%
	18-20	4,4	30	6	1.14	2	17.1	3197	26	0.033	14.67	
	21-25	4,4	55	6	1.14	2	31.35	3461	28	0.033	28.97	
	26-27	4,4	20	6	1.14	2	11.4	3197	26	0.033	9.78	
	28-33	4,4	60	6	1.14	2	34.2	3461	28	0.033	31.60	
	34-35	4,4	20	6	1.14	2	11.4	3197	26	0.033	9.78	
	36-41	4,4	60	6	1.14	2	34.2	3461	28	0.033	31.60	
3	42-52	4	60	3	1.14	1	68.4	2024	16	0.033	36.12	

Table 5
Number of Shortnose Sturgeon Potentially Affected by Pile Driving Using cSEL Criterion – Short Span Bridge Option

Year	Week	Pile Diameter (feet)	Number of piles	Number of piles driven/day	Pile driving time (hours/pile)	Number of concurrently driven piles	Estimated pile driving time (hours)	With 10 dB BMPs: Width of isopleth for 187-db SEL_{cum} (ft)	With 10 dB BMPs: Number of gill nets (125-ft) to span width of isopleth	With 10 dB BMPs: Sturgeon encounter rate per gill net (fish/hr)	With 10 dB BMPs: Number of shortnose sturgeon potentially exposed to pile driving	With 10 dB BMPs: Percent of shortnose sturgeon population (61,057 fish)
	1-14	4	70	3	1.14	1	79.8	2024	16	0.033	42.13	
	15-16	6	12	4	0.33	1	3.96	2120	17	0.033	2.22	
	17-18	6	6	4	0.33	1	1.98	2019	16	0.033	1.05	
	19	6	6	4	0.33	1	1.98	1821	15	0.033	0.98	
	20	6	6	4	0.33	1	1.98	1624	13	0.033	0.85	0.08%
	21	6	4	4	0.33	1	1.32	1440	12	0.033	0.52	
4	22-23	6	8	4	0.33	1	1.64	1060	8	0.033	0.43	
5	50-52	4	15	3	1.14	1	17.1	2024	16	0.033	9.03	0.01%
	1-5	4	25	3	1.14	1	28.5	2024	16	0.033	15.05	
	6-7	6	12	4	0.33	1	3.96	2120	17	0.033	2.22	
	9	6	6	4	0.33	1	1.98	2019	16	0.033	1.05	
	10	6	6	4	0.33	1	1.98	1821	15	0.033	0.98	
	11	6	6	4	0.33	1	1.98	1624	13	0.033	0.85	
	12	6	4	4	0.33	1	1.32	1440	12	0.033	0.52	0.04%
	13	6	4	4	0.33	1	1.32	1280	10	0.033	0.44	
	14	6	4	4	0.33	1	1.32	1060	8	0.033	0.35	
	21	6	6	4	0.33	1	1.98	1346	11	0.033	0.72	
6	22	6	6	4	0.33	1	1.98	1020	8	0.033	0.52	
Potential number of sturgeon within the 187-dB cSEL											**796**	**1.3%**

Table 6

Number of Shortnose Sturgeon Potentially Affected by Pile Driving Using cSEL Criterion – Long Span Bridge Option

Year	Week	Diameter (feet)	Number of piles	Number of piles driven/day	Pile driving time (hours/pile)	Number of concurrently driven piles	Estimated pile driving time (hours)	With 10 dB BMPs: Width of isopleth for 187-db SEL_{cum} (ft)	Number of gill nets to span width of isopleth	Sturgeon encounter rate (fish/hr)	Number of shortnose sturgeon potentially affected by pile driving	Percent of shortnose sturgeon population (61,057 fish)
	40-44	10	50	4	1.55	2	38.75	7186	57	0.033	72.89	
	45-48	6,8	20	7	1.11	2	11.1	5866	47	0.033	17.22	
	49-50	6,8	16	7	1.11	2	8.88	6862	55	0.033	16.12	0.22%
	51	6,8	12	7	1.11	2	6.66	7387	59	0.033	12.97	
1	52	6,8	14	7	1.11	2	7.77	7965	64	0.033	16.41	
	1	6,8	10	7	1.11	2	5.55	7767	62	0.033	11.36	
	2-3	8	12	3	1.11	1	13.32	5648	45	0.033	19.78	
	4-11	4,4	88	6	1.14	2	50.16	3458	28	0.033	46.35	
	12-13	4,4	20	6	1.14	2	11.4	3910	31	0.033	11.66	
	14-21	4,4	80	6	1.14	2	45.6	3458	28	0.033	42.13	0.40%
	22-23	4,4	22	6	1.14	2	12.54	3910	31	0.033	12.83	
	24-30	4,4	73	6	1.14	2	41.61	3458	28	0.033	38.45	
	31-33	4	45	3	1.14	1	51.3	2064	17	0.033	28.78	
2	47-52	4,4	60	6	1.14	2	34.2	3712	30	0.033	33.86	
	1-4	4,4	40	6	1.14	2	22.8	3712	30	0.033	22.57	
	5-18	4,4	160	6	1.14	2	91.2	3910	31	0.033	93.30	
	19	4,4,6	21	10	1.14	3	7.98	3910	31	0.033	8.16	
	20-21	4,6	34	7	1.14	2	19.38	4653	37	0.033	23.66	
	22	4,6	22	7	1.14	2	12.54	4200	34	0.033	14.07	0.34%
	23	4,6	16	7	1.14	2	9.12	3784	30	0.033	9.03	
	24	4,6	11	7	1.14	2	6.27	3512	28	0.033	5.79	
	25	4,6	11	7	1.14	2	6.27	3240	26	0.033	5.38	
3	26-33	4	40	3	1.14	1	45.6	2064	17	0.033	25.58	
	17-20	4	20	3	1.14	1	22.8	2064	17	0.033	12.79	
	23	6	6	4	0.33	1	1.98	2282	18	0.033	1.18	
	25	6	4	4	0.33	1	1.32	1395	11	0.033	0.48	
	28	6	6	4	0.33	1	1.98	1759	14	0.033	0.91	0.03%
	32	6	6	4	0.33	1	1.98	1469	12	0.033	0.78	
5	36	6	6	4	0.33	1	1.98	1178	9	0.033	0.59	
Potential number of sturgeon within the 187-dB cSEL											**603**	**1.0%**

Table 7
Number of Sturgeon That May Occur in Ensonified Areas Over the Project Duration

Species	Life Stage	Bridge Option	Potential for Onset of Physiological Effects (187 dB re 1μPa^2•s)	Potential for Onset of Recoverable Injury (197 dB re 1μPa^2•s)	Potential for Onset of Mortal Injury (207 dB re 1μPa^2•s)
Shortnose sturgeon	Juvenile/Adult	Short Span	796	298	89
	Juvenile/Adult	Long Span	603	218	67
Atlantic sturgeon	Juvenile	Short Span	193-252	113-116	49-50
	Adult		10-27	4-13	0-5
	Juvenile	Long Span	158-303	93-141	40-57
	Adult		4-10	2-5	0-3

Table 8
Potential Effects of Pile-Driving Noise on Adult Atlantic Sturgeon During Spawning Migrations in the Hudson River

	Short Span						Long Span					
	April start			October start			April start			October start		
	187 dB	197 dB	207 dB	187 dB	197 dB	207 dB	187 dB	197 dB	207 dB	187 dB	197 dB	207 dB
Average likelihood of encountering ensonified area during spawning migration	1.7%	0.8%	0.3%	0.6%	0.2%	0.0%	0.8%	0.4%	0.2%	0.3%	0.1%	0.0%
Average number of sturgeon/yr*	5	2	1	2	1	0	2	1	1	1	0	0
Total number of sturgeon during construction	27	13	5	10	4	0	10	5	3	4	2	0
Percentage of the adult Atlantic sturgeon population**	3.1%	1.5%	0.6%	1.1%	0.4%	0.0%	1.2%	0.6%	0.3%	0.5%	0.2%	0.0%

*Assumes a spawning population of 288 Atlantic sturgeon each year participate in spawning.
**Assumes a 3-yr spawning interval and total adult population of 863 Atlantic sturgeon (Kahnle et al. 2007).

The number of sturgeon predicted to encounter ensonified areas associated with the onset of physiological effects (187 dB re 1μPa2•s), recoverable physical injury (197 dB re 1μPa^2•s) and mortal injury (207 dB re 1μPa^2•s) are summarized in terms of the encounter probability. Probabilities were estimated as the average annual time-weighted width of the ensonified area expressed as a percentage of the river width. The scenarios considered the bridge design option (Short Span vs. Long Span) and a construction start-date corresponding to the start of migration when adult sturgeon are present (April) and the period following emigration from the River when adult sturgeon are not present (October).

While pile driving can potentially result in onset of injury to sturgeon in the immediate vicinity of the pile driving activity, it will not jeopardize the continued existence of shortnose or Atlantic sturgeon in the Hudson River. Their relatively small swim bladder and large size would indicate that the physiological impacts of pile driving on sturgeon may not be as great as for other species with larger swim bladders. Furthermore, NMFS has commented (FHWA 2003) that fish like shad and alewife are more susceptible to pressure waves due to their laterally compressed body shape, in comparison to the shortnose sturgeon’s fusiform shape. There is no critical habitat for shortnose or Atlantic sturgeon in the Hudson River.

While pile driving impacts resulting from constructing either Short or Long Span options may potentially injure or result in mortality to some individual shortnose and Atlantic sturgeon, the activity would not jeopardize either population.

6.1.1.19. Effects to Marine Mammals from Pile Driving

Marine mammals rely on the use of underwater sounds to communicate, navigate, and/or obtain information about their environment (the afore-mentioned “auditory scene”) (Richardson et al. 1995; Southall et al. 2007). The ability of marine mammals to hear and respond to underwater sounds depends on auditory capability and thus whether the sound is within the hearing range of the animal. All marine mammals potentially found within the Hudson will be able to hear sounds from pile driving since the frequencies are well within their hearing range (Southall et al. 2007). Moreover, the hearing sensitivity of all of these species is sufficiently acute that they are likely to be able to hear, and behaviorally respond to, the sounds at very substantial distance from the pile driving. Indeed, they are likely to hear the sounds at far greater distances than any fish and move away from the sound well before they get to a location where the pile driving levels would be sufficient to cause potential injury.

Dolphins, harbor porpoises, and seals make occasional use the Hudson River and may occur in the vicinity of the project. These species are marine, and only occur in the tidal Hudson River as transients. Given the scarcity of marine mammals in the study area, it is not possible to reliably estimate the number of animals that may even get close enough to hear pile driving sounds (or noises associated with other construction activities). Based on the few anecdotal observations reported, the presence of these species in the vicinity of the project is rare and is likely attributable to either previously stressed / injured animals or healthy, but transient, individuals. In the case of the former, the pile driving sounds could exacerbate existing stressors and result in either sub-lethal or lethal effects, while in the case of the latter, healthy animals would be expected to retreat from the source of any sounds that produce discomfort. Nevertheless, because this portion of the Hudson River doesn’t provide areas for spawning, nursery, or overwintering, or migratory pathway for these species, any anthropogenic sound in the river is not expected to result in adverse effects to the movement, reproduction, feeding, or sustained population of these species.

6.1.2. Effects from Increased Vessel Traffic

The shortnose and Atlantic sturgeon are known to occur within the stretches of the river that include the project area; therefore, sturgeon also may be directly impacted by increased vessel traffic in these areas. Increased vessel traffic will occur during all phases of the work including mobilization and site preparation activities, dredging for channel access, substructure construction, superstructure construction, and bridge demolition. These activities may result in a substantial increase in commercial vessel traffic in the Tappan Zee Reach. The potential direct effects associated with increases in vessel traffic include potential disturbance of foraging and migratory adults and juveniles associated with an increase in surface activity, vessel-impact mortality and noise.

The increased surface activity and associated noise may be considered to have the potential to displace/disrupt adults and juveniles during foraging and migratory activities, if the sounds are loud enough to be heard by sturgeon, which generally have poor hearing sensitivity (Lovell et al. 2005; Meyer et al. 2010, 2012). The increase in the Hudson River shortnose sturgeon population over the past several decades however, demonstrates the ability of the sturgeon to coexist in areas where commercial and industrial vessel traffic overlap.

Vessel traffic has been reported as a source of mortality for Atlantic sturgeon as a result of direct collisions with the hull or propeller. Vessel-strike mortalities have the potential to impact Atlantic sturgeon populations in the Delaware River and New York Bight by reducing the egg-per-recruit ratio and thus, by reducing the overall reproductive potential of the population (Brown and Murphy 2010). The majority of vessel related sturgeon mortality are likely caused by large transoceanic vessels, with fewer caused by smaller vessels. Large vessels have been implicated because of their deep draft [up to 12.2-13.7 m (40-45 feet)] relative to smaller vessels [<4.5 m (15 feet)], which increases the probability of vessel collision with demersal fishes like sturgeon, even in deep water (Brown and Murphy 2010). Smaller vessels and those with relatively shallow drafts provide more clearance with the river bottom and reduce the probability of vessel-strikes. Because the construction vessels (tug boats, barge crane, hopper scow) have relatively shallow drafts, the chances of vessel-related mortalities are expected to be low. The depth of the construction channel will be 4.3 m (14ft), which is considerably shallower than the typical depths [>6.1-9.1 m (20-30ft)] in which Atlantic sturgeon are found (Hatin et al. 2002). The maximum allowable draft of any of the construction vessels will be 3.2 to 3.6 m (10.5 to 12ft), however, under typical operating conditions, vessels will draft 2.1 to 2.4 m (7 to 8 ft), providing 1.8-2.4 m (6-7 ft) of clearance with the bottom at all times. Maximum allowable drafts will only occur under full load and while turning. Under working conditions, stationary tug boats will maintain 1.8 m (6 ft) clearance between the prop and the bottom and will only infrequently approach 1.1 m (3.5 ft) clearance. The large grain size of the gravel substrate used to armor the bottom of the construction channel is not the desired foraging substrate for sturgeon or their benthic invertebrate prey, which are typically found in fine-grained silt-clay sediments (Hatin et al. 2002, 2007).

The increased vessel traffic associated with the Tappan Zee Bridge replacement is not expected to result in direct interactions with sturgeon, because the life stages present in this reach of the river tend to occupy the bottom meter of the water column over fine-grained substrates in the deepest water areas and would be below the draft of the vessels involved. Furthermore, because sturgeon will tend to avoid areas of increased noise caused by vessel traffic and other construction-related activities, the probability of vessel-related impacts is even less likely. This conclusion is consistent with previous NMFS consultations with regional construction projects (e.g., the opinion issued for the Van Houten Holding Corporation's berthing facility upgrades in Upper Nyack, New York, NMFS 2011, NAN-2010-00832-ESP). Furthermore, NMFS (2012) has indicated that in contrast to the Delaware and James Rivers where several vessel strikes have been identified, very few injuries to Atlantic sturgeon consistent with vessel strikes have been observed from the Hudson River.

Another potential impact associated with increased vessel traffic is radiated noise. It is of considerable importance that fish transiting the navigable Hudson River will encounter an acoustic environment that is generally highly energetic under "normal" conditions. The sound levels lower in the estuary result from the high volume of commercial shipping traffic within the tidal Hudson and New York Harbor, and these do not appear to affect the behavior or migration of sturgeon that bypass this very noisy region each year. While noise levels resulting from shipping in the estuary are not known, it is possible to get a first approximation based upon results of other studies which indicate that sound levels due to radiated vessel noise would be below thresholds for the onset of injury to fish (Wursig et al. 2002). Furthermore, because of the comparatively poor hearing ability of sturgeon (Lovell et al. 2005; Meyer et al. 2010, 2012), it is likely that many of the sounds which are audible to most species, are not audible to sturgeon.

Because these representative values of radiated vessel noise are well below the peak SEL of 206 dB re 1 μPa criterion established for pile driving, and because the Hudson River is subject to substantial commercial and recreational vessel noise under "normal" conditions, any incremental increase sound associated with vessel traffic related to bridge construction is not expected to affect sturgeon.

6.1.3. Effects of Dredging

The frequency of dredging or disturbance of an area affects the invertebrate community and its ability to recover following each dredging event. Since sturgeon feed on benthos, a sizable loss of habitat due to dredging and temporary alteration of habitat could affect foraging opportunities. However, benthic communities found in environments with a great deal of variability such as estuaries normally have high rates of recovery from disturbance, because they are adapted to disturbance. Recovery rates of benthic macroinvertebrate communities following dredging range from only a few weeks or months to a few years, depending upon the type of project, the type of bottom material, the physical characteristics of the environment and the timing of disturbance (Hirsch et al. 1978, LaSalle et al. 1991). In a two year study in the lower Hudson River, Bain et al. (2006) reported that within a few months following dredging, the fish and benthic communities at a dredged location were no different from seven nearby sites that had not been dredged. The results of monitoring did not indicate a lasting effect at the dredged site.

Dredging activities for the project have the potential to remove benthic macroinvertebrates, including oyster beds, and the food resources they provide to other aquatic resources. Approximately 0.67 to 0.71 km^2 (165 to 175 acres) of bottom habitat—including about 0.02 km^2 (5.3 acres) of NYSDEC littoral zone tidal wetland and 0.65-0.69 km^2 (160-170 acres) of open water benthic habitat—would be dredged over a four year period during three stages, each stage being for a duration of three months between August 1 and November 1 (see **Figure 11**). Dredging would be confined to this window to avoid periods of anadromous fish spawning migrations. In addition, the trench would be armored following dredging and the benthic habitat within the dredge zone which was primarily soft sediment would be changed to a substrate of sand and gravel. Since armoring would occur up to 6.1 m (20 feet) of the side slope, total acreage of hard bottom would be approximately 0.63 to 0.67 km^2 (155 to 165 acres). The materials would not be removed after the project completion, since they would become fully buried by the gradual deposition of river sediments over time once construction was completed. The rate of this transformation would begin at approximately 1 foot per year, likely decreasing as the bed nears it natural pre-dredged elevation.

While the dredging would result in the loss of individual macroinvertebrates, it is not expected to result in an adverse impact of these species at the population level within the Hudson River Estuary. The temporary loss of the access channel area would represent a minor fraction of similar available habitat throughout the Tappan Zee region (1.2%) as defined by the Hudson River Utilities (RM 24-33), and an even smaller percentage of the riverwide benthic area (0.2%). The majority of the bottom habitat (and associated benthic macroinvertebrates within the area impacted) is the soft sediment community which dominates the Upper New York Harbor and Hudson River. Deposition within the dredged channel is predicted to occur at a rate of about one foot per year (see Appendix E of DEIS for deposition rate calculations). Recolonization by benthic organisms adapted to softer sediments could be expected to begin within a few months after completion of in-water activities in any given area. Prior to the deposition of sufficient sediment to support a soft substrate benthic invertebrate community, some recolonization of the gravel armor material would be expected occur. Organisms within the nearby gravel substrate located within the main channel (NYSDEC benthic mapper http://www.dec.ny.gov/lands/33596.html, and Nitsche et al. 2007) would serve as a source of organisms to colonize the gravel capping material until the soft sediment is of a sufficient depth to be colonized by soft substrate organisms. Although the area affected by dredging is substantial, the effects to the soft sediment habitat, which is the dominant sediment type in the lower estuary, would be temporary and not cause a long-term adverse effect. Once in-water activities are completed, the dredged channels would be restored over time to their original elevations by action of natural sedimentation, and the river's benthic community would recolonize those areas as well.

While the impact to sturgeon from mechanical dredging is expected to be less than for other types of dredges such as hopper and hydraulic pipeline dredges (NMFS 2007), the potential for taking shortnose sturgeon with a clamshell dredge still exists, albeit in relatively fewer numbers. For example, dredging at various Bath Iron Works facilities on the lower Kennebec River over a period of 1997 to 2003 indicated only one interaction between a bucket dredge and a shortnose sturgeon (NMFS 2007).Interactions with a hydraulic dredge used for maintenance dredging in the lower Kennebec River between 1991 and 2003 caused mortality of two shortnose sturgeon in 1991. No interactions with sturgeon were reported for maintenance dredging events in 1997, 2000, and 2002, but five shortnose sturgeon were entrained by the hopper dredge in 2003, with two of the fish dying on board the dredge, and the others released (NMFS 2011e). NMFS reported one Atlantic sturgeon entrained during a hopper dredge operation in Ambrose Channel, New Jersey, and indicated that there is insufficient information to quantify the numbers of Atlantic sturgeon killed or disturbed during dredging (NMFS 2012).

The number of interactions between dredge equipment and shortnose sturgeon seems to be associated with the length of time the dredging takes, and the time of year the dredging occurs, and the type of gear used (NMFS 2007). Shortnose sturgeon seem better able to avoid a mechanical dredge than a hopper or cutterhead dredge, likely due to the hydraulic suction associated with these latter dredge types which makes avoidance more difficult. The likelihood of a dropping dredge bucket interacting with an individual sturgeon is low due to the slow speed at which the dredge moves and the relatively small area of the bottom it interacts with at any one time. By limiting the dredge period to a ninety day window between August 1 and November 1, and relying upon a clamshell dredge with an environmental bucket, the Tappan Zee Hudson River Crossing Project Sponsors are implementing measures to minimize the potential for interaction of sturgeon with the dredging operation. Nevertheless, considering the large volume of dredge material that will need to be excavated, some capture of shortnose and Atlantic sturgeon can be expected to occur. However, since the project is not located in spawning, nursery, or major overwintering grounds for either species, the number of fish that could potentially interact with the dredge would be even further reduced, to a level that would not have an adverse effect on the population.

In summary, with the exception of up to 13 acres of oyster beds that may be permanently lost where access channels are dredged, there would be a temporary loss of habitat that could affect sturgeon that use the dredged area for foraging. These effects would occur as a result of a localized reduction in benthic fauna. However, the dredging footprint represents a very small percentage of the soft bottom habitat of the Tappan Zee region (1.2%) and the Hudson River Estuary (0.2%). Thus, the temporary reduction of benthic fauna within the dredged area would not substantially reduce foraging opportunities for the river's sturgeon populations, because sturgeon are highly mobile and anadromous, moving up and down the estuary. As noted above, once in-water activities are completed, the dredged channels would be restored over time to their original elevations and the river's benthic community would recolonize those areas. Furthermore, the impact of the dredge interacting and potentially harming sturgeon will be minimized by limiting dredging to three months each year and through the use of a mechanical clamshell dredge with an environmental bucket, rather than a hydraulic dredge.

6.1.3.1. Oyster beds

Oyster beds were mapped using side scan sonar imagery approximately two miles north and south of the existing bridge from depths of 2.4 to 9.1 m (8 to 30 feet). Seven potential oyster beds were identified south of the bridge and six potential beds to the north (see Appendix E-3 of the DEIS for a description of each of the beds). During the subsequent grab sample program all identified oyster beds except one were confirmed to contain at least some live organisms with beds exhibiting differences in terms of oyster density, amount of shell hash, gravel, or sandstone fragments, etc. Dredging would remove about 0.05 km^2 (13 acres) of oyster beds, some or all of which may be permanently lost due to dredging and armoring of the bottom. A permanent loss of these oyster beds would result in an unavoidable adverse impact. Potential for implementation of oyster enhancement, relocation, or restoration projects will be explored and other mitigation strategies will be developed through consultation with the USACE, NMFS, USFWS, and NYSDEC. However, because of its sediment composition, oyster habitat is not considered optimal for sturgeon foraging.

In summary, with the exception of oyster beds that may be permanently lost, where access channels are dredged, there would be a temporary loss of habitat that could affect sturgeon that use the dredged area for foraging. These effects would occur as a result of a localized reduction in benthic fauna. However, the dredging footprint represents a very small percentage of the Hudson River Estuary and its soft bottom habitat. Thus, the temporary reduction of benthic fauna within the dredged area would not substantially reduce foraging opportunities for the river's sturgeon populations, because sturgeon are highly mobile and anadromous, moving up and down the estuary. As noted above, once in-water activities are completed, the dredged channels would be restored over time to their original elevations and the river's benthic community would recolonize those areas.

6.1.4. Effects of Shading

It has been maintained that shading of estuarine habitats can result in decreased light levels and reduced benthic and water-column primary production, both of which may adversely affect invertebrates and fishes that use these areas, particularly with respect to use as refuge and foraging habitat (Able et al. 1998, and Struck et al. 2004). The amount of area shaded by overwater structures will be affected by the height and width of the structure, construction materials and orientation of the structure relative to the arc of the sun (Burdick and Short 1995, Fresh et al. 1995 and 2000, Olson et al. 1996, 1997 in Nightingale and Simenstad 2001) and piling density. Shading due to bridges has been found to affect plant communities such as tidal marshes and SAV, as well as benthic invertebrate communities within tidal marshes (Struck et al. 2004, and Broome et al., 2005 in CZR 2009). However, adverse effects on marsh vegetation and benthic macroinvertebrates have been found to be minimal when the bridge height-to-width ratio is greater than 0.7 (Struck et al, 2004, Broome et al. 2005 in CZR 2009). Significantly fewer oligochaete worms, which are common in the Hudson River, were found under bridges with a height-to-width ratio less than 0.7 when compared to marshes not affected by shading (Struck et al. 2004). Struck et al. (2004) found that bridges with height-to-width ratios greater than 1.5 had the lowest light attenuation beneath the bridge.

Because the elevations of the existing Tappan Zee Bridge and the Replacement Bridge Alternative are not consistent over the length of the structure (see **Figure 2**), the height-to-width ratio of the bridge varies along its length. **Table 9** compares the ratio of the existing bridge and the Short and Long Span Options for the Replacement Bridge Alternative at the stations indicated in **Figure 2**. The two spans of the Replacement Bridge Alternative would be separated by a gap up to 70 feet. While there are no vegetated wetlands or SAV that could be affected by the construction of the Replacement Bridge Alternative, the height-to-width ratios presented below provide an indication of the potential for the existing and Replacement Bridge Alternative to result in shading impacts. As indicated below, the height-to-width ratio for the portion of the existing bridge within the causeway (the western approach to the main span comprising Stations 845+00 to approximately 905+00) is low, ranging from 0.22 to 0.29). The ratio for these same stations for the Replacement Bridge Alternative, Short and Long Span Options, are much higher, ranging from 0.348 near the shoreline to 1.20, with the ratios for the Long Span Option being slightly greater because the height for this approach option is higher. The portion of the western approach just prior to the main span (Stations 920+00 to 935+00) has a ratio that ranges from 0.54 to 1.05 for the existing bridge. Again, the ratios of these stations for the Replacement Bridge Alternative are much greater, ranging from 1.23to 1.82. The ratios for the main span of the existing bridge range from 1.51 to 1.52 and for the Replacement Bridge Alternative 1.4896 to 1.8161, while the ratios for the eastern approach are fairly similar for the existing and Replacement Bridge Alternative, ranging from 0.89 to 1.31 with the Long Span Option for the Replacement Bridge Alternative having the higher ratios.

The ratios in **Table 9** consider the height-to-width ratio separately for the two spans of the Replacement Bridge Alternative, indicating that the separation between the decks of the two spans (i.e., 70 feet at the main span and then decreasing toward the shorelines) allows light to penetrate between the two structures. This represents the best case analysis. Under this case, the Replacement Bridge Alternative would clearly result in a lower potential for shading of aquatic habitat compared to the existing bridge, particularly along the causeway (western approach to the main span). Even under the worst case, which assumes no separation between the spans of the Replacement Bridge Alternative and which would conservatively result in a halving of the height-to-width ratios presented in **Table 9**, the Replacement Bridge Alternative would still result in greater ratios (i.e., less shading) than the existing bridge for the western approach, but may result in more shading than the existing bridge for the eastern approach. Overall, the height-to-width ratios indicate that even if the Replacement Bridge Alternative was treated as a single structure, with no separation between the spans, there would be a decrease in the potential for shading impacts to aquatic resources.

Table 9
Height-to-Width Ratios for the Existing Bridge and Short and Long Span Options for the Replacement Bridge Alternative at Various Stations Across the Length of the Bridge

Location	Existing	Short Span		Long Span	
	91 ft-wide deck	96ft-wide	87ft-wide	96ft-wide	87ft-wide
845+00	0.29	0.34	0.38	0.44	0.48
860+00	0.22	0.52	0.57	0.60	0.67
875+00	0.22	0.70	0.78	0.78	0.86
890+00	0.22	0.91	1.00	0.96	1.06
905+00	0.22	1.08	1.20	1.13	1.24
920+00	0.54	1.23	1.36	1.24	1.37
935+00	1.05	1.46	1.61	1.46	1.61
950+00	1.52	1.65	1.82	1.65	1.82
965+00	1.51	1.49	1.64	1.49	1.64
980+00	1.01	1.19	1.31	1.19	1.31
995+00	1.07	0.99	1.09	0.89	0.98

The approximately 99,153-square foot permanent platform at the Rockland Bridge Landing would result in additional aquatic habitat affected by shading. Considering the extensive area of aquatic habitat not affected by shading within the study area, the additional shading caused by the permanent platform and by the bridge would not result in direct effects to sturgeon.

6.2. Indirect Effects

6.2.1. Impacts Associated with Resuspended Sediment

Dredging, pile driving, and construction vessel prop wash have the potential to re-suspend bottom sediments in the vicinity of the activity. Resuspension of sediments can have a range of impacts to fish depending on the species and life stages being considered. Lethal levels of TSS vary widely among species; one study, which included a variety of fish species common to the proposed construction site and representative of tolerant and sensitive species (white perch (*Morone americana*), spot (*Leiostomus xanthurus*), silversides (Atherinidae), bay anchovies (*Anchoa mitchilli*) and menhaden (*Brevoortia* spp.)) found that the tolerance of adult fish for suspended solids ranged from 580 mg/L to 24,500 mg/L (Sherk et al. 1975 as cited in NMFS 2003). Common impacts to fishes can be classified as biological/physiological or behavioral. Among the biological/physiological impacts are: abrasion of gill membranes resulting in a reduction in the ability to absorb oxygen, decrease in dissolved oxygen concentrations in the surrounding waters and effects on growth rate. Behavioral responses by fishes to increased suspended sediment concentrations include impairment of feeding, impaired ability to locate predators and reduced breeding activity. Increased TSS can inhibit migratory movements as well. A study conducted by NOAA concluded that TSS concentrations as low as 350 mg/L could interfere with upstream migrations of various species (NOAA 2001). At high suspended sediment concentrations, mortality has also been documented. Fish, however, are mobile and generally avoid unsuitable conditions in the field, such as large increases in suspended sediment and noise (Clarke and Wilber 2000). The effects of habitat avoidance are not expected to have widespread consequences for the ecology of the fish community based on their ability to move from the impacted area and because the spatial distribution of the community is considerably greater than the predicted extent of increased suspended sediment concentrations and the dredge footprint.

Lethal and sublethal effects of suspended sediments on fish species common to the study area have been observed at concentrations well above those expected during project construction. In terms of sublethal effects, a stress response (e.g., elevated corticosterol levels) was reported for striped bass (1,500 mg/L), white perch (650 mg/L) and hogchoker (1,240 mg/L) well above expected concentrations (Wilber and Clarke 2001). Striped bass did not avoid concentrations of 954 to 1,920 mg/L to reach spawning sites (Summerfelt and Mosier 1976, Burton 1993, both as cited in NMFS 2011d) which are well above the levels likely to be encountered during dredging operations. Burton (1993 as cited in NMFS 2011d) indicated that concentrations of suspended solids can reach thousands of milligrams per liter before an acute reaction is observed. Lethal effects were demonstrated between concentrations of 580 mg/L for sensitive species and 700,000 mg/L for more tolerant species. Lethal effects were not observed until suspended sediment concentrations exceeded 750 mg/L, at which point 100% mortality was observed for bluefish, Atlantic menhaden and white perch. More tolerant species exhibited 50% mortality at concentrations above 2,500 mg/L, including silversides (2,500 mg/L), spot (20,340 mg/L), cunner (28,000 mg/L) and mummichog (39,000 mg/L).

Sublethal effects on fish eggs and larvae have been reported in terms of slowed development, delayed hatching or reduced hatching success. Wilbur and Clarke (2001) in a literature summary of available data indicated that hatching is delayed for striped bass and white perch at concentrations of 800 mg/L and 100 mg/L, respectively, however, reduced hatching success (i.e., egg mortality) was not observed until concentrations reached 800-1,000 mg/L for these species. For eggs of Atlantic herring, there were no sublethal effects observed at suspended sediment concentrations of 300-500 mg/L (Wilber and Clarke 2001), while eggs of blueback herring and Atlantic menhaden exhibited no change in hatching or development at a concentration of 1,000 mg/L (Wilber and Clarke 2001).

Hydrodynamic modeling conducted for the Tappan Zee Hudson River Crossing DEIS (FHWA 2012) indicated that on flood and ebb tides, concentrations of 10 mg/L above ambient conditions may extend in a relatively thin band approximately 1,000 to 2,000 feet from the dredges, while concentrations of 5 mg/L may extend a greater distance (**Figures 26 to 29**). These changes are considered well within the natural variation that has been observed within the Hudson River. For example, during the sampling conducted for the project TSS concentrations ranged from 13 to 111 mg/L. Data recorded at Poughkeepsie indicated that during higher freshwater flow periods the difference between suspended sediment concentrations can vary by 20 to 40 mg/L. The TSS projected to occur as a result of the project's construction would be expected to be below the lethal and sublethal thresholds of adult and larval fish and also below concentrations that would be expected to impact migration. Furthermore, anadromous fish including shortnose and Atlantic sturgeon spawn well upriver and their most vulnerable early life stages such as eggs and yolk-sac larvae would not be expected to occur in the Tappan Zee vicinity. Impacts due to increased water column suspended sediments are expected to be minimal and would not result in adverse impacts to anadromous fish within the Lower Hudson River estuary.

While there are no studies on the effects of resuspended sediments on either the shortnose or Atlantic sturgeon they are routinely encountered in turbid waters (Dadswell et al. 1984) and as such are thought to be highly tolerant of suspended sediment at the levels that are generated by marine construction activities (NMFS 2011b). In fact, sturgeon feed on invertebrates that occur both on and within the bottom substrate, and have evolved to tolerate high concentrations of suspended sediment. The act of feeding by sturgeon itself may lead to substantial resuspension of sediments. In a study of Atlantic sturgeon feeding patterns in the Bay of Fundy, sturgeon feeding activity has been linked to significant quantities of clay and silt becoming redistributed (Pearson et al. 2007). Within the area studied, these researchers estimated as much as 1,220 m^3 of sediment being resuspended during the six weeks during which peak sturgeon feeding activity occurred. NMFS has also concluded that the effect of suspended sediment concentrations in the range of 10-350 mg/L from dredging, pile driving and other construction activities for a marina project in the Haverstraw Bay region would be insignificant to shortnose sturgeon (NMFS 2011d). Citing the literature, NMFS indicated that the concentrations of TSS that would be expected to show adverse impacts to fish would be 580.0 mg/L for the most sensitive species, with 1,000 mg/L being more typical.

Hydrodynamic modeling conducted for the Tappan Zee Hudson River Crossing DEIS (FHWA 2012) has been used to project the path and extent of the plume of resuspended sediment that would result from sediment disturbing construction activities such as dredging and pile driving, and to anticipate the fate and transport of this plume within the Hudson River estuary.

Inputs to the hydrodynamic models included the following:

- Results of SedFlume[1] analysis of sediments within the vicinity of the area to be dredged conducted by Dr. Donald Hayes that indicated sediments within the study area are highly susceptible to resuspension. Dr. Hayes is the director of the Institute for Coastal Ecology and Engineering at the University of Louisiana at Lafayette Department of Civil Engineering and a recognized expert in the areas of dredging, sediment management, beneficial uses and contaminated sediment (Louisiana Sea Grant program (http://www.laseagrant.org/comm/experts/hayes.htm).

- Existing information to characterize the Hudson River Estuary within the study area, examples of which include bathymetry from the National Oceanic and Atmospheric Administration (NOAA) navigational charts, tidal data from US Geological Survey (USGS) and NOAA tide stations, USGS freshwater discharge, salinity and suspended sediment concentration data, and USGS suspended sediment concentration data.

- Results of numeric models developed by Dr. Hayes to estimate suspended sediment loadings that would result from dredging; pile driving; coffer dam installation; dewatering; removal; and vessel movement as described below. Inputs to these models are presented below.

    - Suspended sediment generated by dredging—dredging area (up to approximately 173 acres (about 0.52 km^2, or 0.2 square miles) and volume (up to 1.37 million cubic meters, or 1.8 million cubic yards), rate of dredging [about 5,734 cubic meters (7,500 cubic yards) per dredge per 24 hour period with two dredges operating concurrently], use of environmental/closed bucket with no barge overflow and a conservative sediment loss rate of

1 High Shear Stress flume (SEDflume http://www.erdc.usace.army.mil) is designed for estimating gross erosion rates of fine-grained and mixed fine/coarse-grained sediments and the variation of the erosion rate with depth below the sediment-water interface. The erosion data are used to predict stability for contaminated sediments, capping material, native sediment, or dredged material and are often incorporated into numerical sediment transport models. The flume is designed to erode sediment cores layer by layer. Each core layer is eroded by regulating flow over the core surface. The flume is operator-controlled, so the operator selects the range of shear stresses (starting at a low value and proceeding through higher values) for measuring erosion rate.

about 1 percent. This conservative loss rate, combined with the projected dredging rate and the sediment characteristics results in an average sediment resuspension rate for each dredge of 39 kilograms per minute (kg/min), and a maximum rate of 94 kg/min.

- Suspended sediment generated by cofferdam construction and dewatering—In the absence of existing information on sediment resuspension rates associated with cofferdam construction, resuspension of sediment during installation of sheet pile for cofferdams was developed on the basis of results of suspended sediment monitoring conducted for the San Francisco-Oakland Bay Bridge East Span Seismic Safety Project during dredging and in-water construction activities. (http://biomitigation.org/bio_overview/subjects_overview.asp#water). Results of monitoring for that project indicated that installation of sheet pile for cofferdam construction resulted in average resuspension of bottom material that was about 30 percent of the average resuspension during dredging.
- Suspended sediment generated by pile driving and dewatering—Existing information on sediment resuspension from pile driving and dewatering was similarly absent and was estimated to be approximately 40 percent of that observed during dredging on the basis of the suspended sediment monitoring for the San Francisco-Oakland Bay Bridge East Span Seismic Safety Project.
- Suspended sediment generated by vessel movement and prop scour—As discussed previously a layer of gravel and sand would be placed at the bottom of the dredged channel to minimize sediment re-suspension. However, this layer would not prevent the resuspension of sediment that would be naturally deposited each day. Using an estimated depositional rate of sediment within the dredged channel of 104 kilograms per meter per day developed on the basis of van Rijn (1986) and total suspended sediment concentrations measured during studies conducted for the Replacement Bridge Alternative, the hourly scour rate of sediment as the vessels move along the channel was estimated as 8.7 kg per meter per hour (kg/m/hr).

As indicated in the construction timeline presented in **Figure 7**, there are periods when sediment disturbing activities evaluated in the hydrodynamic modeling would occur concurrently, with the majority of the potential for sediment resuspension occurring during the first two dredging periods. The hydrodynamic modeling results for this project are reflective of conservative scenarios that would be expected to result in the greatest sediment resuspension, namely:

- Stage 1 dredging with pile driving for the main span (Zone C) and trestles;
- Pile driving and cofferdam installation and dewatering for Zones C and B, movement of construction vessels, and trestle construction after Stage 1 dredging is complete; and
- Stage 2 dredging combined with pile driving and cofferdam installation and dewatering for Zones C and B, and movement of construction vessels.

6.2.1.1. Sediment Resuspension and Transport

The Long Span Option would have fewer piers than the Short Span Option (see **Figures 12** and **13**), resulting in a shorter construction duration (4½ years) than the Short Span Option (5½ years). While the number of main span piers is the same for the two options, the long span option has far fewer piers in the approaches.

Sediment disturbing construction activities include dredging, cofferdam construction, and pile driving within Substructure Zones A and B, pile driving within Substructure Zone C (see **Figures 12** and **13** for the location of these zones) and the movement of construction vessels within the construction access channel for the Long and Short Span options. Within Construction Zones A and B (see **Figures 12** and **13**) pile driving would occur within the cofferdams and would not have the potential to re-suspend sediment within the river. Within Zone C, piles would be driven first and then the pile caps installed within hanging cofferdams. Therefore, only the Zone C piles would have the potential to result in additional sediment re-suspension. Hydrodynamic modeling was used to project the plume of resuspended sediment that would result from these concurrent sediment disturbing construction activities and the fate and transport of this plume within the river estuary.

Placement of the sand/gravel armoring material within the dredged area, similar to the placement of granular capping material over contaminated sediment, has the potential to result in sediment resuspension when the capping material is deposited upon the sediment, but would not be expected to affect the magnitude of sediment resuspension projected through the hydrodynamic modeling. Results of monitoring conducted during placement of granular capping material on soft sediment indicated that resuspended sediment plumes were due to fines washed of the sand cap material and not due to resuspension of bottom sediment as the capping material was put in place (USACE 2005a). Measures would be implemented during placement of the sand layer of the armoring to minimize resuspension of the newly exposed sediment. These measures are the same type of measures that have been demonstrated to successfully cap contaminated sediment with minimal mixing of the cap with contaminated sediment (Palermo et al. 2011), and for the capping of subaqueous dredged material (Palermo et al. 1998). They include both mechanical (dry sand capping material with bottom-dump barge, side-casting, bucket/clamshell, tremie (gravity-fed downpipe)) and hydraulical (wet/slurry of sand placed from a pipe or tremie, or from a spreader barge) placement of the capping material (USACE 2005a and 2006, USEPA 1994, Palermo et al. 2011). Mechanical methods rely on the gravity settling of the granular capping materials in the water column (Palermo et al. 2011) which can result in less water column dispersion than discharge of hydraulically-handled cap material because it settles faster in the water column (USACE 1991). Hydraulic methods can allow for a more precise placement of the material at the surface or depth but may require use of a dissipation device to reduce sediment resuspension (Palermo et al. 2011, USACE 1991).

Placing sand capping material in layers has been found to allow gentle spreading, resulting in a more stable sand cap (Ling and Leshchinsky undated), and avoiding displacement of or mixing with the underlying sediment (USEPA 2005). This results in a decrease in the turbidity plume with each successive cap layer. The reduction in sediment resuspension observed by placing granular capping material in lifts or layers may afford the ability to place subsequent layers using an alternative methodology that would allow faster placement (USEPA 2008). Therefore, once the sand layer of the proposed armoring is in place, the placement of the gravel would have limited potential to result in sediment resuspension. With the implementation of these methods of placement of granular capping material that have been proven to reduce sediment resuspension during placement, additional sediment resuspension that would occur during the placement of the armoring material would be minimized and would not be expected to result in adverse water quality impacts.

In summary, the results of the hydrodynamic modeling of changes in suspended sediment resulting from construction activities—dredging, pile driving, cofferdam construction, and vessel movement—indicate that with the exception of the portion of the mixing zone within the immediate vicinity of the dredge, increases in suspended sediment would be minimal for the Long and Short

Span Options and within the natural range of variation of suspended sediment concentration within this portion of the river. Sediment resuspension resulting from dredging and other sediment disturbing activities would be expected to meet the Class SB turbidity standard at the edge of the mixing zone. Resuspended sediment would dissipate shortly after the completion of the dredging activities, and would not result in adverse impacts to water quality. During the periods of in-water construction when no dredging is occurring, the limited sediment resuspension during pile driving, cofferdam installation and removal, and vessel movement would be localized, would be expected to dissipate shortly after the completion of in-water construction activity and would not result in adverse water quality impacts. Similarly, with the implementation of measures demonstrated to minimize sediment resuspension during placement of capping or armoring material, the placement of the armoring material within the dredged area would not result in adverse water quality impacts.

For all of the reasons presented above, the modest increase in suspended sediment projected to result from dredging and other in-water sediment-disturbing construction activities, even under the worst case scenarios, and the placement of armoring within the dredged channel, would not be expected to result in any adverse effect to shortnose or Atlantic sturgeon in the Hudson River, which are extremely tolerant of elevated levels of suspended solids.

6.2.1.2. Sediment Quality

The results of sediment quality analyses are summarized in Tables 10, 11 and 12, and identify the samples classified as Class B (moderate contamination) or Class C (high contamination) for metals (see **Table 10**), SVOCs (see **Table 11**), and pesticides, PCBs, and dioxins (see **Table 12**) in accordance with NYSDEC's In-Water and Riparian Management of Sediment and Dredged Material (NYSDEC 2004). Contaminants observed that were classified as Class B or Class C included Total PCBs, Total PAH, mercury, dioxin/furan TEQ, Total DDT, DDD and DDE, arsenic, copper, and cadmium. While there are some locations for which certain contaminants fall under the Class B or Class C category, these concentrations typically apply to only the upper few feet and the concentrations of these contaminants decline to those meeting Class A (no appreciable contamination) category within a few feet of the mudline. Resuspension of sediments during dredging can also affect water quality through the release of contaminants dissolved in the sediment pore water (i.e., the water occupying the spaces between sediment particles). Considering the limited plume of increased suspended sediment above ambient concentrations projected to occur during the three-month dredging periods between August 1 and November 1, and the limited area of sediments with low to moderate levels of contamination within the area to be dredged, the release of any contaminants would not result in adverse effects to sturgeon that may come into contact with the plume.

The other in-water construction activities with the potential to result in sediment resuspension (pile driving, installation of the cofferdam and vessel movement) for the Long and Short Span Options are projected to result in a minimal increase in SSC above ambient concentrations. These projected increases would actually be much lower, because within Zones A and B, the sand/gravel armoring layer installed throughout these two zones to minimize scouring would also minimize any resuspension of sediment resulting from the installation of the cofferdams.

Table 10
Results of Sediment Quality Analysis – Metals

Parameter	Sediment Criteria		Hudson River Average[2]	Number of Samples Analyzed	Detection Rate	Minimum (mg/kg)	Average (mg/kg)	Median (mg/kg)	95th Percentile (mg/kg)	Maximum (mg/kg)
	ERL[1] (mg/kg)	ERM[1] (mg/kg)								
Aluminum	NC	NC	10256.9	313	100%	483	11,714	11,700	17,300	21,700
Antimony	NC	NC	--	156	0%	ND	ND	ND	ND	ND
Arsenic	8.2	70	7.2	313	97%	ND	8.06[A]	7.4[A]	14[B]	26.4[B]
Barium	NC	NC	--	313	92%	ND	43	32.9	91.04	190
Beryllium	NC	NC	--	313	47%	ND	0.79	0.76	1.1	2.61
Cadmium	1.2	9.6	1.0	313	46%	ND	1.9[B]	1.92[B]	3.2[B]	6[B]
Calcium	NC	NC	--	313	98%	ND	4,919	2,620	16,550	64,600
Chromium	81	370	38.1	313	100%	1.17	31	21.9	85.86	116
Cobalt	NC	NC	--	313	96%	ND	10	9.8	13.7	17.3
Copper	34	270	42.4	313	99%	ND	32[A]	12.4[A]	102.55[B]	1,550[C]
Iron	NC	NC	--	313	100%	1380	24,227	24,200	32,600	40,900
Lead	46.7	218	44.6	313	100%	1.42[A]	36[A]	10.9[A]	137.4[B]	604[C]
Magnesium	NC	NC	--	313	100%	252	5,765	5,760	7,476	39,600
Manganese	NC	NC	--	313	100%	21.8	626	587	1,170	1,600
Mercury	0.15	0.71	0.38	313	37%	ND	0.89[B]	0.53[B]	2.46[C]	6.33[C]
Nickel	20.9	51.9	21.5	313	99%	ND	21	20.6	32.6	38.3
Potassium	NC	NC	--	313	97%	ND	2181	2,130	3,257	4,460
Selenium	NC	NC	--	313	43%	ND	4.01	3.945	6.2775	12.6
Silver	1	3.7	1.5	156	17%	ND	2.02	1.9	3.04	3.3
Sodium	NC	NC	--	313	94%	ND	2,229	2,035	3,761.50	5,730
Thallium	NC	NC	--	156	1%	ND	12.4	12.4	12.4	12.4
Vanadium	NC	NC	--	313	99%	ND	24.7	23.7	36.3	54.1
Zinc	150	410	129.2	313	100%	8.74	90	65	221	399

Notes: mg/kg = milligrams per kilogram; NC = no criteria; ND = not detected, -- = not available.

Sources:

[1] NYSDEC 1999

[2] Llanso et al. 2003

[A] Concentration falls within Class A - no appreciable contamination/no toxicity to aquatic life (NYSDEC 2004).

[B] Concentration falls within Class B - moderate contamination/chronic toxicity to aquatic life (NYSDEC 2004).

[C] Concentration falls within Class C - high contamination/acute toxicity to aquatic life (NYSDEC 2004).

Table 11
Results of Sediment Quality Analysis – SVOCs

Parameter	Sediment Criteria: ERL[1] (µg/kg)	Sediment Criteria: ERM[1] (µg/kg)	Hudson River Average[3]	Number of Samples Analyzed	Detection Rate	Minimum (µg/kg)	Average (µg/kg)	Median (µg/kg)	95th Percentile (µg/kg)	Maximum (µg/kg)
Acenaphthene	16	500	289.4	156	8%	ND	36	ND	89	3,270
Acenaphthylene	44	640	139.2	156	16%	ND	13	ND	111	206
Anthracene	85.3	1,100	283.2	156	27%	ND	47	ND	155	2,030
Benzo(a)anthracene	261	1,600	176.4	156	43%	ND	130	ND	418	3,760
Benzo(a)pyrene	430	1,600	174.1	156	51%	ND	133	37	496	3,020
Benzo(b)fluoranthene	NC	NC	184.7	156	42%	ND	110	ND	445	2,460
Benzo(g,h,i)perylene	NC	NC	123.5	156	42%	ND	64	ND	260	1,530
Benzo(k)fluoranthene	NC	NC	163.4	156	42%	ND	91	ND	328	2,370
Chrysene	384	2,800	178.7	156	44%	ND	134	ND	487	3,490
Dibenzo(a,h)anthracene	63.4	260	--	156	15%	ND	14	ND	78	456
Fluoranthene	600	5,100	218.9	156	49%	ND	333	ND	994	13,300
Fluorene	19	540	291.2	156	10%	ND	28	ND	81	2,210
Indeno(1,2,3-c,d)pyrene	NC	NC	104.8	156	33%	ND	53	ND	220	1,510
2-Methylnaphthalene	70	670	--	156	1%	ND	0.96	ND	ND	113
Naphthalene	160	2,100	111.0	156	9%	ND	11	ND	49	504
Phenanthrene	240	1,500	299.1	156	40%	ND	163	ND	539	7,030
Pyrene	665	2,600	265.7	156	48%	ND	288	ND	999	9,570
Total PAHs (sum of above)	4,020	44,792	3,003	156	--	22.8[A]	1,673[A]	113[A]	6,079[B]	48,211[C]
bis(2-Ethylhexyl)phthalate	NC	NC	--	156	33%	ND	82	ND	259	4,240
Butyl benzyl phthalate	NC	NC	--	156	12%	ND	101	ND	289	5,140
Carbazole	NC	NC	--	156	3%	ND	5.25	ND	ND	349
Dibenzofuran	NC	NC	--	156	5%	ND	20	ND	6.6	2,660
Di-n-butyl phthalate	NC	NC	--	156	3%	ND	30	ND	ND	4,360

Notes: µg/kg = micrograms per kilogram; NC = no criteria; ND = not detected; -- = not available.

Sources:

[1] NYSDEC 1999; [2] NYSDEC 1999; [3] Llanso et al. 2003

[A] Concentration falls within Class A - no appreciable contamination/no toxicity to aquatic life (NYSDEC 2004).

[B] Concentration falls within Class B - moderate contamination/chronic toxicity to aquatic life (NYSDEC 2004).

[C] Concentration falls within Class C - high contamination/acute toxicity to aquatic life (NYSDEC 2004).

Table 12
Results of Sediment Quality Analysis – Pesticides, PCBs, and Dioxins

Parameter	Sediment Criteria: ERL[1] (µg/kg)	ERM[1] (µg/kg)	BA- Chronic[1] (µg/gOC)	BA- Acute[1] (µg/gOC)	WA[1] (µg/gOC)	Hudson River Average[2]	Number of Samples Analyzed	Detection Rate	Minimum (µg/kg)	Average (µg/kg)	Median (µg/kg)	95th Percentile (µg/kg)	Maximum (µg/kg)
alpha-Chlordane	NC	NC	NC	NC	0.006	--	156	1%	ND	0.1	ND	ND	16
gamma-Chlordane	NC	NC	NC	NC	0.006	--	156	1%	ND	0.09	ND	ND	15
Chlordane (sum of above)	NC	NC	0.002	0.05		--	156	--	--	0.19[A]	--	--	31[B]
Dieldrin	NC	NC	17.0	NC	NC	--	156	1%	ND	0.03[A]	ND	ND	4.8[A]
4,4'-DDD	NC	NC	-	-	NC	5.7	156	14%	ND	2.07	ND	12	54
4,4'-DDE	2.2	27	-	-	NC	--	156	7%	ND	0.47	ND	3.85	17
4,4'-DDT	1	7	1	130	NC	19.7	156	5%	ND	2.47	ND	0.73	352
Sum of DDT, DDD, and DDE	1.58	46.1	-	-		25.4	156	--	--	5.01[B]	--	16.58[B]	423[C]
Aroclor 1242	NC	NC	NC	NC	NC	--	156	13%	ND	51	ND	280	1,520
Aroclor 1248	NC	NC	NC	NC	NC	--	156	8%	ND	35	ND	239	1,200
Aroclor 1254	NC	NC	NC	NC	NC	--	156	4%	ND	6.13	ND	ND	221
Total PCBs	22.7	180	-	-	NC	726.8	156	--	40[A]	169.95*[B]	64[A]	682.25[B]	1,520*[C]
TCDD TEQ (pptr)	NC	NC	NC	NC	0.0002	--	17	100%	0.069[A]	11.84[C]	0.89[A]	54.2[C]	94.67[C]

Notes: µg/gOC = micrograms per gram of organic carbon; µg/kg = micrograms per kilogram; NC = no criteria; ND = not detected; BA = Benthic Aquatic; WA = Wildlife Accumulation; -- = not available; - ERM/ ERL applies.

Sources:

1 NYSDEC1999

2 Llanso et al. 2003

* The sum of PCBs is multiplied by two to determine the total PCB concentration (NYSDEC 2004).

A Concentration falls within Class A - no appreciable contamination/no toxicity to aquatic life (NYSDEC 2004).

B Concentration falls within Class B - moderate contamination/chronic toxicity to aquatic life (NYSDEC 2004).

C Concentration falls within Class C - high contamination/acute toxicity to aquatic life (NYSDEC 2004).

6.2.2. Effects of Existing Bridge Demolition

Bridge demolition would occur in two stages. The first stage includes partial demolition to allow for construction of the replacement bridge in the vicinity of the Westchester shoreline. The second stage includes the remaining demolition after completion of the replacement bridge. Use of turbidity curtains during removal of the columns and footings and cutting of the timber piles would minimize the potential for sediment resuspended during the bridge removal activities to adversely affect water quality. Following removal of the existing bridge, sediment that has been deposited within mounds in the vicinity of the existing bridge piers may erode over time until reaching a new equilibrium elevation. Because the Tappan Zee portion of the Hudson River is considered to be neither a depositional or erosional environment (i.e., in equilibrium) (Nitsche et al. 2007), the erosion of these sediments in the vicinity of the existing bridge would be limited under normal river conditions and would most likely occur during high flow events. While some of these sediment deposits have elevated concentrations of certain contaminants (Class B or Class C categories), these elevated concentrations do not extend more than a few feet below the mudline. Therefore, the gradual erosion of some areas of contaminated sediment following the removal of the bridge would not be expected to result in adverse impacts to water quality or result in water quality conditions that fail to meet the Class SB standards.

Turbidity curtains would be used during removal of the columns and footings and cutting of the timber piles would minimize the potential for sediment that may be resuspended during bridge removal activities to affect benthic macroinvertebrates and other aquatic biota. Since the benthic sampling program for the project indicated similar benthic community structure in bottom sediments at both existing and proposed bridge location, and because the demolition is not expected to substantially alter sediment characteristics, the benthic community recolonizing the restored bottom habitat following bridge demolition would be expected to be similar to that lost as a result of dredging. Demolition of the existing bridge would also remove the benthic invertebrates and algae that are attached to the bridge, which provide forage and structural habitat for fish. However, the new bridge would offset much of these losses by providing similar structural habitat for these species. Any effects to shortnose sturgeon due to increased water column suspended sediments from bridge demolition activities are expected to be minimal and temporary, and would not be expected to materially affect shortnose sturgeon feeding opportunities or migrations.

6.2.3. Altered Predator-Prey Relationships

Shortnose and Atlantic sturgeon are benthic predators that forage in the substrate and consume primarily crustaceans, insects, mollusks and polychaete worms (Scott and Crossman 1973, Dadswell 1979, Pottle and Dadswell 1982, Dadswell et al. 1984, Bain 1994, Bain 1997, Bain 2001). Foraging habitat for both sturgeon species in the Hudson River is characterized by deep water and fine, silty sediments (Haley et al. 1996, Bain et al. 2000, Bain 2001) although shortnose sturgeon also feed in shallow areas and along river banks in water 1-5 meters deep, but concentrate in deeper water during late summer (Dovel 1978, Dadswell et al. 1984) where they remain during the winter months (Bain 1997). Within the study area, fine clayey silt substrates are common (**Figure 5**), but deep-water habitat is limited to the channel along the eastern shoreline. Despite the prevalence of fine sediment in the study area though, the primary sturgeon foraging habitat is located well upstream of the Tappan Zee region (Haley et al. 1996, Bain et al. 2000, Bain 2001). For sturgeon that forage within the study area, the most likely potential impacts of the Project are related to dredging of benthic feeding areas and habitat exclusion caused by pile-driving noise.

The dredging and armoring of the 165 to 175 acre (0.67 to 0.71 km2) access channel will create an area of reduced foraging opportunities for shortnose and Atlantic sturgeon during the construction period. However, the dredged area represents a comparatively small percentage of the available benthic area within the Tappan Zee region (1.2%) as defined by the Hudson River Utilities (RM 24-33), and an even smaller percentage of river-wide benthic area (0.2%). Because both sturgeon species typically forage at depths exceeding those in the proposed dredged location, this relatively shallow area is not likely to be preferred foraging habitat prior to dredging. Following dredging, water depths would still be relatively shallow at 4.3 m (14 feet) and the coarse gravel substrate used to armor the channel bottom would not likely support the preferred prey items of sturgeon. Benthic habitat outside of the dredged area would not be expected to change in terms of sediment grain size or forage opportunities for sturgeon.

Temporary habitat exclusion caused by pile driving noise is expected to create an ensonified zone that could be unavailable for foraging during certain periods of the day; however these periods would be limited to less than 12 hours daily during most pile driving, and less than 5 hours a day during the time period when large piles are driven. Although noise levels in these areas may restrict diurnal foraging opportunities during pile driving, both species of sturgeon are known to forage nocturnally and would still be able to use the ensonified area during the night. There would also be considerable foraging habitat available within the study area and outside of the dredged channel and the ensonified area. Shortnose sturgeon, in particular, are known to travel up to 13.5 km (8.4 miles) within a day (McCleave et al. 1977), which means that construction activities would not prevent foraging as sturgeon could move through the study area to unaffected foraging areas. The preferred foraging habitat in deep waters, specifically in the navigation channel, would remain available for foraging throughout the large majority of bridge construction based on the location and extent of modeled noise isopleths.

Atlantic sturgeon are less likely than shortnose sturgeon to be affected by potential loss of foraging habitat because their use the Hudson River is more intermittent. Adult females migrate directly to spawning grounds, which are deep, channel or off-channel habitats (Dovel and Berggren 1983) in the freshwater portions of the River, upstream of the study area (K. Hattala, pers. comm.). During the upstream spawning migration, females are thought to fast (Dadswell 1979, Smith 1985). Post-spawn Atlantic sturgeon remain in fresh water habitats upstream of the study area until emigration to coastal marine waters (Smith 1985). Furthermore, Atlantic sturgeon typically remain in water deeper than 7.5 meters (Bain et al. 2000). Therefore, use of the Tappan Zee region for foraging by Atlantic sturgeon adults is likely minimal and loss of benthic habitat due to dredging of the construction channel or from pile-driving noise is not likely to impact adult Atlantic sturgeon. Juvenile Atlantic sturgeon remain in the Hudson River for several years and are found primarily upstream of the study area between river kilometers 68 and 107 (RM 42 to 67) and in water depths from 10-25 meters (Bain et al. 2000), except from November through March when they occupy deep, channel habitats between km 19 to 74 (RM 12 to 45), which includes the study area (Dovel and Berggren 1983).

Several project-related factors reduce the likelihood of impacting sturgeon foraging in the study area, including the restricted schedule for pile driving and the relatively small area of unavailable foraging habitat within the 187 dB SEL_{cum} noise isopleths as well as the shallow depth and small spatial extent of the dredged access channel. These factors, coupled with the spatial distribution of juvenile and adult sturgeon and their primary foraging habitats within the Hudson River relative to the study area (i.e. primarily deep water and upstream) as well as the intermittent occupancy of the Hudson River by adult Atlantic sturgeon make it unlikely that any long-term indirect effects on sturgeon foraging would be realized as a result of the project’s construction.

6.2.4. Long-Term Habitat Alteration

The area where the Replacement Bridge Alternative will be constructed is neither shortnose nor Atlantic sturgeon spawning habitat. Both these species spawn well north of the Tappan Zee Bridge with the principal spawning area for the shortnose being as far north as Albany. However, dredging of the access channel will result in a temporary modification of benthic habitat. Over time deposition processes would allow much of the benthic habitat to return to its pre-construction state. The rate of this transformation would begin at approximately 1 foot per year, likely decreasing as the bed nears it natural pre-dredged elevation. The temporary loss of the access channel area would represent a minor fraction of similar habitat available to sturgeon throughout the Tappan Zee Reach. Except for the permanent loss of up to 0.05 km^2 (13 acres) of oyster habitat (discussed in Section 6.1.3) which would not be considered optimal shortnose sturgeon foraging habitat, and a 1.35 acre loss due to a permanent platform (discussed below), a long-term habitat alteration would not occur.

The DEIS indicated that construction of the permanent platform along the Rockland County shoreline would result in the loss of 2.16 acres of benthic habitat. Revisions to the construction plans since the DEIS was drafted have reduced the acreage of habitat loss due to the permanent platform to 1.35 acres. The area of permanent habitat loss is equivalent to <0.01% of the available soft-sediment benthic habitat in the Tappan Zee region (RMs 24-33), as defined by the Hudson River Utilities. The permanent platform will be constructed in water depths of 6-10 feet and will extend out from the Rockland County shoreline along the upstream edge of the proposed bridge. The platform will be located approximately 1.5 miles from the 20-ft depth contour and the edge of the navigation channel.

The habitat in which the permanent platform will be located is outside of the habitat typically used by shortnose and Atlantic sturgeon. Within the Hudson River, both species of sturgeon are found in greatest abundance between West Point (RM 47) and points upriver from there. Greater than 90% of all individuals reported from Utilities Fall Shoals surveys were collected upstream of the Tappan Zee region; the majority (>80%) of those collected within the Tappan Zee region were collected upstream of RM 28 and the project area. Throughout the

Hudson River and within the Tappan Zee region specifically, both species are most frequently collected in benthic habitats at depths exceeding 20 feet (Sweka et al. 2007, Utilities Fall Shoals data) and over soft sediments. Within the construction area, the majority (9 of 12) of shortnose sturgeon collected during gill-net sampling in 2007 and 2008 were collected at depths greater than 10 feet. Furthermore, NMFS has previously determined that shortnose and Atlantic sturgeon are not likely to use water depths <13 feet in the Tappan Zee region for feeding, overwintering, resting, thermal refuge during summer and would not likely be adversely affected by construction activities occurring greater than 1 mile from the navigation channel (NMFS 2011d). Given the spatial and depth distribution of both sturgeon species within the Hudson River, the relatively low abundance of sturgeon within the Tappan Zee region and their preference for deeper habitats, it is unlikely that the majority of Hudson River sturgeon will be adversely affected by the construction of, or loss of habitat associated with the permanent platform.

6.3. Cumulative Effects

The assessment of cumulative effects addresses the potential impacts from the project and other projects proposed within, or in the vicinity of, the study area that may affect shortnose and Atlantic sturgeon. The proposed Champlain Hudson Power Express Inc. cable project and the American Sugar Refining, Inc. maintenance dredging project are the projects identified for evaluation of cumulative effects with the Tappan Zee Replacement Bridge Alternative. At the present time, US Gypsum, located upriver within Haverstraw Bay, is not expected to dredge its Stony Point facility and is not, therefore, evaluated with respect to cumulative impacts for the Replacement Bridge Alternative.

Champlain Hudson Power Express Inc. filed an application for a Certificate of Environmental Compatibility and Public Need Pursuant to Article VII of the Public Service Law of New York State. The Applicant is proposing to construct and operate a 1,000 MW submarine, underground, high-voltage, direct current, cable transmission system which will transport power from Canada and upstate New York to load centers in the New York City metropolitan area. The proposal calls for burying cables within two separate trenches 6 feet apart along a 118-mile stretch of the Hudson River that includes the study area for the Tappan Zee Replacement Bridge Alternative. Within the study area, the cables would be buried through the use of water jetting, where possible, and by hydroplow or dredging where water jetting is not feasible (i.e., within Haverstraw Bay).

Depending upon the proposed timing of the submarine cable installation, there is a potential for conflict between the competing activities of the cable and Replacement Bridge Alternative that would need to be resolved for the portion of the cable that would be traversing the study area. Water jet embedment as a technique for underwater cable installation is considered to have temporary and minimal impacts to aquatic resources compared to dredging. This is because the trench (four feet deep and two feet wide) created by the jetting device for each cable and its installation would only result in a temporary disturbance of the river bottom (ESS 2011). The associated increase in suspended sediments would also be expected to be short-term and localized because much of the resuspended sediments would be contained within the limits of the trench wall, with only a minor percentage of the re-suspended sediments leaving the trench. Any re-suspended sediments leaving the trench would be expected to settle out within proximity of the trench depending on sediment grain size, composition, water currents and the hydraulic jetting forces imposed on the sediment column (HDR/DTA, April 2010, *Champlain Hudson Power Express HVDC Transmission Project*, *Least Environmentally Damaging Practical Alternative Evaluation*, Prepared for Champlain Hudson Power Express, Inc., Toronto, Ontario, http://www.chpexpress.com/docs/regulatory/USACE/CHPE_USACE_Application_Apendices.pdf).

Water jetting would potentially result in the loss of some benthic organisms unable to move from within the footprint of the trench, due to direct contact with the water jet or an inability to tolerate burial. The benthic community within the disturbed area would be expected to recover following completion of the trenching process (Ocean Surveys, Inc. 2005 in HDR/DTA 2010). Finfish would be expected to avoid areas of temporarily increased suspended sediment (HDR/DTA 2010). Within the study area, the proposed cable project would not have the potential to affect shortnose or Atlantic sturgeon spawning habitat.

Cumulative adverse impacts to shortnose and Atlantic sturgeon are not expected as a result of the cable project and maintenance dredging activities with the Replacement Bridge Alternative although project details would need to be forthcoming and potential impacts more rigorously evaluated by regulatory agencies. Collectively, these projects would not have the potential to affect spawning habitat within the study area. The limited duration and area of disturbance resulting from cable installation within the study area would not be expected to result in changes in water quality (i.e., increases in suspended sediment) or result in long-term changes to aquatic habitat. Furthermore, the cumulative activities of these projects are not expected to adversely affect shortnose sturgeon foraging or migration through the study area for either sturgeon species. Should dredging be required for the installation of the cable in Haverstraw Bay, the distance between the study area and Haverstraw Bay is greater than 5 miles and outside the projected area of incremental increase in suspended sediment due to the project and would not result in cumulative adverse impacts to water quality within the study area. Therefore, cumulative adverse effects to water quality would not be expected to occur from construction of the cable project and the Tappan Zee Hudson River Crossing Project.

American Sugar Refining, Inc. received authorization from the NYSDEC and the USACE to conduct maintenance dredging (approximately 80,000 cubic yards) within an approximately 5-acre berth area (approximately 650- to 850-feet long and extending into the river from the shoreline for about 300 feet) located about 14 miles downriver from the study area. The NYSDEC permit expires on October 31, 2016. It restricts dredging to the period of July 1 to October 31 and requires that anti-sedimentation curtains (floating boom with attached silt curtain with a minimum 3-ft depth) be deployed around the spoil-receiving barge and the mechanical dredge during dredging to minimize dispersal of dredged material. Dredge material was determined to meet the requirements for disposal at the Historic Area Remediation Site (HARS) and would be transported to the HARS in bottom-opening barges.

Maintenance dredging by American Sugar Refining, should it occur concurrently with dredging for the project, would be at least 14 miles down-river. This distance is far beyond the 1,000 to 2,000 feet over which the incremental increase in suspended sediment of 10 mg/L due to the Replacement Bridge Alternative has been projected by the hydrodynamic modeling and beyond the 5 mg/L incremental increase in projected suspended sediment.

The area of maintenance dredging for American Sugar Refining extends only 300 feet into the river from the east bank and does not extend into the navigation channel. Therefore, the three projects would not be expected to result in cumulative adverse impacts to migration of shortnose sturgeon, Atlantic sturgeon, or other anadromous fish species.

Chapter 7 Biological Assessment for Transport to and Placement of Project Dredged Material at HARS

7.1. Introduction

As discussed in Section 4.2.3, "Transport and Disposal of Dredged Material," there is a preference that the dredged material from construction of the access channel be disposed of at the HARS. Transport by ocean scow and placement in the HARS in the New York Bight would offer a number of benefits to the project including cost, schedule, logistics and the avoidance of impacts to the surrounding residential communities on the Rockland and/or Westchester shorelines. Because this option is being considered, a biological assessment and effects determination for the transport to, and placement of Remediation Material at the HARS is needed for the recently listed Atlantic sturgeon, which spend a considerable portion of their lives in coastal waters.

This chapter provides:

- an overview of HARS, describing its location, the history of the site and the regulatory agencies responsible for its remediation through the placement of dredged material;
- identifies the permits required for placement of dredged material at HARS and criteria related to contaminants that must be met for placement;
- identifies the environmental reviews and consultations that have been undertaken for remediation of HARS;
- summarizes the existing habitat at the HARS;
- identifies the volume and characteristics of dredged material from the project that would be placed at the HARS as Remediation Material;
- evaluates potential direct, indirect and cumulative impacts to Atlantic sturgeon due to transport and placement of dredged material from the project at the HARS.

7.2. Background

The HARS is located approximately 4 miles (3.4 nautical miles) east of Highlands, New Jersey and about 9 miles south of Rockaway, Long Island. It comprises about 20 square miles within the apex of the New York Bight[1] that includes the approximately 3-square-mile Mud Dump Site (MDS). Over the past century, dredged material from the Port of New York and New Jersey was routinely disposed of at the MDS. The USEPA formally designated the MDS as an "interim" ocean dredged material disposal site in 1973, and gave it final

[1] The New York Bight is a region defined as ranging from Cape Cod, MA, to Cape May, NJ, and includes Buzzard's Bay, Long Island Sound, New York Harbor and the New Jersey shore (http://web2.uconn.edu/seagrantnybight/).

designation in 1984. On September 29, 1997, the USEPA under 40 CFR §228, closed MDS and simultaneously re-designated the site and surrounding areas that were used historically as disposal sites for contaminated dredged material as the Historic Area Remediation Site (HARS), and proposed that the site be managed to reduce impacts to acceptable levels (in accordance with 40 CFR §228.1(c)) (62 FR 46142) through remediation with uncontaminated dredged material (Remediation Material)(i.e., dredged material that meets current Category I standards[1] and will not cause significant undesirable effects, including through bioaccumulation)(USACE and USEPA 2009). USEPA published final rule 67 FR 62659 on March 17, 2003, to modify the designation of the HARS to establish a HARS-specific worm tissue polychlorinated biphenyl (PCB) criterion of 113 parts per billion (ppb) for use in determining the suitability of proposed dredged material for use as Remediation Material. This amendment to the HARS designation established a pass/fail criterion for evaluating PCBs in worm tissue from bioaccumulation tests performed on dredged material proposed for use at HARS as Remediation Material (USACE and USEPA 2009).

The HARS comprises three areas (see Figure 30): Priority Remediation Area (PRA), a 12 square-mile (9 square nautical miles) area to be remediated with at least about 3 feet (1 meter) of Remediation Material which is divided into 9 areas; a Buffer Zone, a 0.3-mile-wide (0.27 nautical miles) band around the PRA in which no placement of Remediation Material will be allowed, but may receive Remediation Material that incidentally spreads out of the PRA; and No Discharge Zone, an approximately 1.3-square-mile (1 square nautical mile) area in which no placement or incidental spread of Remediation material is allowed. From 1997 through December 2008, approximately 36 million cubic yards (MCY) of Remediation Material from 61 dredging projects have been placed at HARS as part of the remediation. These remediation projects have included private and Federal maintenance dredging and private and federal deepening projects, with the majority of the Remediation Material (approximately 26 MCY) from Federal Deepening projects. Of the nine PRAs at HARS, only the western PRAs (PRAs 1 through 4) have been remediated. As of 2008, about 13 percent, 17 percent, 64 percent, and 86 percent of the area in PRAs 1, 2, 3, and 4, respectively, and PRAs 5 through 9 are available for Remediation Material.

U.S. Army Corps of Engineers (USACE) New York District and the U.S. Environmental Protection Agency (USEPA) Region 2 jointly manage the HARS in accordance with the *Site Management and Monitoring Plan for the Historic Area Remediation Site* revised May 5, 2009 (SMMP) (USACE and USEPA 2009). The SMMP:

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[1] USEPA Region 2 and USACE New York District classify dredged material into three categories on the basis of sediment toxicity and bioaccumulation tests:

- Category I: Sediments that meet ocean disposal criteria. Test results indicate no unacceptable toxicity or bioaccumulation. These sediments are acceptable for "unrestricted" ocean disposal. There are no potential short-term (acute) impacts or long-term (chronic) impacts; no special precautionary measures are required during disposal.

-Category II: Sediments that meet ocean disposal criteria. Test results indicate no significant toxicity but a potential for bioaccumulation. To protect from this potential, EPA and the USACE will require appropriate management practices such as capping. This is referred to as "restricted" ocean disposal.

-Category III: Sediments that do not meet ocean disposal criteria. These sediments are those that fail acute toxicity testing or pose a threat of significant bioaccumulation that cannot be addressed through available disposal management practices. These sediments cannot be disposed in the ocean.

- provides guidelines to document remediation of required areas within the HARS resulting from placement of an approximately 3-foot (1 meter) minimum required cap thickness of Remediation Material;
- specifies the collection of data to ensure that no significant adverse environmental impacts occur from the placement of Remediation Material at the HARS;
- enforces compliance with Marine, Protection, Research and Sanctuaries Act of 1972 (MPRSA) permit conditions;
- provides a baseline assessment of conditions at the HARS;
- provides a program for monitoring the HARS;
- describes special management conditions/practices to be implemented at the HARS;
- specifies the quantity of Remediation Material to be placed at the HARS ant the presence, nature, and bioavailability of the contaminants in Remediation Material;
- specifies the anticipated use of the HARS, including the closure date; and
- provides a schedule for review and revision of the HARS SMMP.

7.3. Permitting at HARS

Under MPRSA, the USACE and USEPA share responsibility for permitting and HARS designation and management. Placement of dredged material as Remediation Material at the HARS requires a permit from USACE under Section 103 of the MRPSA, subject to USEPA review and concurrence that the material meets applicable ocean disposal criteria. To receive the permit, the materials must be suitable for remediation, in that they meet certain criteria related to contaminants based on sediment toxicity and bioaccumulation tests. In addition, in accordance with 40 CFR §227.16, the USEPA must evaluate alternative disposal options before permitting placement of dredged material at the HARS, and must find that there are no practicable alternative locations and methods of disposal or recycling available. In support of this required finding, an alternatives analysis can be found in Appendix F-4 to the Draft Environmental Impact Statement for the Tappan Zee Hudson River Crossing Project documenting that there are no practicable alternative locations for the placement of the dredged material other than at the HARS site.

7.4. NEPA and Section 7 Consultation

Pursuant to the National Environmental Policy Act (NEPA) the USEPA Region 2 prepared a Supplement to the Environmental Impact Statement (SEIS) on the Dredged Material Disposal Site Designation for the Designation of the HARS (USEPA 1997). Consultations pursuant to Section 7 of the Endangered Species Act (ESA) have taken place for the area of the HARS during preparation of the SEIS. The USEPA prepared a biological assessment that concluded that the closure of the Mud Dump Site and designation of the HARS would not be likely to adversely affect loggerhead and kemps ridley sea turtles and humpback and fin whales (USEPA 1997). Special conditions are included in USACE Section 103 permits for placement of Remediation Material at HARS that requires the presence of NMFS approved Endangered Species Observer(s) on disposal scows during their trips to the HARS. The role of these observers is to prevent adverse impacts to endangered or threatened species transiting the area between the proposed dredge site and the HARS. With the implementation of these conditions placement of Remediation Material at the HARS would not result in adverse impacts to previously listed endangered or threatened species. However, on February 6, 2012, NMFS promulgated regulations to list the New York Bight Distinct Population Segment (DPS) of Atlantic sturgeon as endangered under the ESA with an effective date of April 6, 2012. An effects determination for the placement of Remediation Material at the HARS is therefore, included in this BA for Atlantic sturgeon.

7.5. Existing Habitat at the HARS

The HARS is located on the shallow continental shelf within the New York Bight. Water depths at the HARS range from 46 to 138 feet. Circulation in the New York Bight is complex with temporal and regional variability. Low frequency meteorological forcing, over 3 to 10 day periods, is responsible for much of the current fluctuations over the shelf. During spring and summer the wind energy is reduced and the water column is tratified. The magnitude of the currents increases with the distance offshore and decreases with depth (Beardsely and Boicourt 1981 in USACE 2002). Circulation in the Bight is dominated by a relatively slow flow to the southwest (0.1 feet per second (fps)) with an occasional clockwise bottom gyre. The southerly flow of the Hudson River plume along the New Jersey shoreline forces an opposing northward flow of more saline waters to the east (USEPA 1982 in USACE and USEPA 2009). Near bottom oscillatory tidal currents at the HARS are relatively weak, with maximum speeds of 0.3 fps. Mean currents are also less than 0.3 fps with directions that are dependent upon location, water depth and bottom topography (SAIC 1994b in USACE and USEPA 2009). Surface waves are generally less than about 7 feet in height except during major storms which are most common in the fall and winter (SAIC 1995 in USACE and USEPA 2009). Wave-induced near-bottom currents are greater than 0.7 fps only when surface wave heights are greater than 10 feet and storm centers are to the east or southeast. These wave conditions would occur less than 3 percent of the time in fall and winter, and less than 1 percent of the time in spring and summer (SAIC 1994a in USACE and USEPA 2009).

Maximum salinities (33 to 34 ppt) occur inshore during the winter (February and March) when sub-freezing conditions reduce river runoff. Surface salinity, particularly near shore decreases with spring thaw and strong vertical gradients may develop. In summer, surface salinities are at the annual minimum (27 to 31 ppt) with bottom salinities of 27 to 29 ppt (USEPA 1982 in USACE and USEPA 2009). Turbidity is low through the water column with a small mid-depth maximum in the central portion of the HARS. The effects of dredged material placement on water quality of the New York Bight have been observed to be minimal, with contaminant concentrations in disposal plumes at the MDS dissipating quickly (less than one hour) to background levels. While plume behavior varies with the grain size of the dredged material, total suspended solids near the center of the dredged material placement plume body have been observed to reach near background levels in 35 to 45 minutes (Battele 1994 in USACE and USEPA 2009). Dissolved oxygen are consistently above 2.0 milligrams per liter (USACE 2002).

Use of the New York Bight Apex as a disposal area over the past 100 years has influenced sediment characteristics within the HARS (USACE 2009). The HARS is dominated by mounded dredged material that rises up to 40 feet from the historic sea floor in some areas (USEPA 1997 in USACE 2002). Surface sediments are heterogeneous, ranging from areas dominated by muddy (fine-grained) sediments to areas covered with coarse sediments (primarily sand) at the former cellar dirt site (USACE 2002). Toxicity testing of the sediments at HARS using amphipods found a wide range of survival percentage (Battele 1996 a in USACE 2002). Sediments exhibiting significant toxicity were generally located across the middle of the HARS (USACE 2002).

Sampling of benthic invertebrates within the HARS indicated the majority of the species to be annelids (61 percent, including *Prionospio steenstrupi*, a surface deposit feeder, *Polygordius*, and *Pherusa*, a surface deposite feeder) followed by crustaceans (17 percent) and mollusks (11 percent) (USACE and USEPA 2009).
The New York Bight Apex is a transitional region for many species of fish and shellfish. Finfish known to occur in the region include:

- Demersal species—silver hake, red hake, yellowtail flounder, scup, summer flounder, winter flounder, tautog, cod, black sea bass, little skate, windowpane flounder, four spot flounder, ocean pout, cunner, spiny dogfish, spotted hake, northern sea robin, gulf stream flounder, sea raven and longhorn sculpin.
- Pelagic species—butterfish, Atlantic herring, bluefish, and weakfish.
- Pelagic/Anadromous—American shad, alewife and striped bass (USACE and USEPA 2009).

Shellfish include surf clam, sea scallop, American lobster, long-finned squid, rock crab, horshoe crab, short-finned squid, and jonah crab (USACE and USEPA 2009).

7.6. Placement of Dredged Material at the HARS from the Project

Remediation Material has been placed at the HARS since at least 1998. Permit and contract specifications require placement at pre-determined locations within the HARS. Since development and installation of the Automated Disposal Surveillance System (ADISS) monitoring/positioning systems aboard scows and tugs, discrete placement grids have been used for organized placement at the HARS. ADISS allows placement at designated latitude-longitude coordinates. Specific grid coordinates and instructions/requirements are contained in the Department of the Army permits issued by the USACE. Placement of Remediation Material within the nine PRAs (approximately 1 square nautical mile) is managed in priority order, beginning with PRA-1 and ending with Area 9. Use of a particular PRA may be discontinued upon completion of remedial activities and demonstration that at least a 1 meter cap of Remediation Material has been placed over the entire area. Placement is occurring in several phases within each area to allow consolidation of sediments and assessment of coverage. The USACE, using the STFate numerical model, determine the distance from the HARS border where material can be placed such that water quality standards are not exceeded. Most maintenance dredging projects, which are predominantly composed of silt and clay, have been used to remediate the central and eastern portions of HARS PRAs 1, 2, and 3 and the northern portion of PRA 4. Remediation Material that is mostly sand and dredged rock has been used to remediate areas closer to the outer edges of PRAs 1 through 3 (USACE and USEPA 2009).

The grid area designated for placement is proportional to the estimated volume of material for remediation associated with each project with higher volume projects using larger area grids. Grid cells are typically 250 feet by 500 feet, with cells of 100 to 150 feet by 100 to 200 feet used for coarse material. The goal is to provide 0.5 to 3 feet of coverage within a grid during each dredging project. If an area has been used for placement of maintenance mud, usually the area is not used for additional placement for a year to allow compaction and dewatering of the mud. Grids for concurrent projects are spaced far enough apart, at least 3280 feet if one grid is due north of the other, to avoid vessel interference during placement (USACE and USEPA 2009).

As presented in Table 1, dredging would be conducted in three stages, each stage conducted during a separate dredging season occurring within a three-month period from August 1 to November 1. For the Long Span Option, the option with the higher dredging quantities, approximately 1.12 MCY would be dredged during Stage 1, 0.43 MCY during Stage 2, and 0.19 MCY during Stage 3, for a total of 1.74 MCY. This volume is about 5 percent of the volume of Remediation Material placed at the HARS in PRAs 1 through 4 as of December 2008.

As discussed in Section 3.1.2, Hudson River bottom sediments in the study area are primarily clayey silt, similar to much of the sediment within the HARS and already evaluated by the USEPA and the USACE with respect to water quality effects during placement. Additionally, the dredged material from the project would only be placed at HARS as Remediation Material if it is determined to meet the Category I sediment criteria, and therefore, would not cause significant undesirable effects to aquatic biota, including through bioaccumulation. The dredged material would be placed at the location and in accordance with the placement protocols that would be specified in conditions issued by the USACE in the permit for the project. Therefore, increases in suspended sediment and concentrations of contaminants that may be released due to placement of the dredged material from the project within the HARS would be expected to dissipate rapidly and would not result in adverse impacts to water quality or result in adverse effects to Atlantic sturgeon and other aquatic biota due to changes in water quality. Similarly, the location for placement selected by the USACE, would be determined on the basis of the sediment characteristics developed thru sediment sampling conducted as part of the Section 103 permit application, and would not be expected to adversely affect water quality outside the mixing zone established for the HARS.

7.7. Potential Effects to Atlantic sturgeon of Transport to, and Placement of Category I Dredged Material at the HARS

Details regarding transport of the dredged material (e.g. size and number of ocean scows per unit of time) have not yet been fully developed and will be finalized by the contractor.

However, vessel strikes between Atlantic sturgeon and loaded dredge material barges or their tugboats transiting to and from the HARS are considered unlikely. These vessels are towed at low speeds and are probably easily avoided by large fish such as Atlantic sturgeon. The USEPA (1997) reached similar conclusions regarding the potential for vessels transporting material to the HARS for interacting with threatened or endangered whales and sea turtles. Since Atlantic sturgeon are bottom feeders interactions with vessels would not occur during foraging. Furthermore, the USACE incorporates a special condition within permits authorizing placement of dredged material at the HARS that requires the presence of a NMFS approved Endangered Species Observer on disposal scows during their trips to the HARS (USACE 2005b). The role of these observers is to prevent adverse impacts to threatened or endangered species transiting the area between the proposed dredge site and the HARS. As long as established protocols for protected species are implemented (e.g. NMFS approved Endangered Species Observers on the disposal scow, speed restrictions) there should be minimal risk to interactions with Atlantic sturgeon during transport to and from the HARS.

The USACE prepared a programmatic EFH for placement of Category 1 Dredged material at the HARS (USACE 2002), which was reviewed by NMFS. The Programmatic EFH for the HARS assessed the potential effects of the placement of Category I dredged material on the managed fish species identified as having EFH within the HARS (USACE 2002). Many of these effects would be expected to be similar to potential effects that could be experienced by Atlantic sturgeon.

As evaluated in the programmatic EFH, direct impacts to fish during placement of the dredged material at the HARS would be expected to be minimal due to the small contact footprint of the fluidized sediments as they leave the barge (typically 50 foot by 100 foot). Similarly, direct effects to Atlantic sturgeon would also be expected to be minimal. Remediation Material is placed sequentially in a predetermined grid, resulting in continuous remediation in one zone rather than random placement increasing the chance of avoidance of Atlantic sturgeon using the area, and noise from vessels repetitively working in one area would further increase the likelihoods that Atlantic sturgeon and other fish would leave the area receiving placement of material.

Because there would be sufficient similar habitat available nearby with similar benthic invertebrates, adverse effects due to loss of prey species would not be expected to occur to Atlantic sturgeon. It is anticipated that these Atlantic sturgeon would avoid the Remediation Material and plume, and simply relocate to neighboring waters. Because the characteristics of the sediment from the project would be similar to those in and around the HARS, benthic invertebrates would be expected to quickly recolonize the cells used for the placement of this material.

Effects to foraging ability of Atlantic sturgeon could result from the burial of the benthic community with Remediation Material and temporary increases in suspended sediment. However, this loss of potential benthic prey species would be minimized spatially and temporally through use of a grid system for the placement of Remediation Material. Although the placement of Remediation Material would have the potential to result in increased turbidity and contaminant concentrations, these effects are typically short-lived (less than one hour) and would cause no more than minimal impact on bottom communities (USACE 2002). Furthermore, recolonization of a healthier benthic community would occur by those benthic individuals able to unbury themselves and recolonization by individuals from nearby similar habitats.

The placement of Remediation Material could result in indirect effects through minor changes in bathymetry (not more than 3 feet) which would not be expected to adversely affect the suitability of the sediment for benthic invertebrates on the basis of depth or light penetration. Benthic invertebrates contained in the dredged material from the project would have the potential to provide additional prey for any Atlantic sturgeon using the habitats in the vicinity of the cells receiving placement of the Remediation Material.

The cumulative impacts resulting from placement of Remediation Material at the HARS would be beneficial because the “remediation of the HARS will result in an improved benthic community, and ultimately, improvement of the fishing and shellfishing resources of the New York Bight” (USACE 2002). Given the large area of the HARS still available for remediation purposes, placement of the dredged material from the project concurrent with placement of material from other projects would not be expected to result in adverse effects to Atlantic sturgeon.

The programmatic EFH for the HARS indicated that, “The remediation of the HARS with Category I sediments is the most expeditious means of eliminating the potential risk associated with contaminated sediments of the Priority Remediation Area. Decreased contaminant toxicity and bioavailability to fish and shellfish resources will greatly reduce the risk to biota of the New York Bight. The planned remediation will also prevent dispersion of degraded sediments from the seafloor as a result of resuspension due to high-energy events.” Placement of Category I dredged material at the HARS was determined to result in “no more than minimal impact to Essential Fish Habitats” for the species evaluated and that “remediation efforts at the HARS should be conducted without the need for seasonal restrictions or mitigation measures to protect habitat or individual species” (USACE 2002). Remediation of the HARS would have a similar positive effect for any Atlantic sturgeon that might use the region for foraging or passage.

Finally, the HARS may not be optimal habitat for Atlantic sturgeon. An analysis of data from five fishery independent surveys (Dunton et al. 2010) indicated that depth was the primary environmental characteristic defining coastal Atlantic sturgeon distribution. They defined essential habitat for Atlantic sturgeon as being coastal waters less than 20 meters in depth, concentrated in areas adjacent to estuaries such as Hudson River-New York Bight. Dunton et al. (2010) indicated that this narrow band of shallow coastal water (located closer to shore than the HARS) appears to represent an important habitat corridor and potential migration path. The data indicated most of the regional sturgeon catches were collected closer to the Sandy Hook and Rockaway shorelines, located west and north of the HARS, respectively. While water depths in the HARS ranges from 12-40 m in depth, the vast majority of the HARS is greater than 20 m in depth, and therefore, not likely to be widely used by Atlantic sturgeon, although Atlantic sturgeon have been reported to occur in deeper waters. For example, Stein et al. 2004 indicated that the depth of Atlantic sturgeon bycatch varied by region, being captured in depths of less than 25 m along the mid-Atlantic Bight and in deeper waters in the Gulf of Mexico and Cape Cod, where bycatch was still common down to 65 m.

Chapter 8 Effect Determinations

8.1. Effect Determination for Listed and Proposed Species

The results of this BA indicate that:

1. For individual shortnose and Atlantic sturgeon within the immediate vicinity of pile driving and other in-water construction activities, there is a potential for injury.

2. There is potential for interaction with the clamshell dredge that could result in injury to a limited number of shortnose and Atlantic sturgeon.

3. Pile driving and dredging would have minimal effects to sturgeon migratory activities as there will always be large portions of the river width that will not be ensonified, and dredging will be limited to three month windows that will take place between August 1 and November 1 during three of the 4 ½ or 5 ½ construction years.

4. There is no designated critical habitat for shortnose sturgeon or Atlantic sturgeon.

5. Dredging of 0.67-0.71 km^2 (165-175 acres) for access channels will create an area of reduced foraging opportunities for both shortnose and Atlantic sturgeon due to loss of habitat. However, upon completion of in-water activities in a given area, estuarine depositional processes would, over time, allow the benthic habitat to return to its pre-construction condition. The temporary loss of the access channel area would represent a minor fraction of similar habitat in the Tappan Zee portion of the Hudson River.

6. Incidental vessel strikes will be insignificant because sturgeon are generally found within one meter of the bottom in the deepest available water. Based on the types of vessels to be employed and their drafts, there should always be sufficient clearance between vessels and the river bottom.

7. Indirect effects from resuspended sediments are expected to be insignificant.

8. The loss of 2.16 acres of bottom habitat associated with the permanent platform would not result in meaningful direct or indirect effects to shortnose or Atlantic sturgeon. The permanent platform will be located in 6-10 feet of water along the western edge of the river approximately 1.5 miles from the 20-ft depth contour, and is not located in primary habitat for sturgeon migration, foraging, or overwintering.

9. A review of the literature indicates that the likelihood of the project to affect the four other DPS of Atlantic sturgeon in any meaningful way is low. The Biological Opinion for the Pile Installation Demonstration Project (NMFS 2012) indicated that 92% of the Atlantic sturgeon in the action area would have originated from the New York Bight DPS, 6% from the Gulf of Maine DPS, and 2% from the Chesapeake DPS.

10. Marine mammals rarely occur in the project area and only as transients in this portion of the Hudson River. Because this portion of the Hudson River does not provide areas for spawning, nursery, or overwintering, or migratory pathways for these species, any anthropogenic sound in the river is not expected to result in adverse effects to the movement, reproduction, feeding, or sustained population of marine mammal species.

11. The transport to, and placement of project dredged material at the HARS will present minimal risks to Atlantic sturgeon, provided established protocols and permit conditions are followed.

The BA concludes that while the Replacement Bridge Alternative may potentially injure or result in mortality to some individual shortnose and Atlantic sturgeon in the immediate vicinity of the pile driving resulting in an incidental take, and dredging and armoring of the bottom will result in a temporary reduction in foraging opportunities, the project will not jeopardize the continued existence of the shortnose or Atlantic sturgeon populations of the Hudson River.

Based on the fact that marine mammals are rare, transients to the study area, the proposed project will not jeopardize the continued existence of the marine mammal species that have been reported in the Tappan Zee reach of the Hudson River.

There is a possibility that the Historic Area Remediation Site (HARS) will be used for the disposal of the project's dredged material. Consultations pursuant to Section 7 of the Endangered Species Act (ESA) have taken place for the area of the HARS during preparation of the SEIS. The USEPA prepared a biological assessment that concluded that the closure of the Mud Dump Site and designation of the HARS would not be likely to adversely affect loggerhead and kemps ridley sea turtles and humpback and fin whales (USEPA 1997). Special conditions are included in USACE Section 103 permits for placement of Remediation Material at HARS that requires the presence of NMFS approved Endangered Species Observer(s) on disposal scows during their trips to the HARS. The role of these observers is to prevent adverse impacts to endangered or threatened species transiting the area between the proposed dredge site and the HARS. With the implementation of these conditions placement of Remediation Material at the HARS would not result in adverse effects threatened or endangered species, also including marine mammals.

8.2. Effect Determination for Critical Habitat

There is no designated critical habitat for the shortnose or Atlantic sturgeon. As a consequence, there will be no effect on critical habitat.

8.3. Overall Effect Determination

Overall project effects are summarized below in **Table 13**, which lists affected species and major project elements, as well as the effect determinations associated with each.

Table 13
Overall Project Effects

Jurisdiction	Federal Status	Common Name	Effect Determination					
			Pile Driving	Interaction with Dredge	Permanent Loss of Habitat Due to Dredging	Vessel Traffic	Sediment Resuspension	Overall Project
NMFS	Endangered	Shortnose Sturgeon	Likely to adversely affect	Likely to adversely affect	No effect	No effect	No effect	Likely to adversely affect
NMFS	Proposed for Listing	Atlantic Sturgeon	Likely to adversely affect	Likely to adversely affect	No effect	No effect	No effect	Likely to adversely affect
NMFS	Various	Marine Mammals	No effect	No effect	No effect	No effect	No effect	No effect

8.3.1. Reasonable and Prudent Measures to Minimize Take

As outlined previously, every effort will be made to ensure that the potential for incidental take of Atlantic and shortnose sturgeon is minimized by observing a number of environmental commitments and assurances. Briefly, these include: 1) pilot testing of various noise abatement and sediment containment measures during the PIDP, 2) reduction of noise impacts through the implementation of BMPs and by limiting the duration of pile-driving activities with impact hammers, particularly during biologically significant time periods (e.g., spawning migrations), 3) use of vibratory hammers to the fullest extent possible, 4) maintenance of a minimum 5,000-ft corridor of passage outside of the ensonified area to allow fish migration through the study area, 5) minimization of suspended sediments using cofferdams and silt curtains, 6) monitoring of water quality, water quality and sturgeon for injury and mortality during pile-driving to ensure re-consultation with NMFS if warranted, and, 7) use of a clamshell dredge and limiting dredging to a three-month period from August 1 to November 1 for the three years of the construction period in which dredging would occur, and 8) development of a comprehensive monitoring plan.

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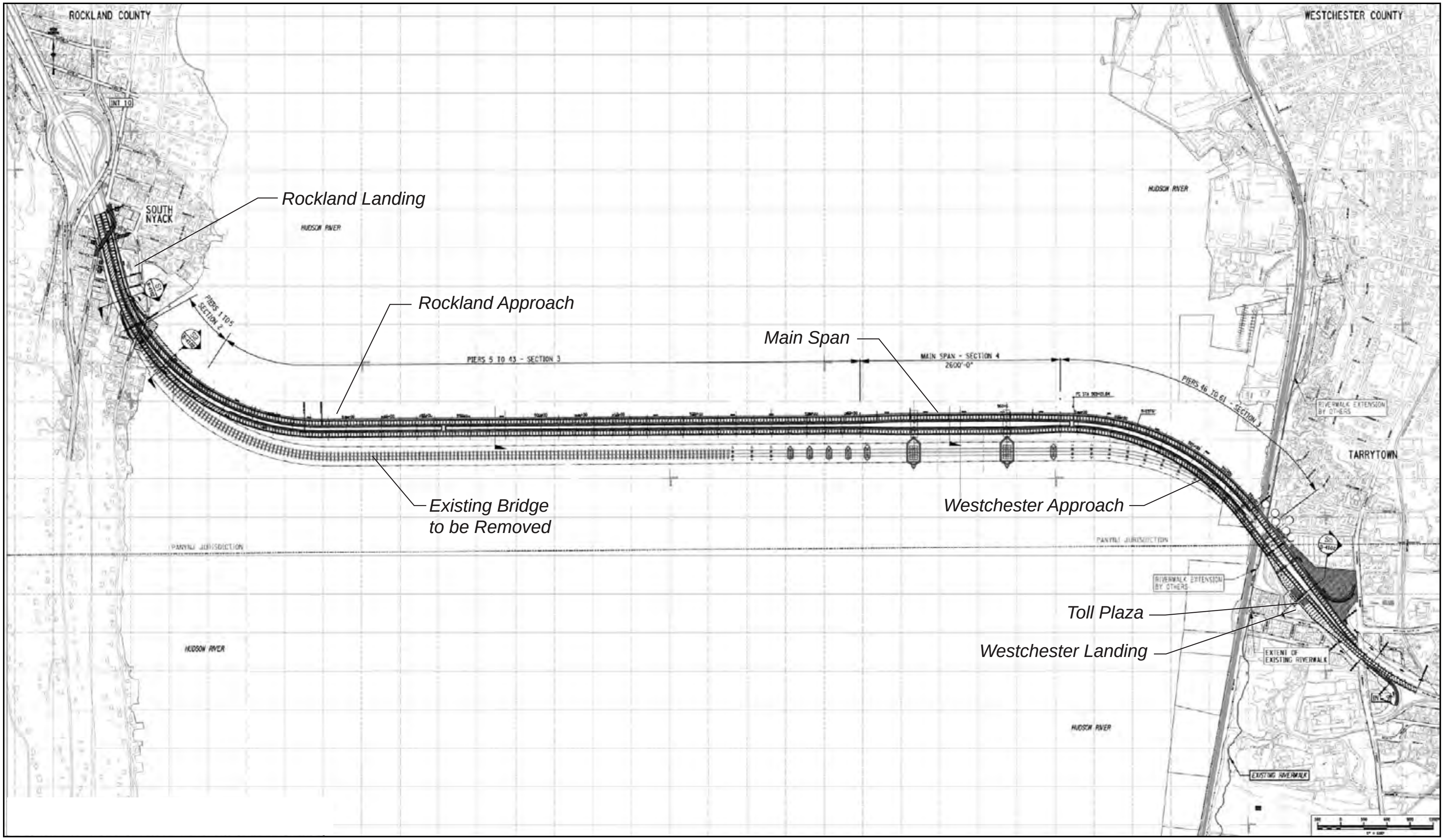
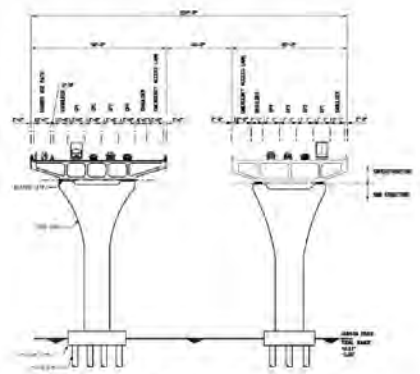


Figure 1

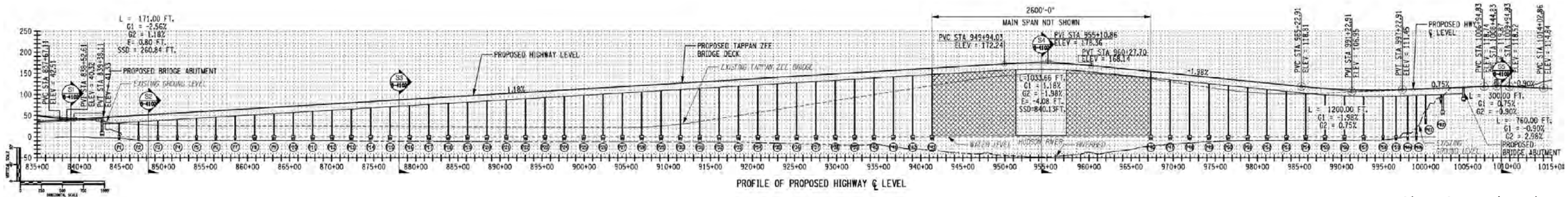
Approach Spans, Main Span, and Ancillary Facilities of the Replacement Bridge Alternative

1.4.12

Short Span Option

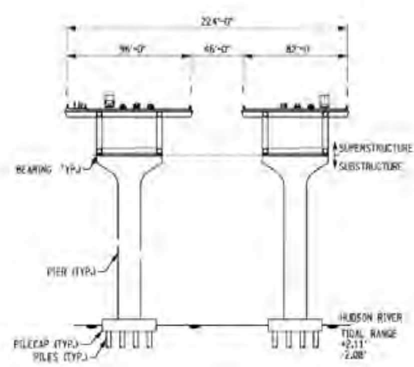


Short Span Cross-Section

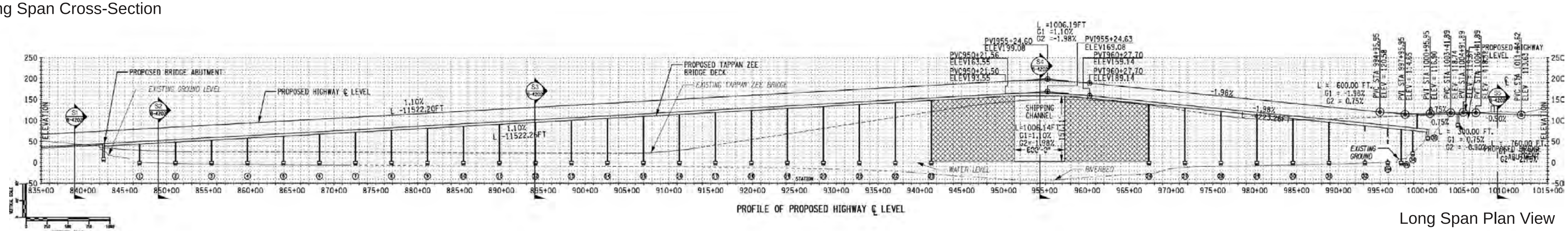


Short Span Plan View

Long Span Option



Long Span Cross-Section

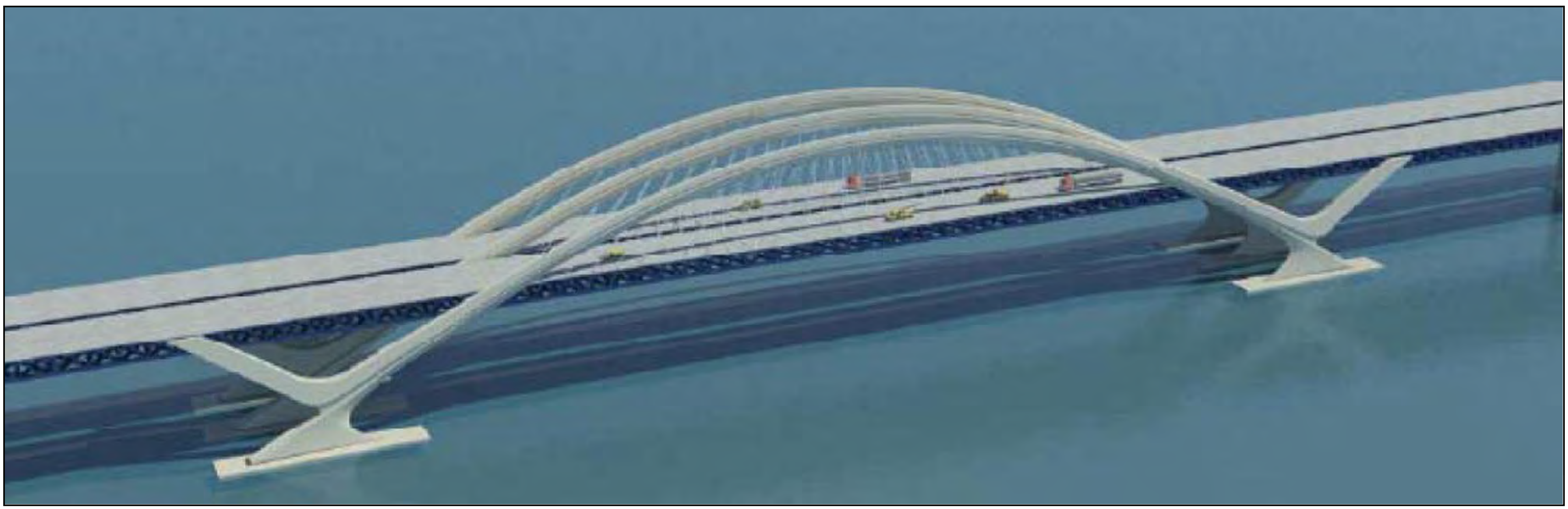


Long Span Plan View

Figure 2

Plan View of Short Span and Long Span Options

Example of Cable-Stayed Option (Oresund Bridge, Denmark/Sweden)



Example of Arch Option (Rendering)

Figure 3
Examples of Cable-Stayed and Arch Bridge Designs

1.4.12

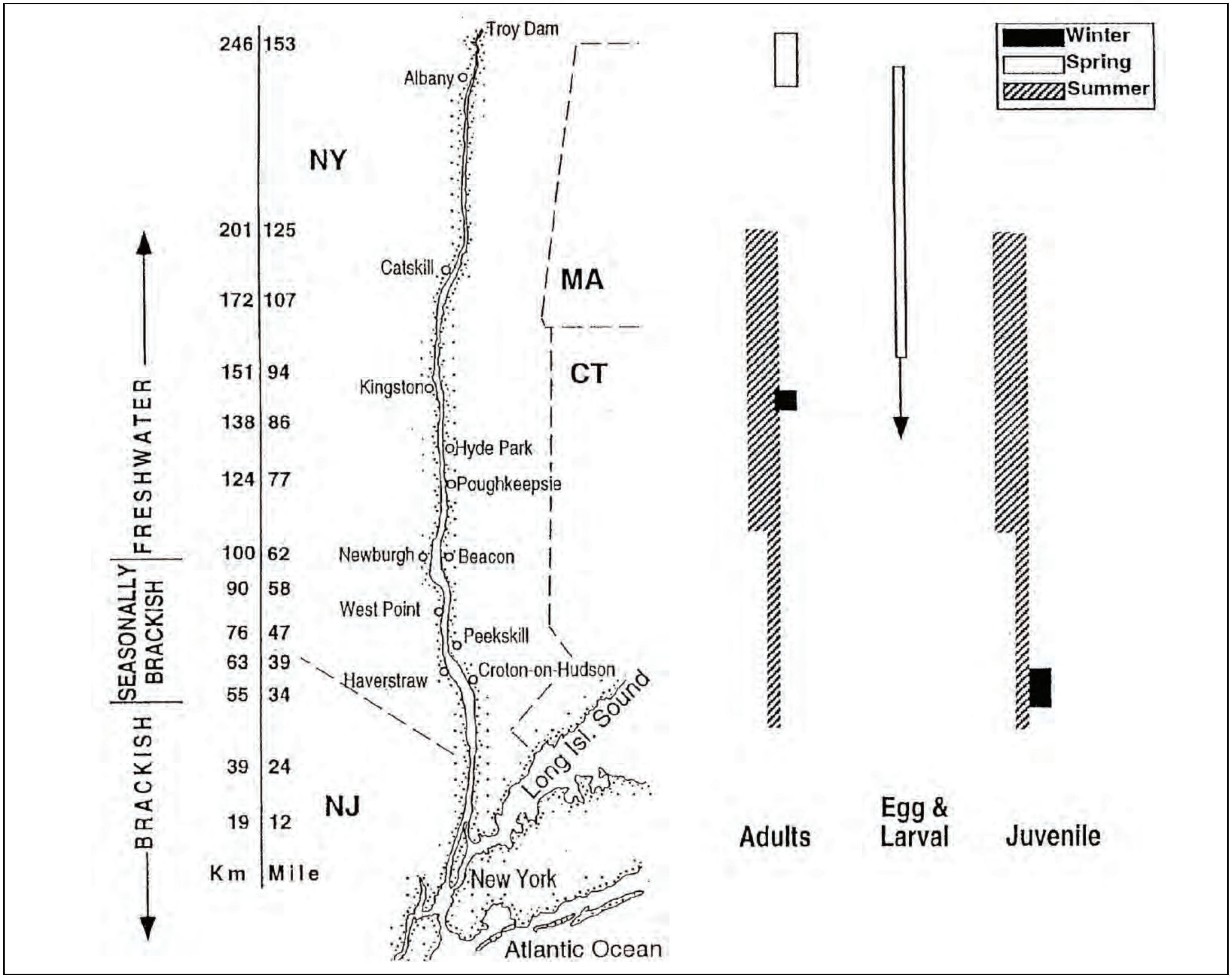


Figure 4

Distribution and Life History Pattern of Shortnose Sturgeon in the Hudson River Estuary by Major Life Stage and Season

Figure 5
Sediment Texture

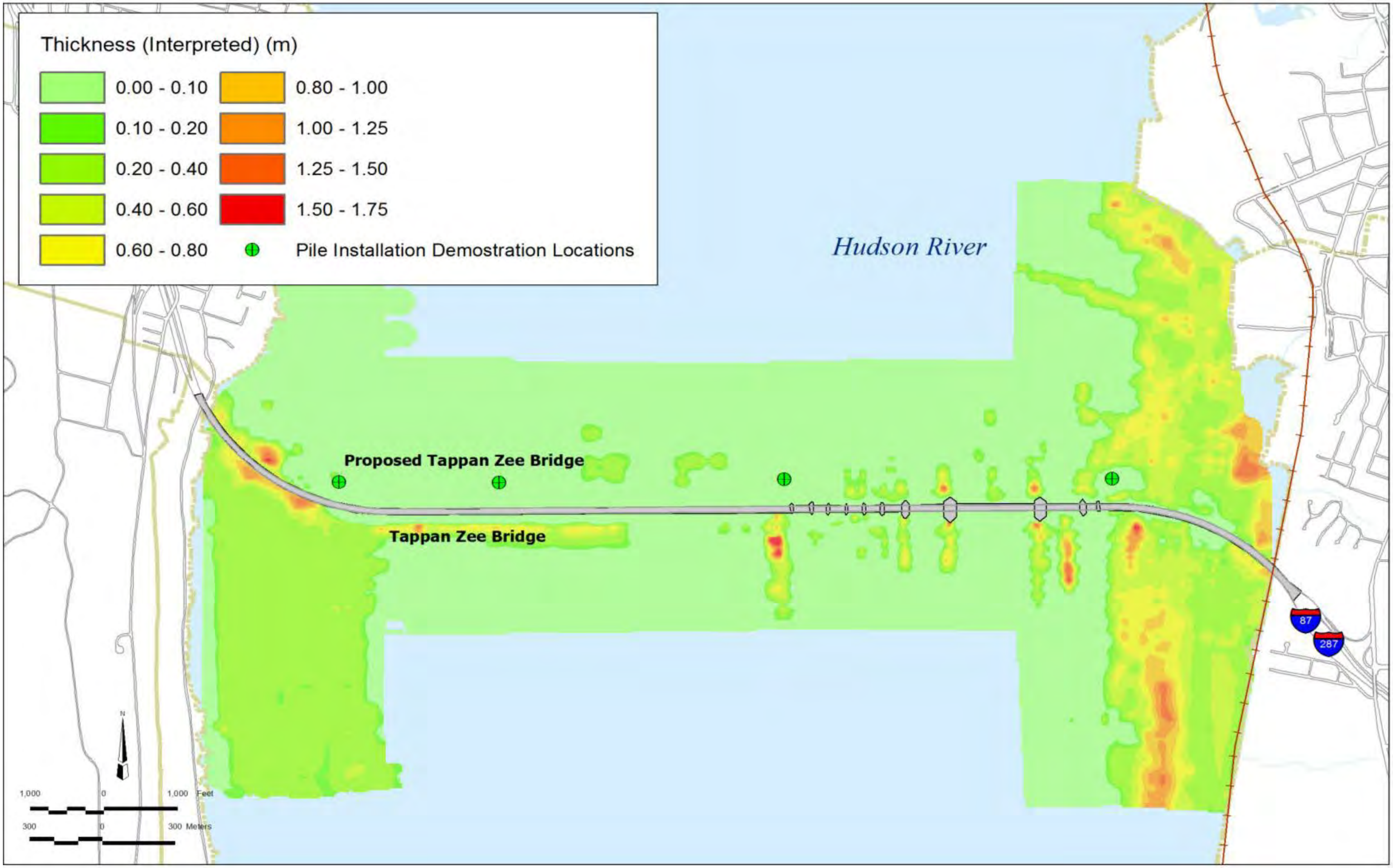


Figure 6
Recent Sediment Deposit Thickness

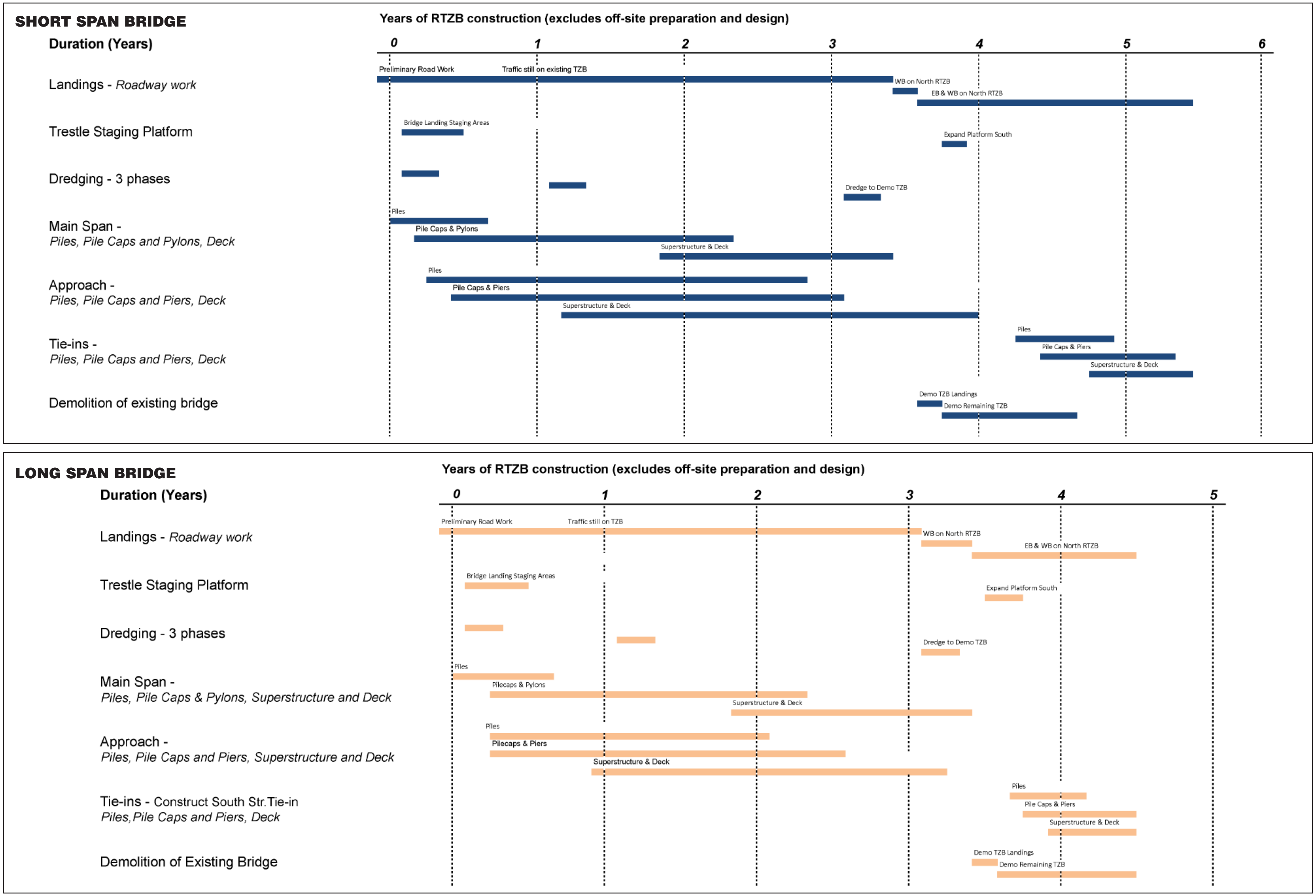


Figure 7

Construction Schedules for Short Span and Long Span Option

Figure 8
Potential Upland Staging Areas

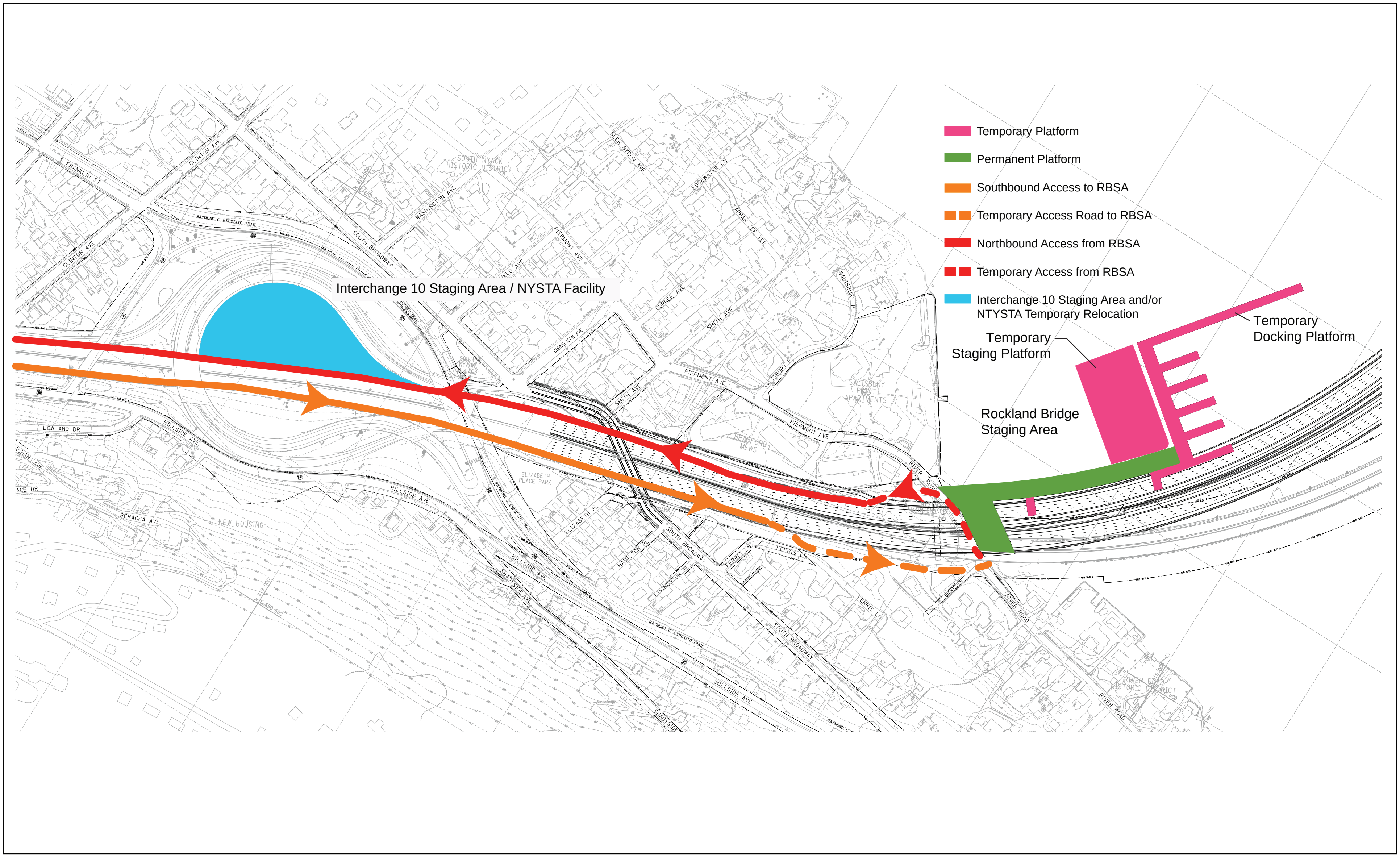


Figure 9
Rockland Landing Construction Access

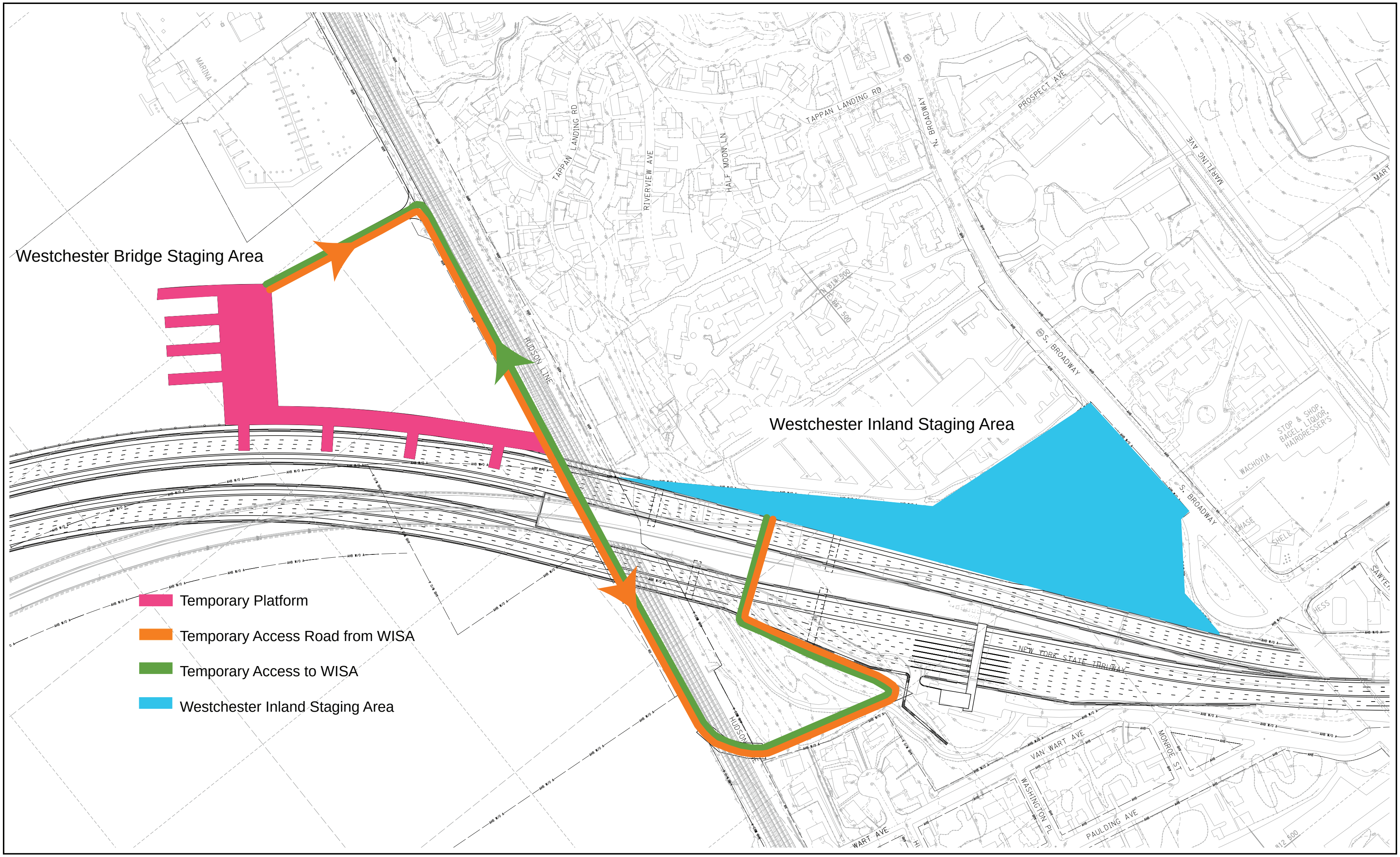
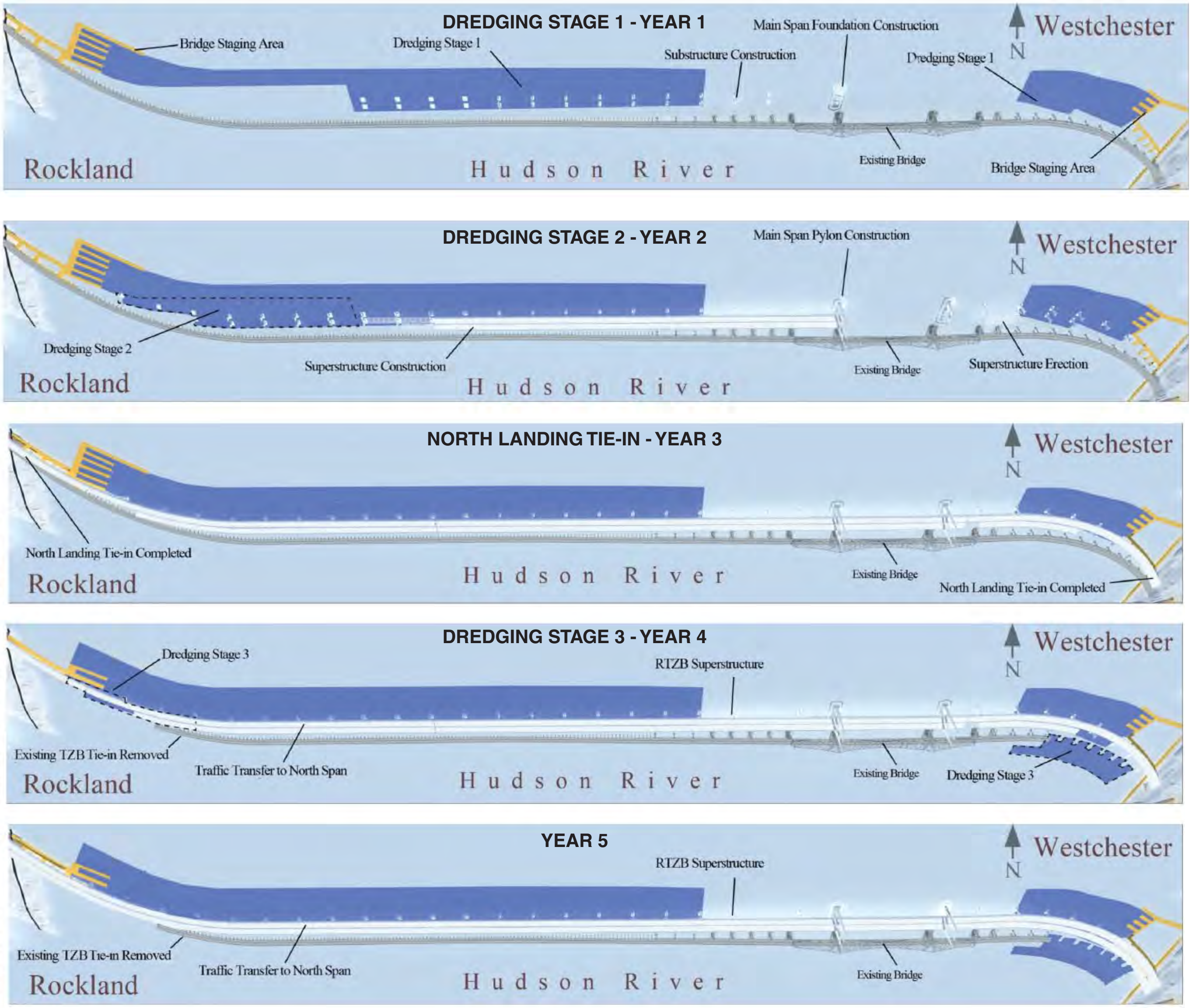


Figure 10
Westchester Landing Construction Access



Note: Long Span Option is depicted, Short Span Option will be similar

Figure 11
Dredging Sequence, Years 1 to 5

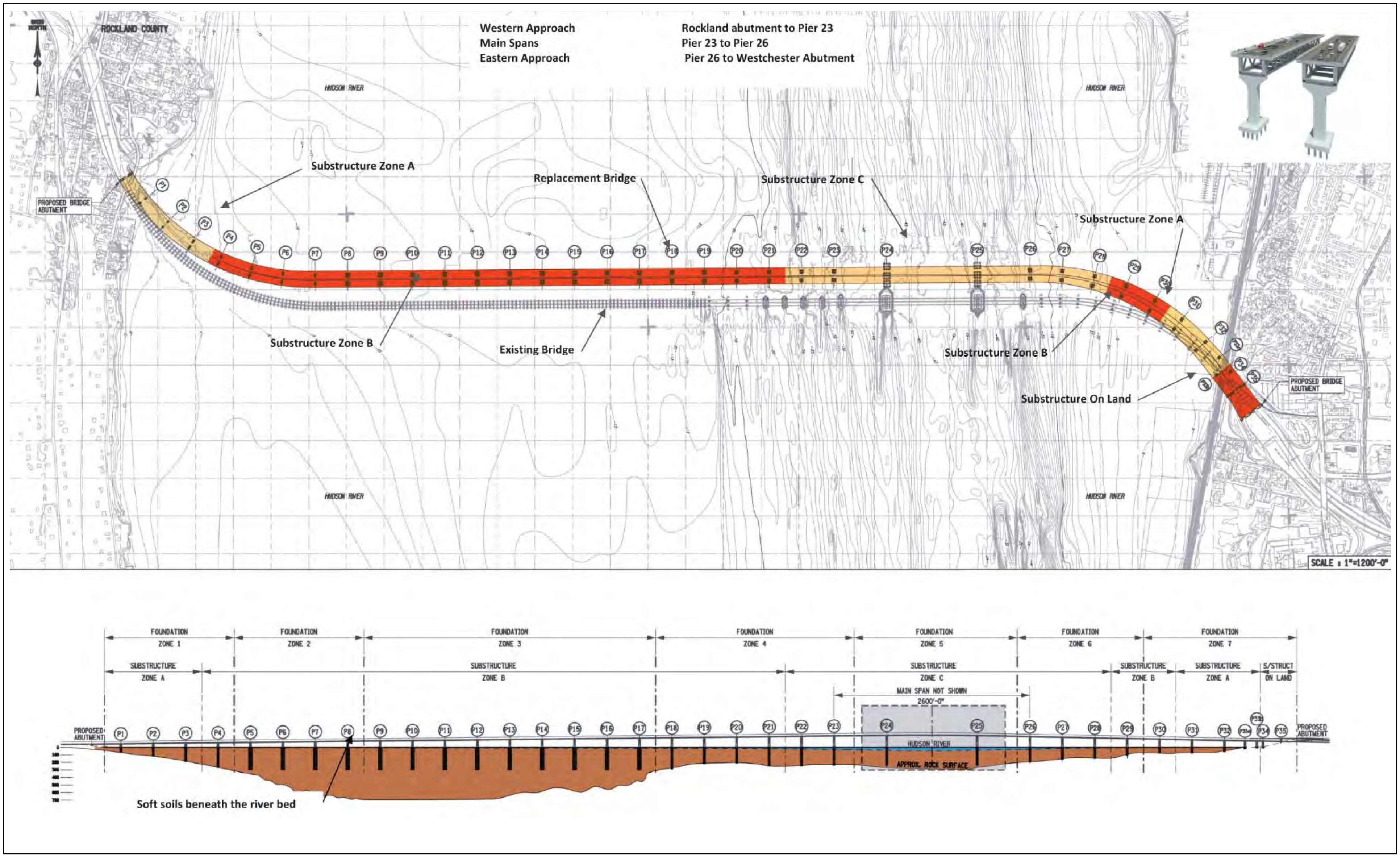


Figure 12
Construction Zones for Long Span Option

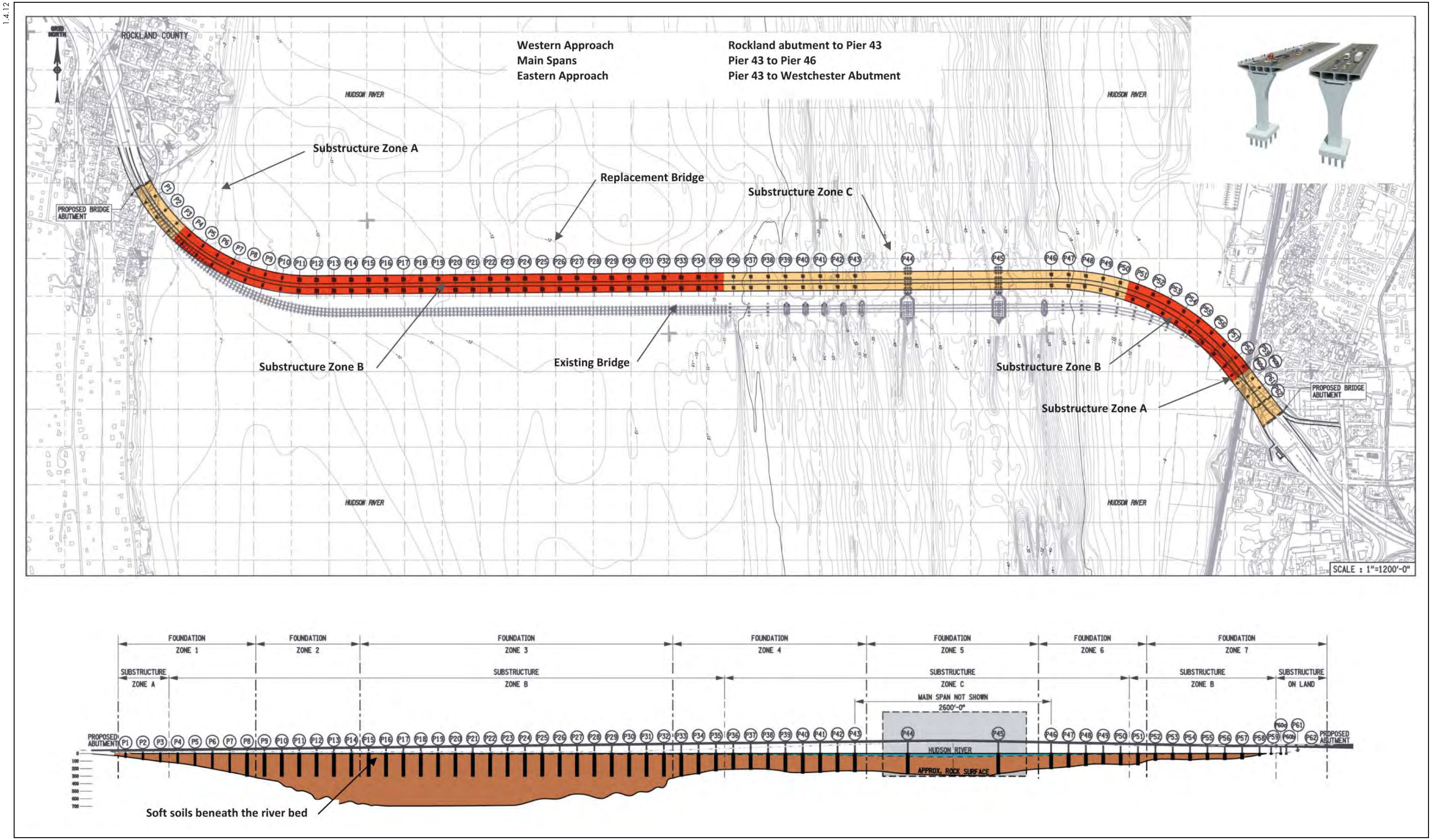


Figure 13
Construction Zones for Short Span Option

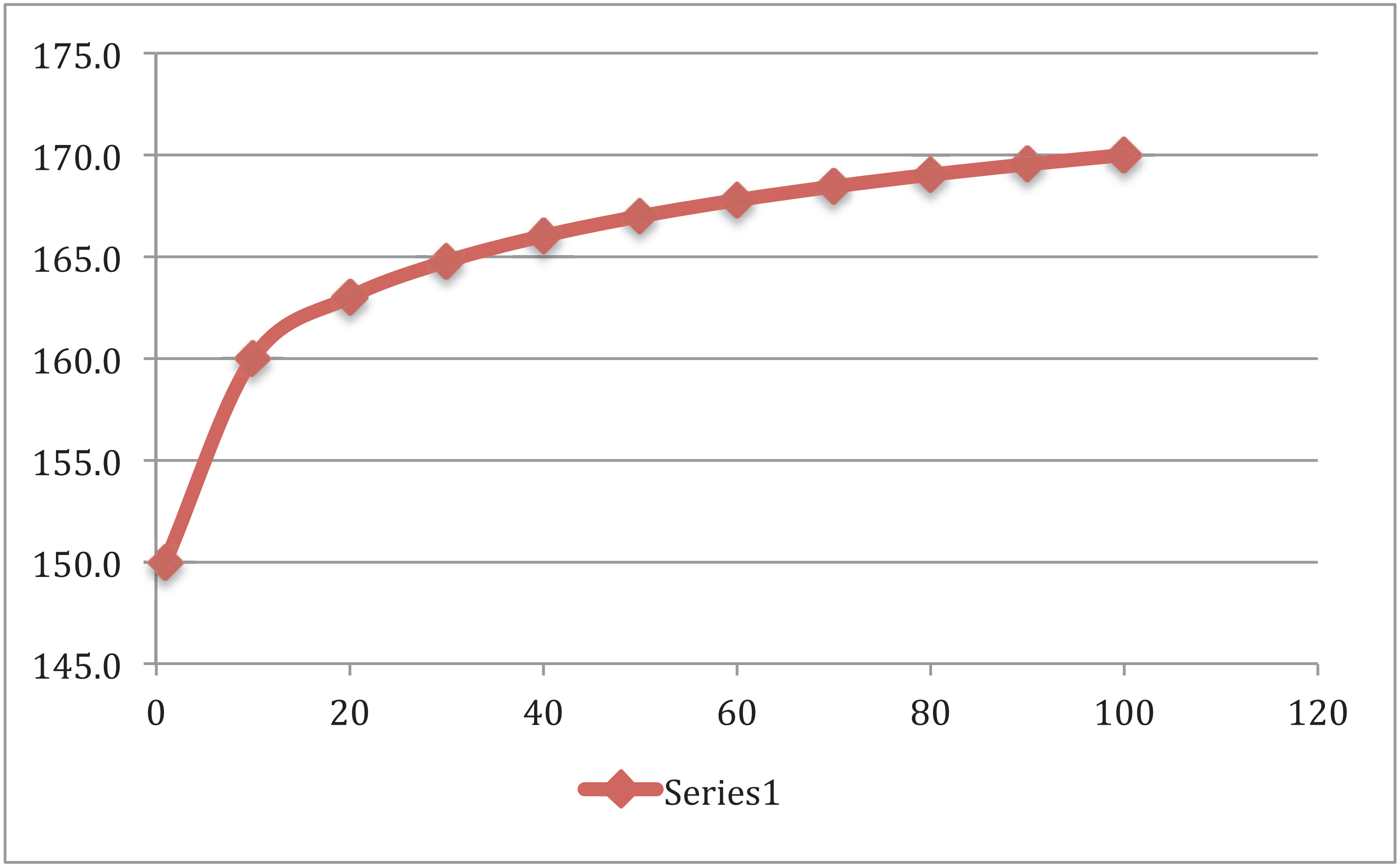


Figure x: Demonstration of the increase in SELcum with an increasing number of strikes. In this case, the *received* level of a single strike at a fish in the river is SELss = 150 dB. After 20 strikes, the SELcum=164 dB and the growth of SELcum is relatively slow over increased numbers of strikes.

Figure 14

Demonstration of the Increase in SEL_{cum} with an Increasing Number of Strikes

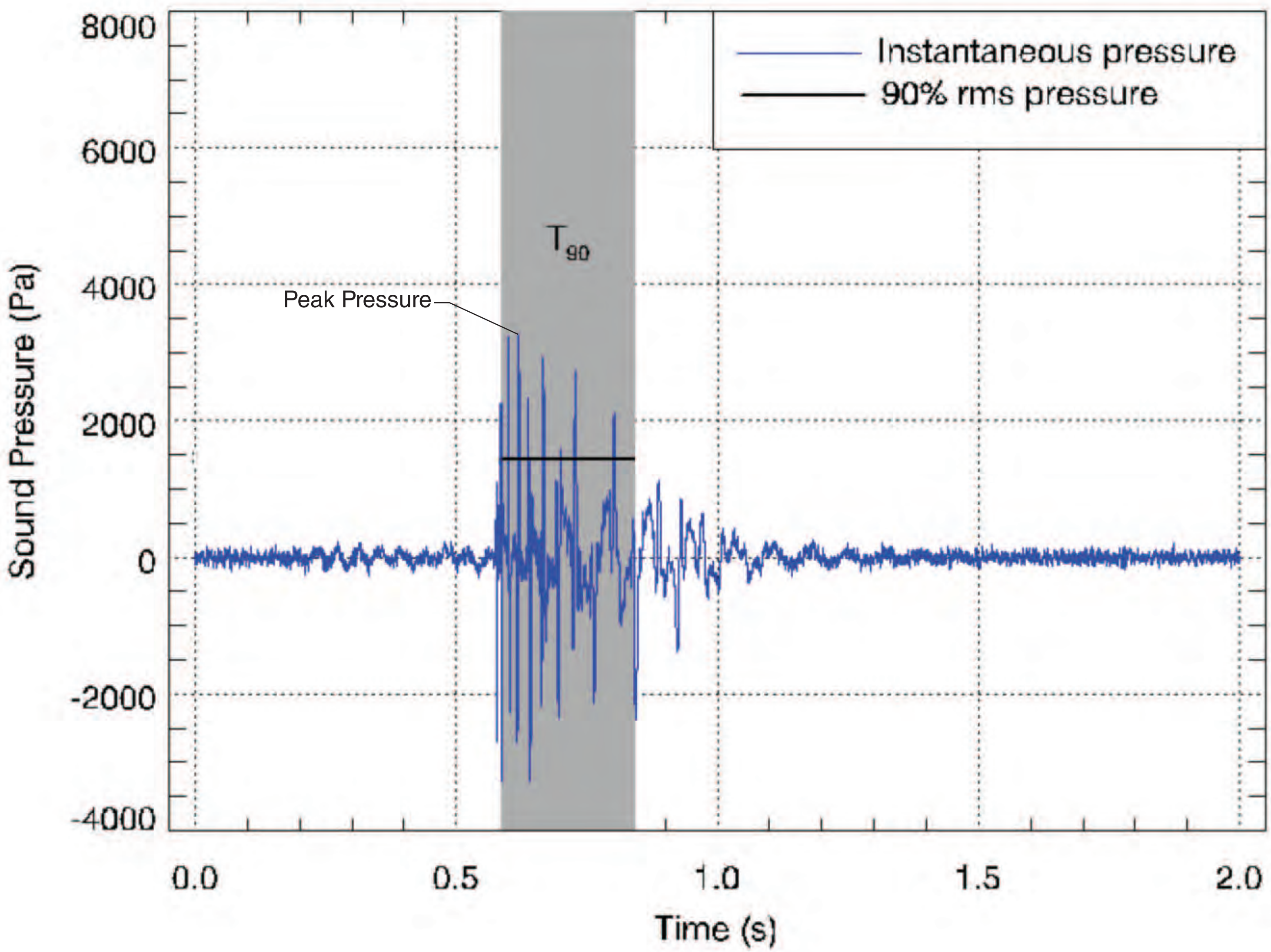


Figure 15
The Sounds of a Single Pile Driving Strike

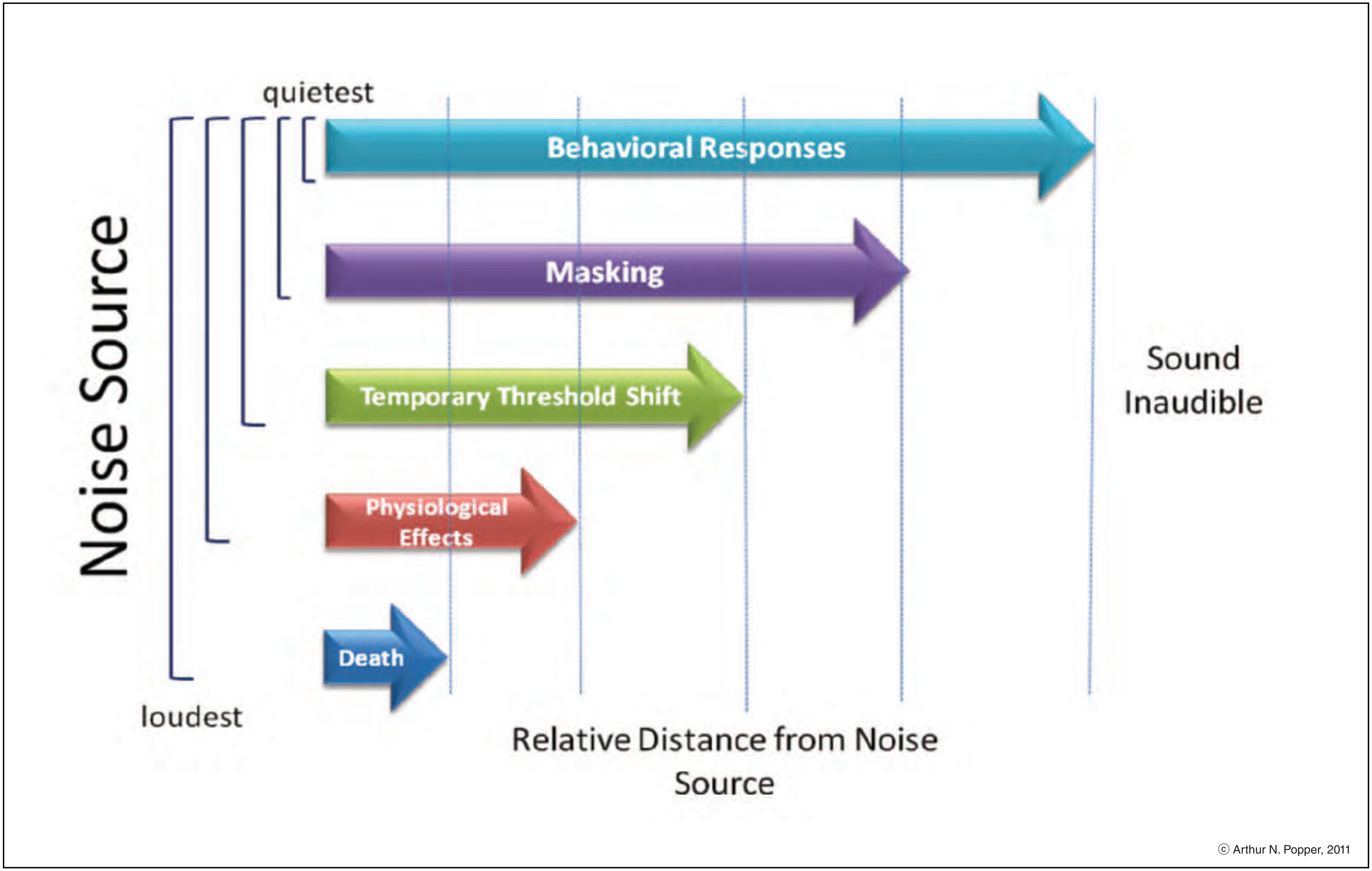


Figure 16
Relationship Between Noise Levels, Distance, and Potential Effects

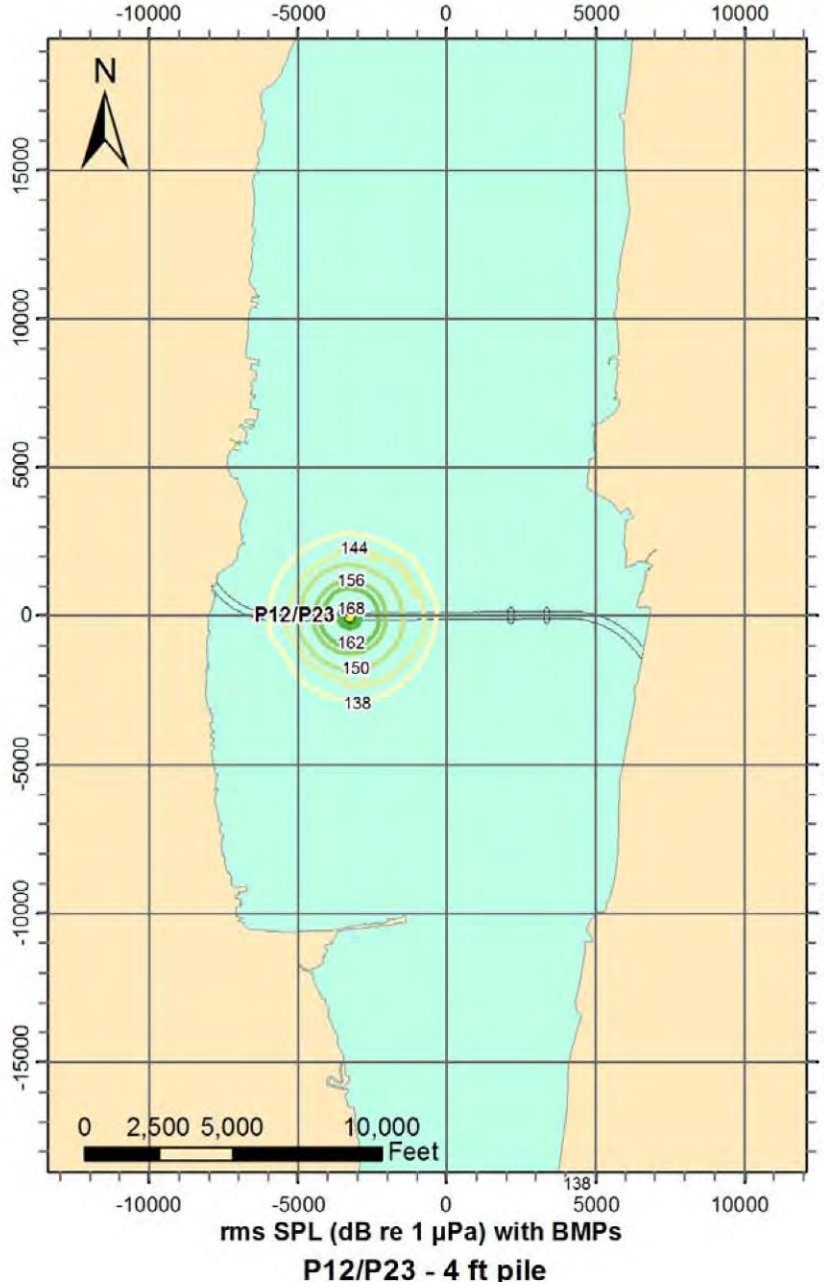


Figure 17

Isopleths for Root Mean Square (rms) Sound Pressure Level from Pile Driving for 4-foot Diameter Piles (with 10dB Reduction from BMPs)

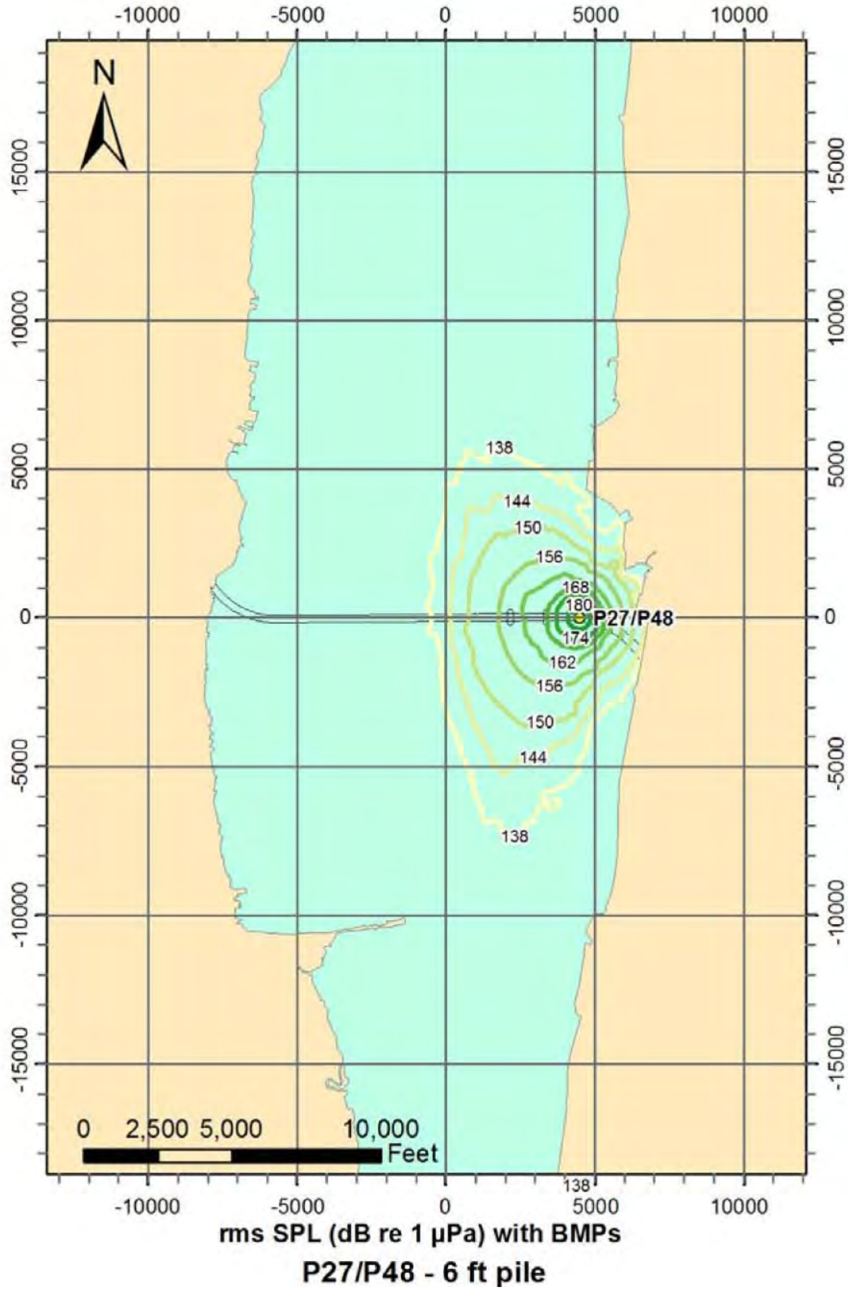


Figure 18
Isopleths for Root Mean Square (rms) Sound Pressure Level from Pile Driving for 6-foot Diameter Piles (with 10dB Reduction from BMPs)

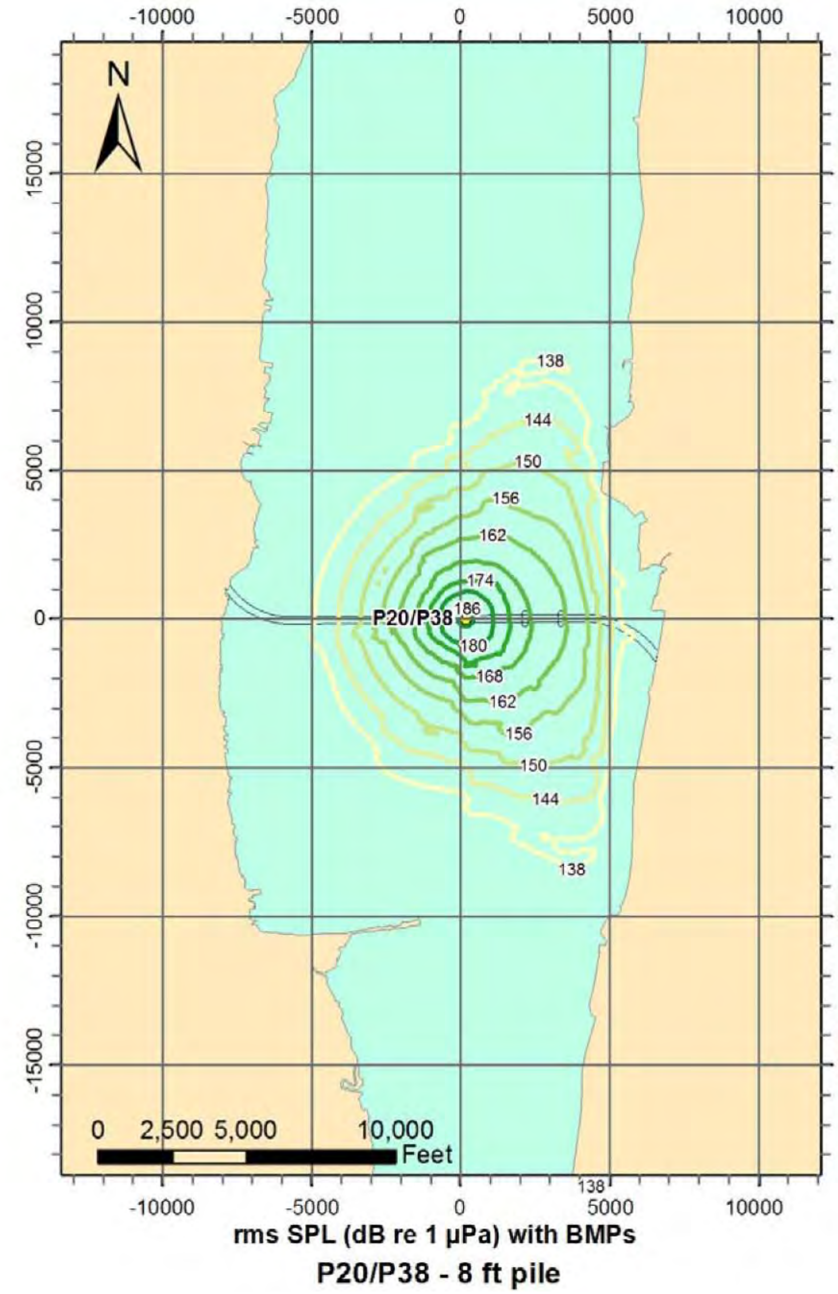
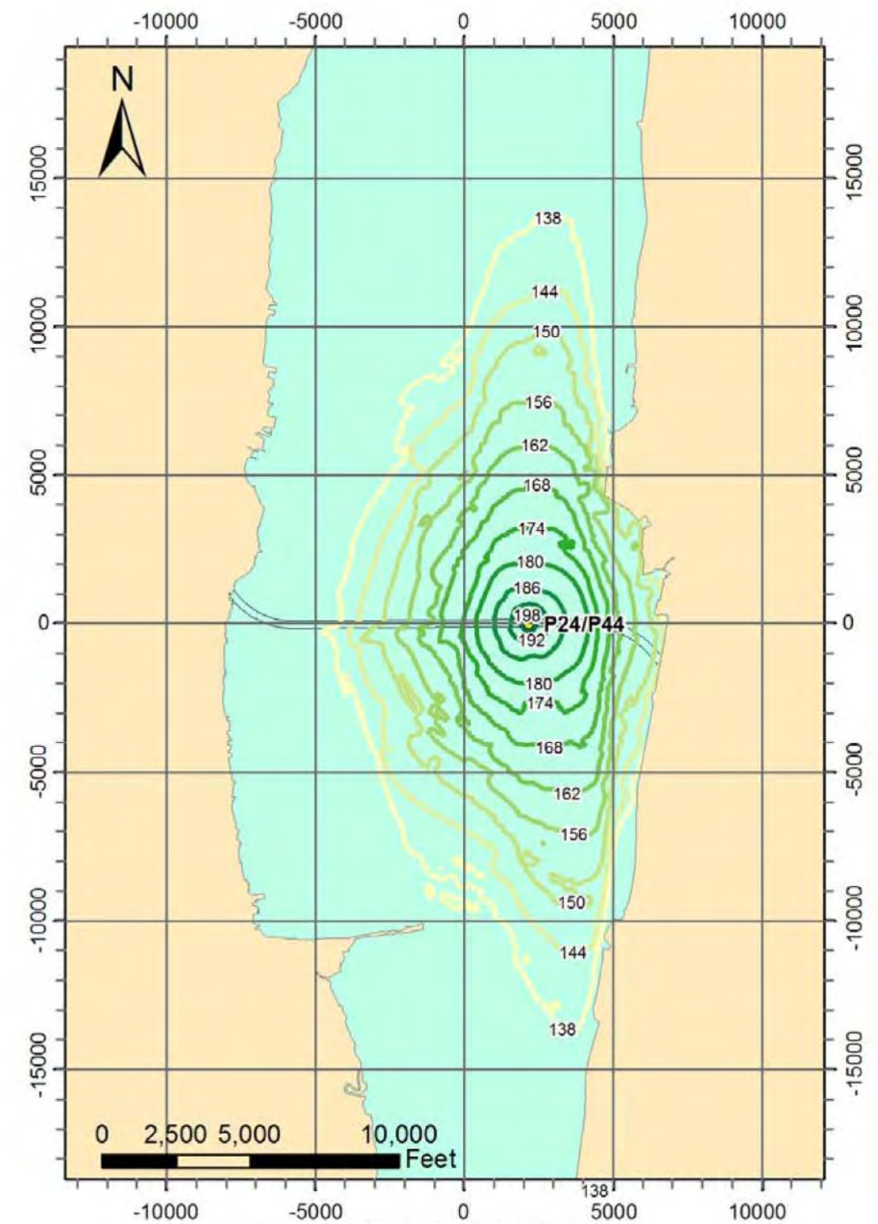


Figure 19

Isopleths for Root Mean Square (rms) Sound Pressure Level from Pile Driving for 8-foot Diameter Piles (with 10dB Reduction from BMPs)



rms SPL (dB re 1 μPa) with BMPs

P24/P44 - 10 ft pile

Figure 20

Isopleths for Root Mean Square (rms) Sound Pressure Level from Pile Driving for 10-foot Diameter Piles (with 10dB Reduction from BMPs)

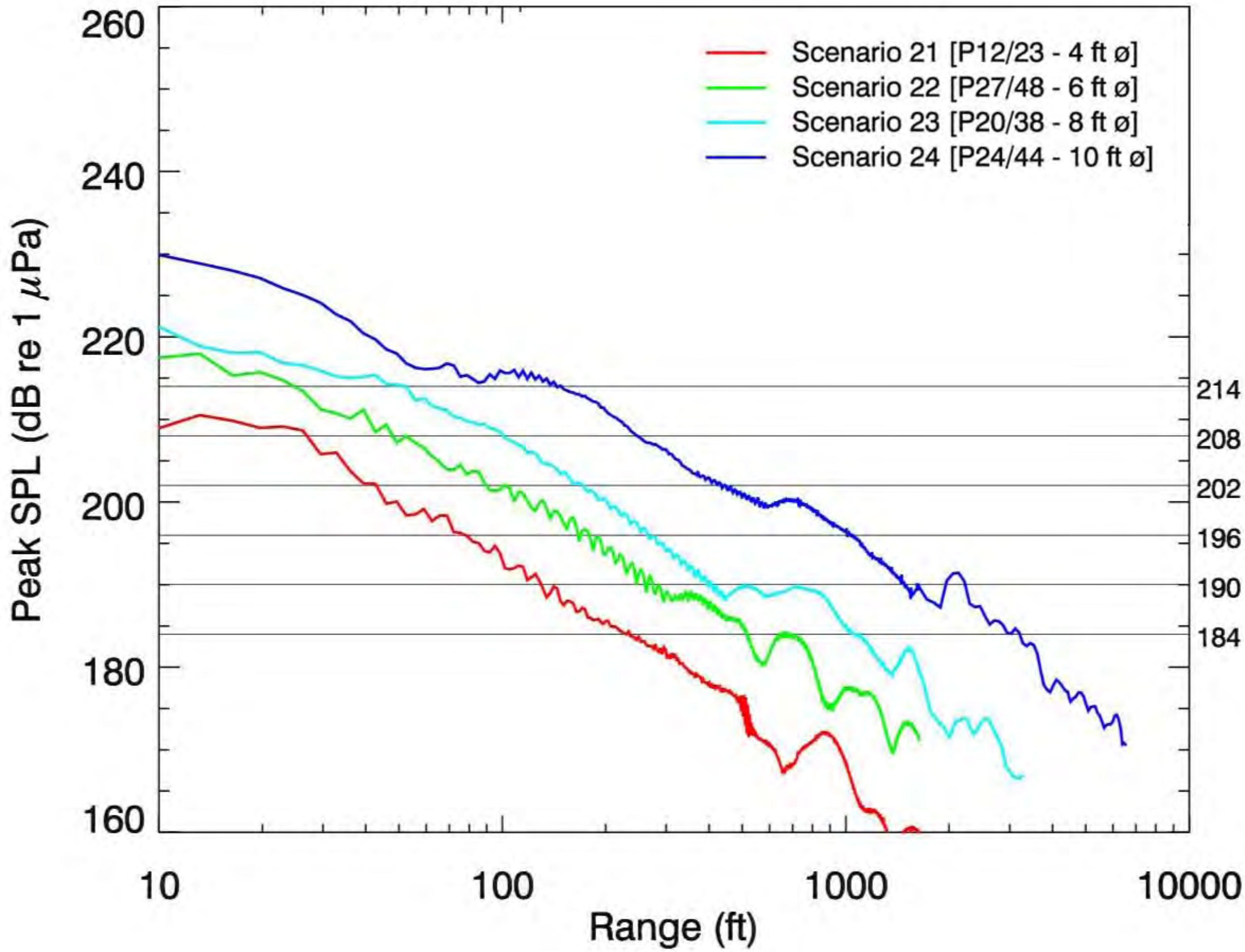


Figure 21

Attenuation of Peak Sound Pressure Level with 10dB Reduction from BMPs as a Function of Distance from Pile Driving for 4-, 6-, 8-, and 10-foot Diameter Piles

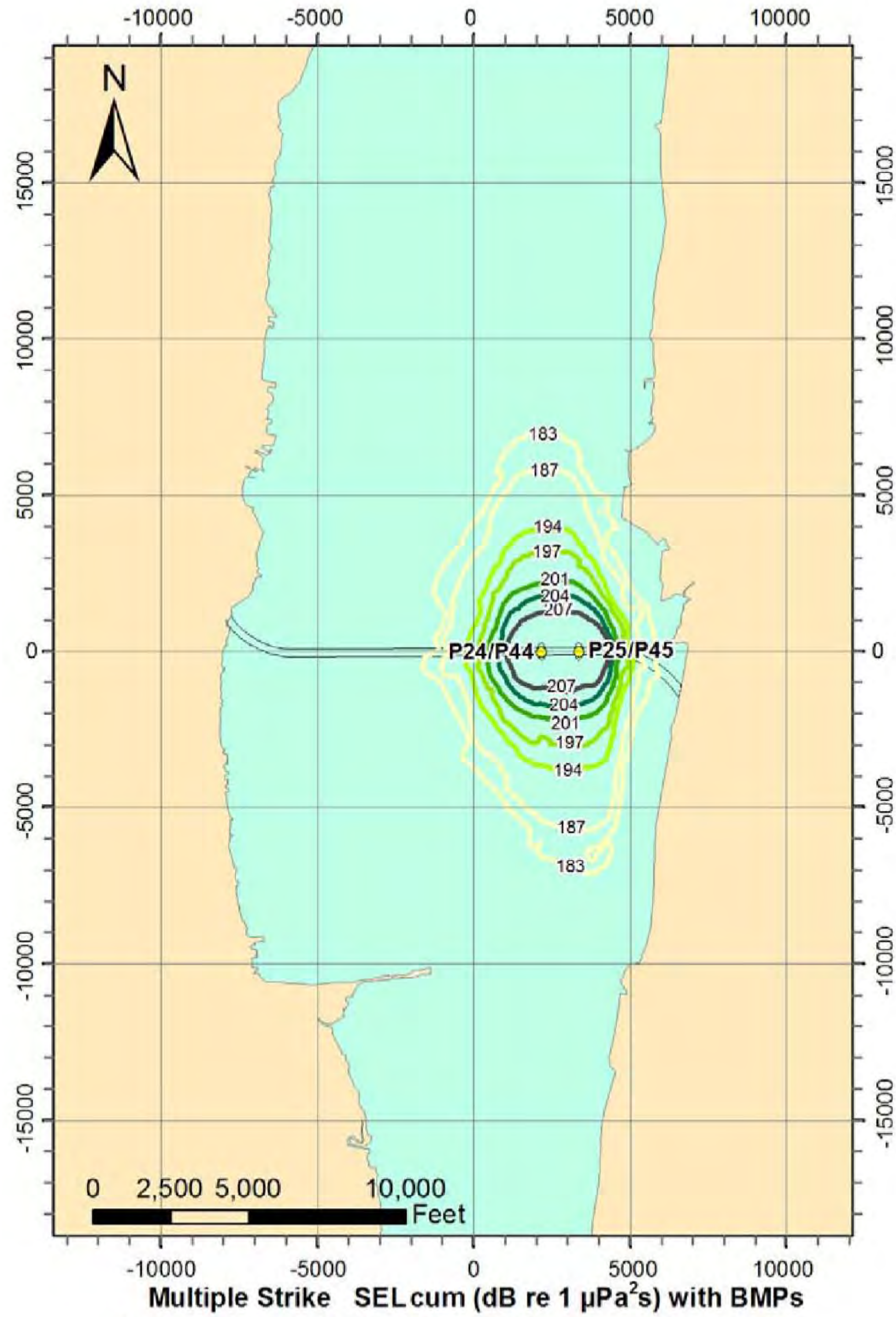


Figure 22
Isopleths for Short and Long Span Options - Driving of Two 10 Foot Piles at Piers 24, 25, 44 & 45

4.12.12

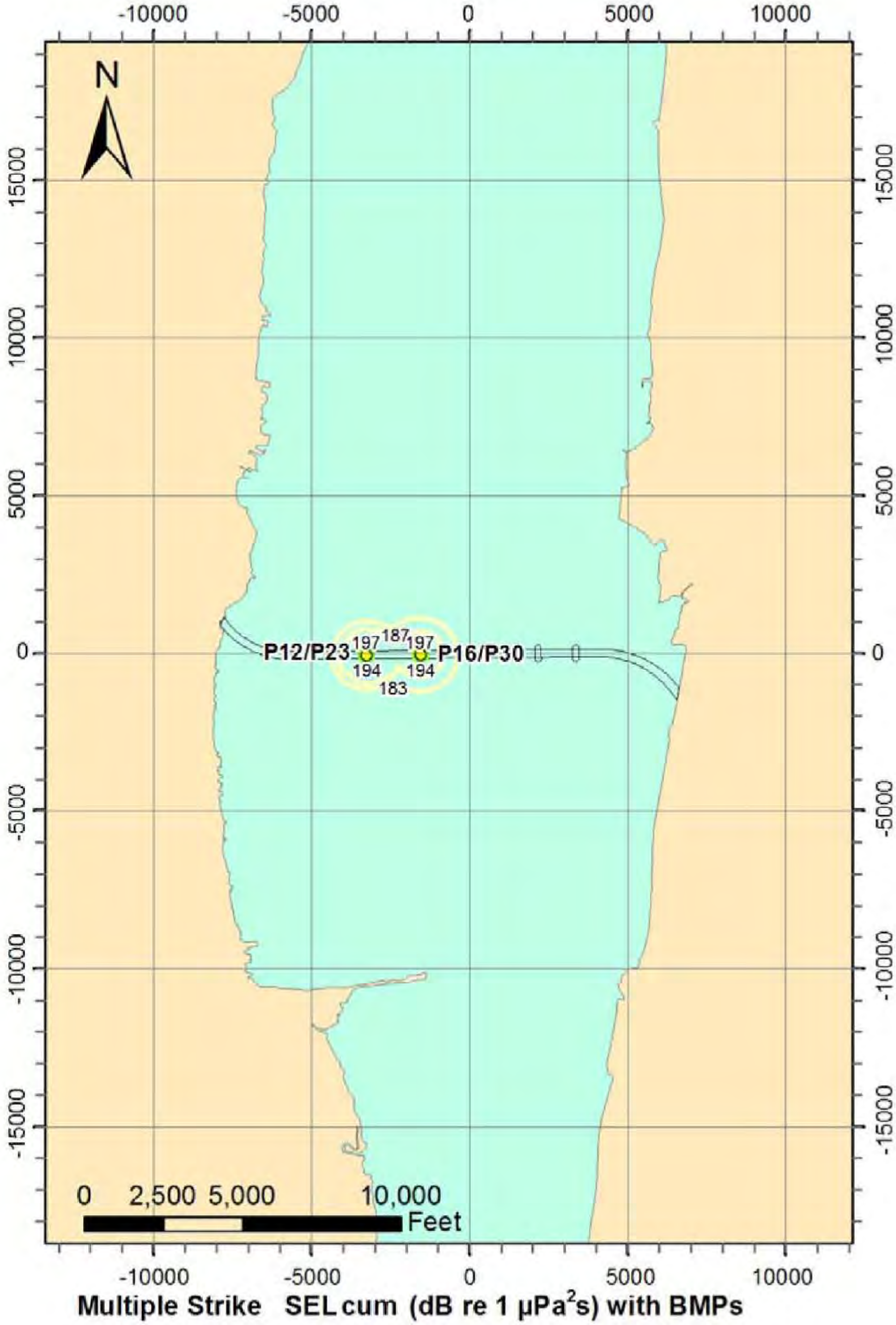


Figure 23

Isopleths for Short and Long Span Options - Driving of Four 4 Foot Piles at Piers 12, 16, 23 & 30

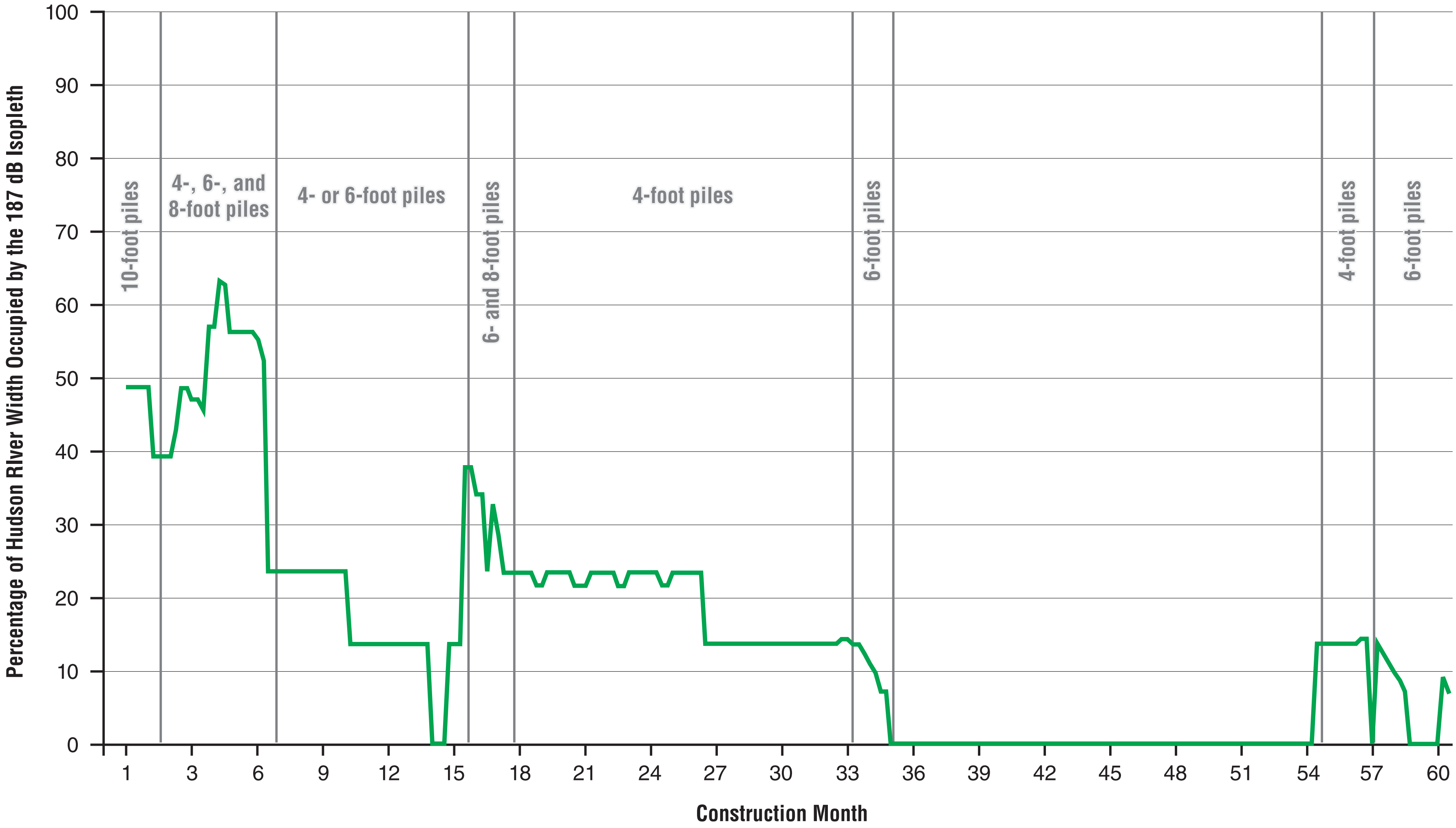


Figure 24

Percent of the Hudson River Width Occupied by the SEL_{cum} 187 dB re 1 $\mu Pa^2 \cdot s$ Isopleth During Pile Driving at the Proposed Tappan Zee Crossing Short Span Option

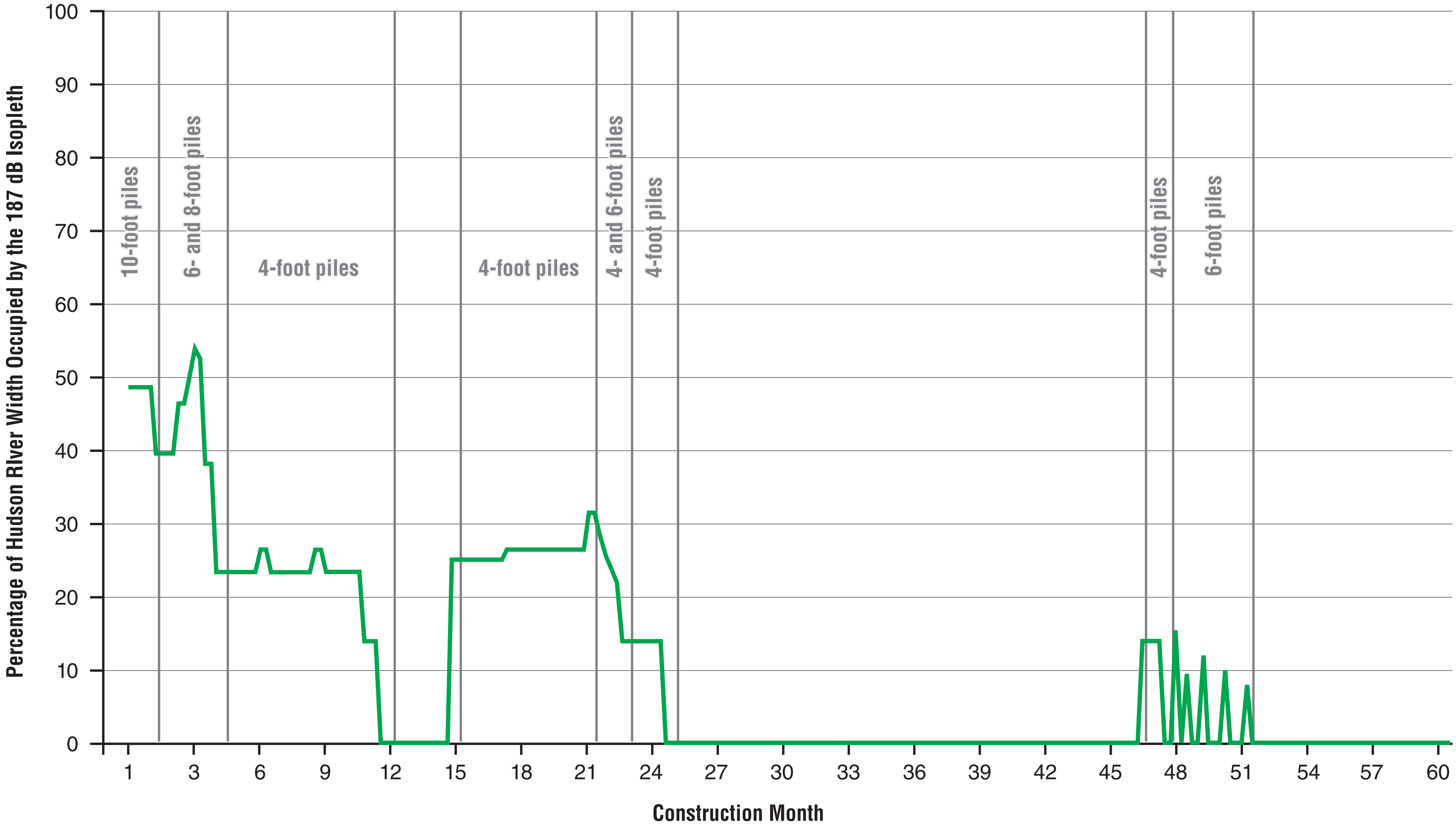
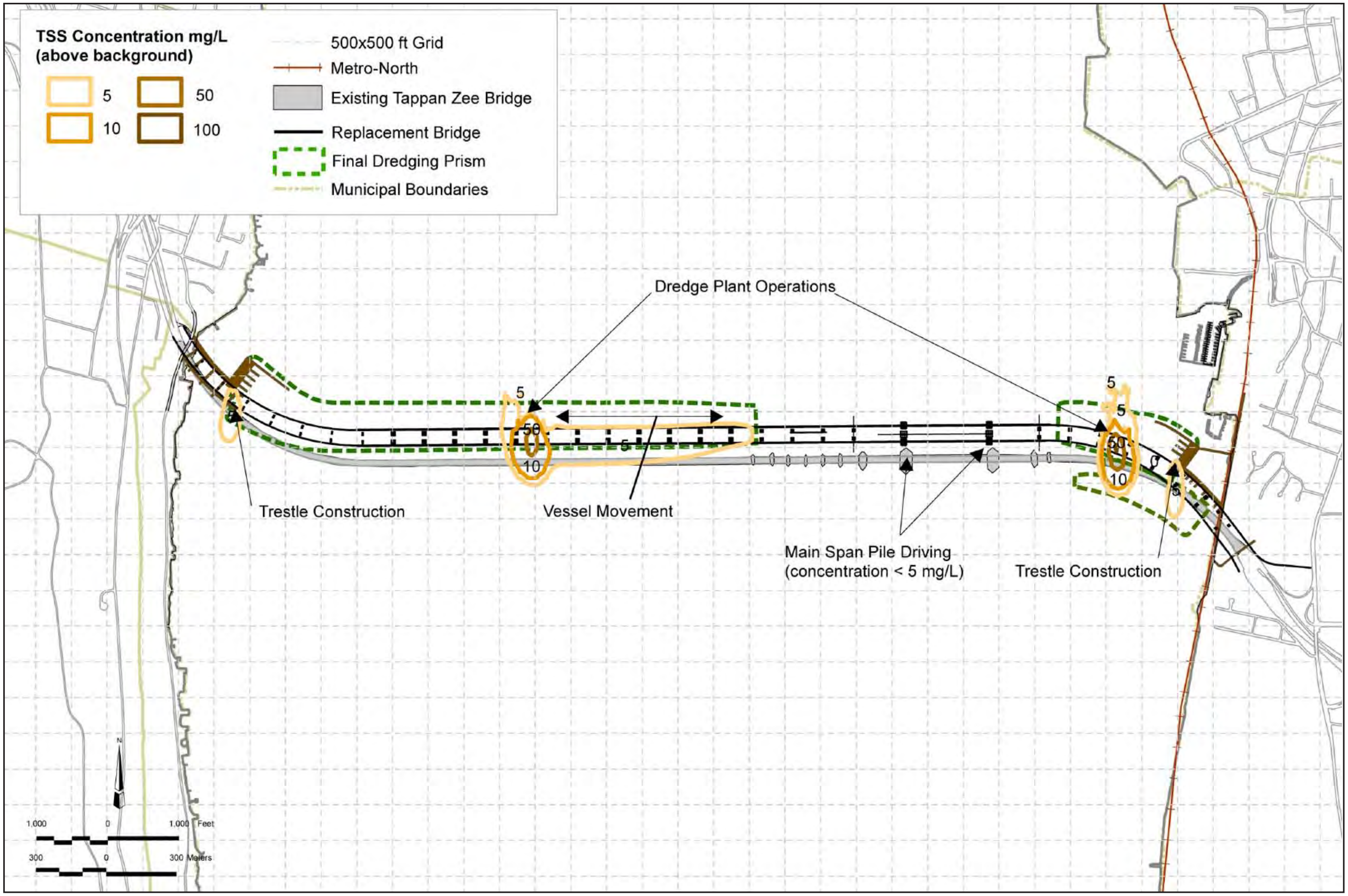


Figure 25

Percent of the Hudson River Width Occupied by the SEL_{cum} 187 dB re 1 $\mu Pa^2 \cdot s$ Isopleth During Pile Driving at the Proposed Tappan Zee Crossing Long Span Option

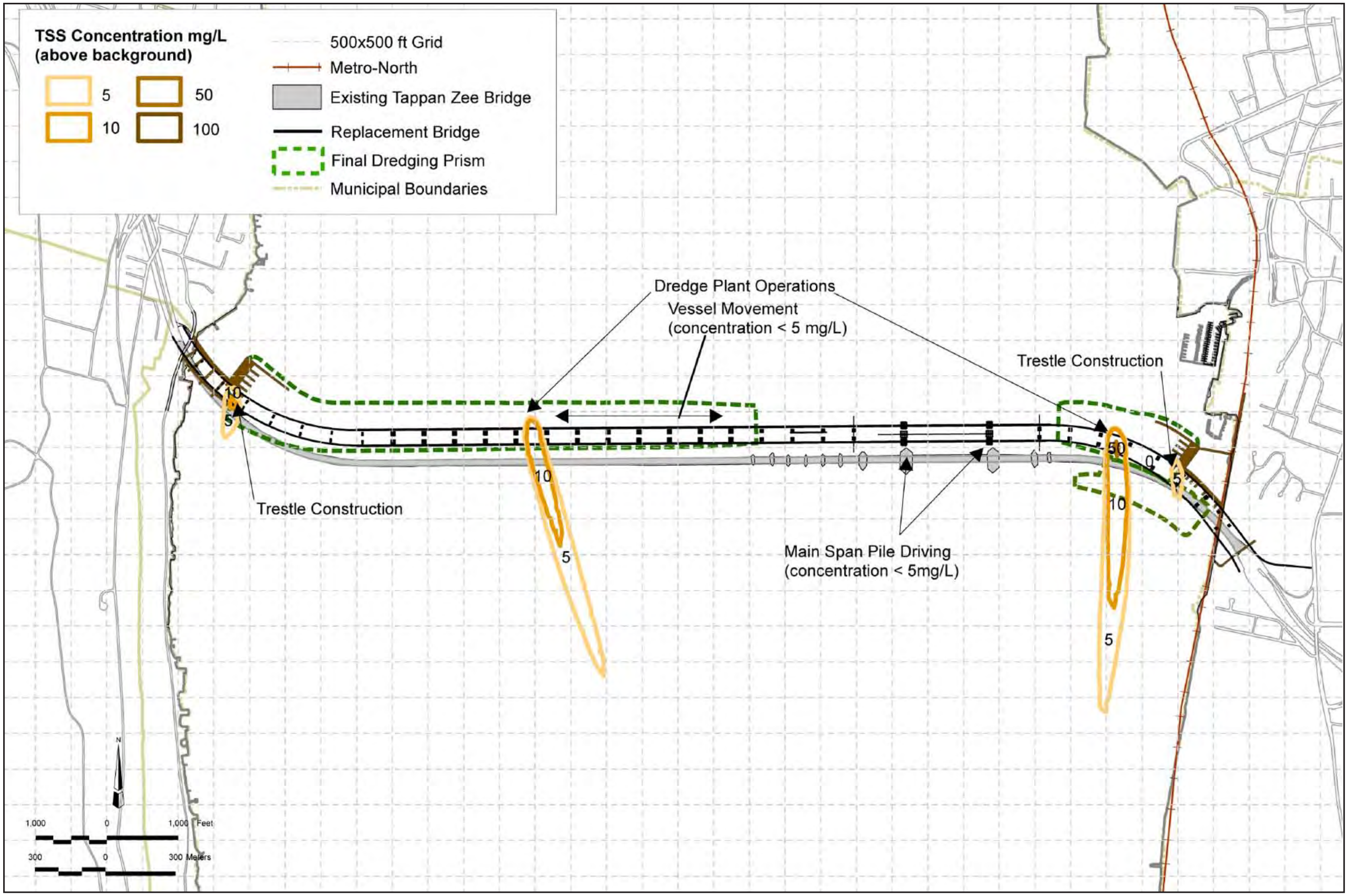


Projected Total Suspended Sediment Concentration for the Long Span Replacement Bridge Option* During Stage 1 Dredging-Near Slack Tide

*Note: Short Span Option would be similar

Figure 26

Projected Total Suspended Sediment Concentration for the Long Span Replacement Bridge Option During Stage 1 Dredging – Near Slack Tide

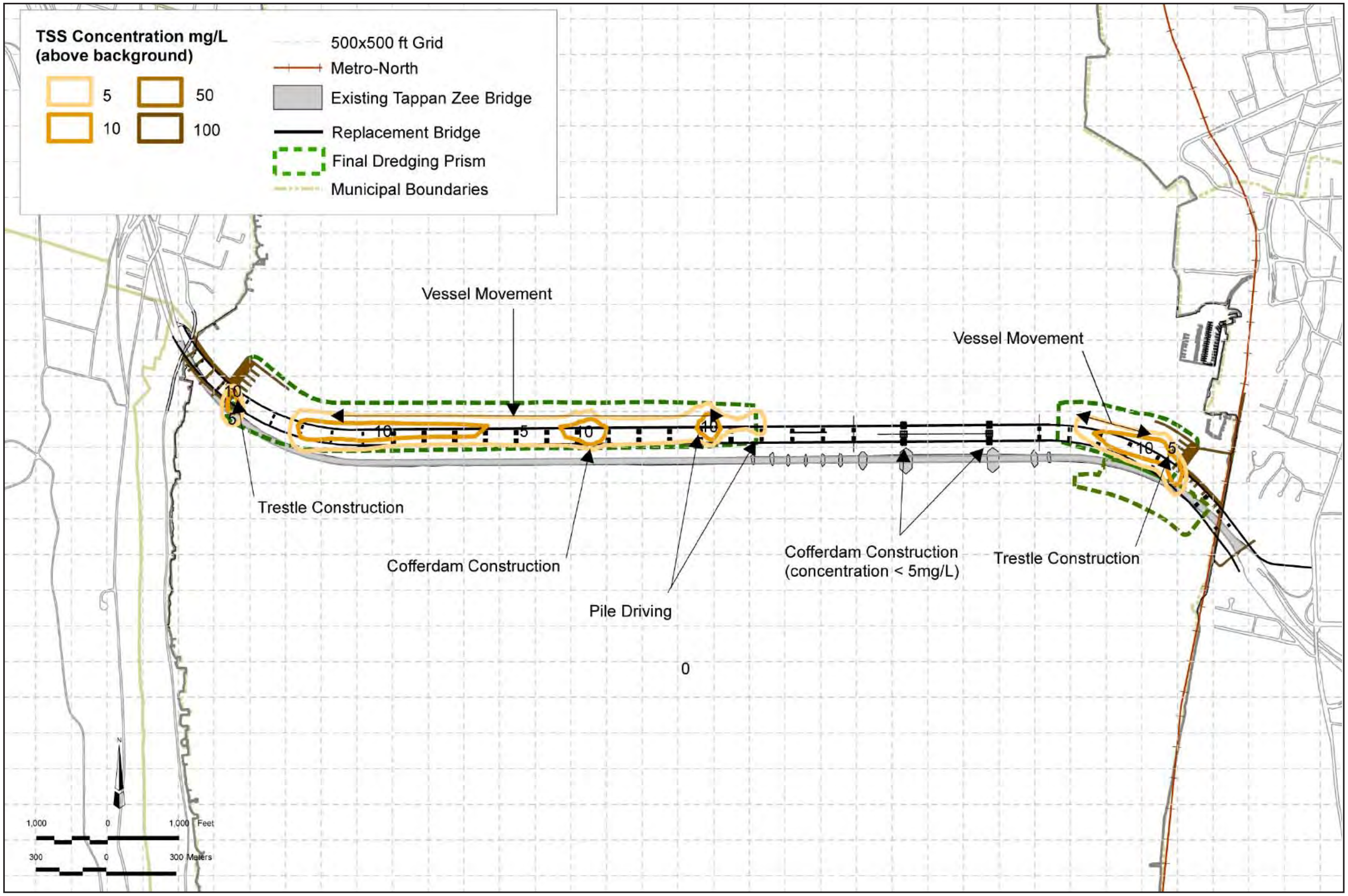


Projected Total Suspended Sediment Concentration for the Long Span Replacement Bridge Option* During Stage 1 Dredging-Ebb Tide

*Note: Short Span Option would be similar

Figure 27

Projected Total Suspended Sediment Concentration for the Long Span Replacement Bridge Option During Stage 1 Dredging – Ebb Tide

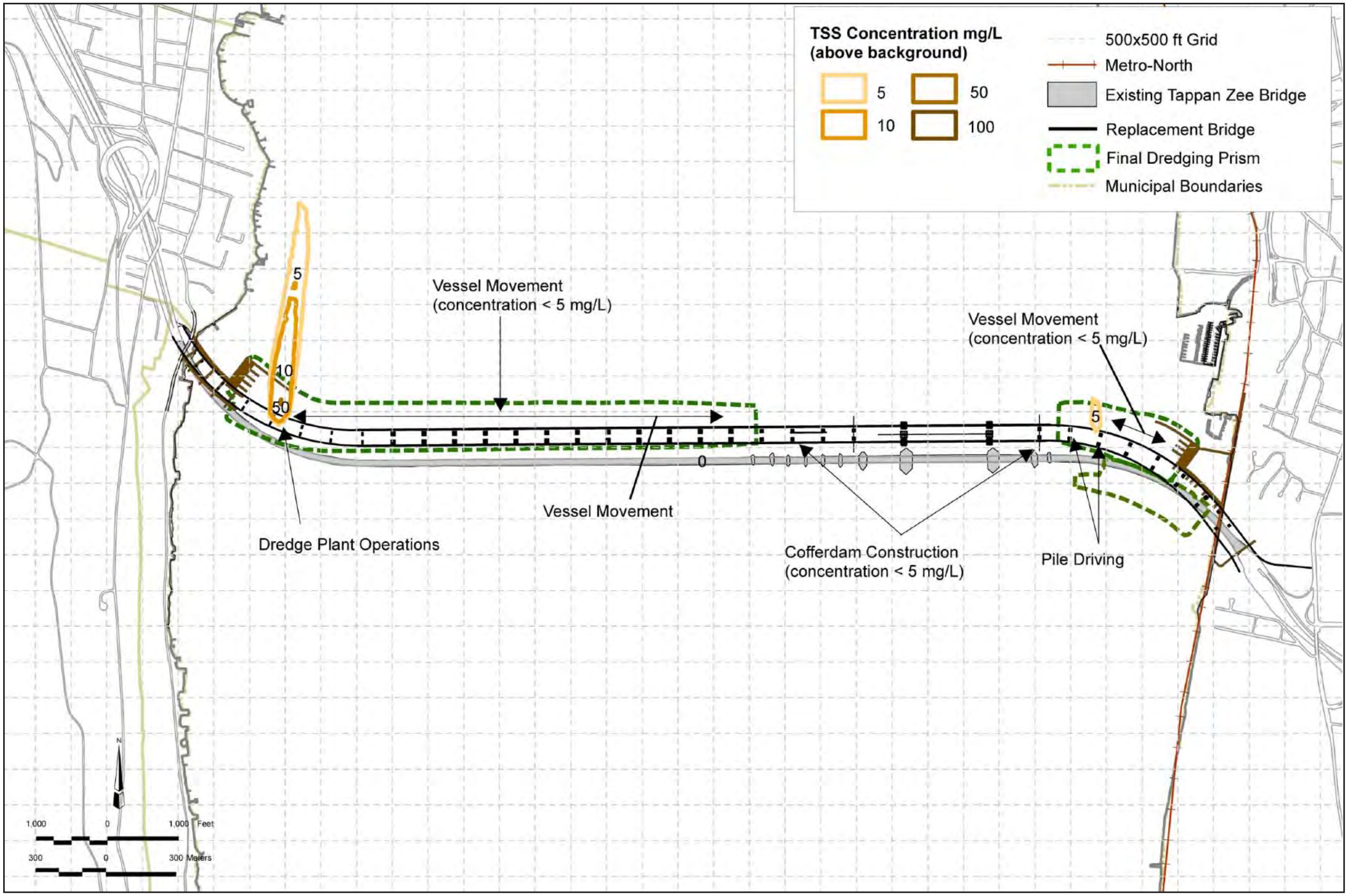


Projected Total Suspended Sediment Concentration for the Long Span Replacement Bridge Option* Zones C and B Construction After Dredging and Armoring – Near Slack Tide

*Note: Short Span Option would be similar

Figure 28

Projected Total Suspended Sediment Concentration for the Long Span Replacement Bridge Option Zones C and B Construction After Dredging and Armoring – Near Slack Tide



Projected Total Suspended Sediment Concentration for the Long Span Replacement Bridge Option* During Stage 2 Dredging and Zones C and B Construction– Flood Tide

*Note: Short Span Option would be similar

Figure 29

Projected Total Suspended Sediment Concentration for the Long Span Replacement Bridge Option During Stage 2 Dredging and Zones C and B Construction – Flood Tide

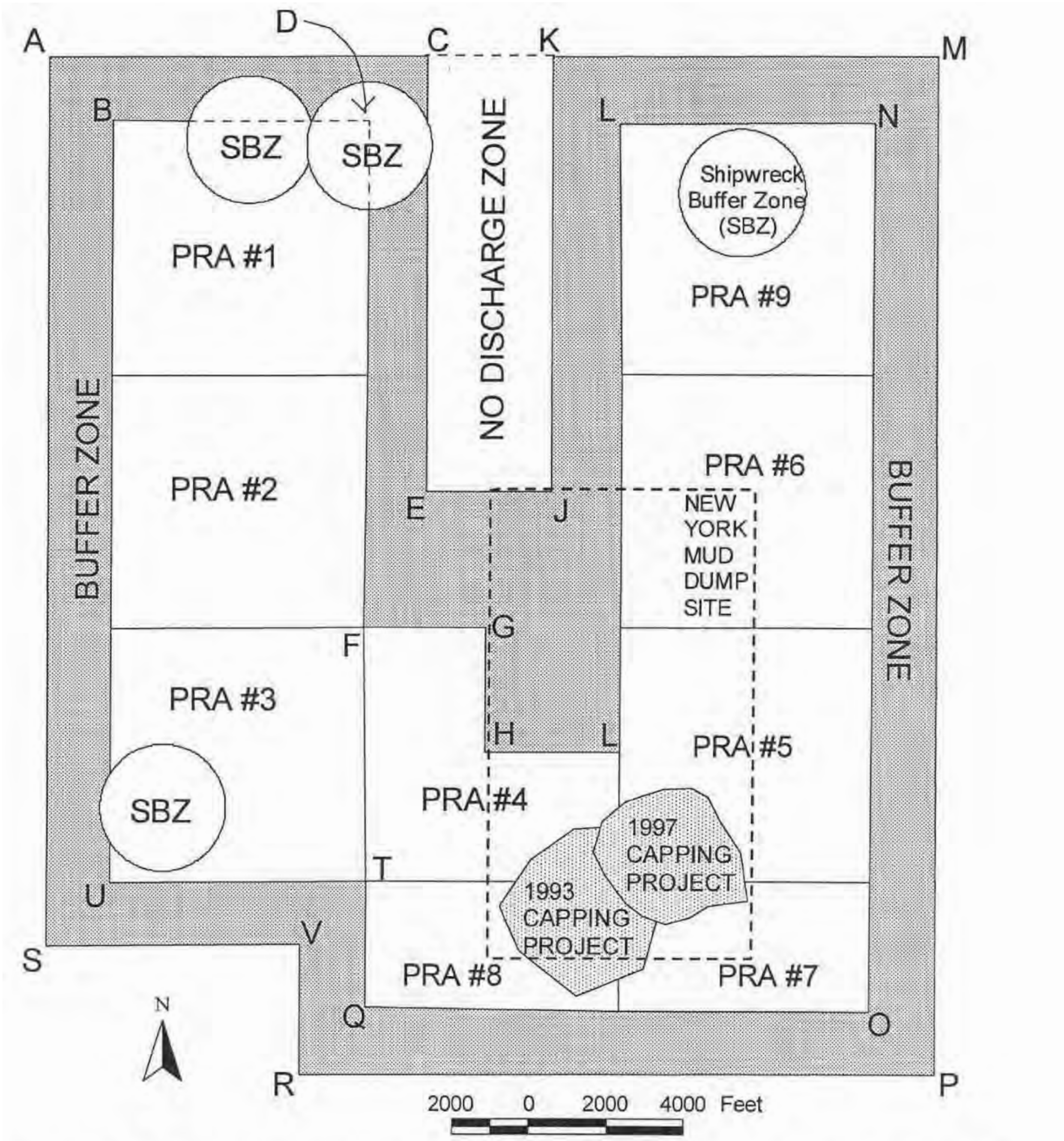


Figure 30
Priority Remediation Areas, Buffer Zone and No Discharge Zone

Exhibit 3: Biological Assessment and Biological Opinion

3-2 Biological Opinion

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
NORTHEAST REGION
55 Great Republic Drive
Gloucester, MA 01930-2276

JUN 22 2012

Mr. Jonathan McDade
Division Administrator, New York Division
U.S. Federal Highway Administration
Leo W. O'Brien Federal Building, Room 719
11A Clinton Avenue
Albany, New York 12207

RE: Transmittal of Biological Opinion– Tappan Zee Bridge Replacement Project

Dear Mr. McDade,

Please find enclosed a copy of the Biological Opinion (Opinion) on the effects of the proposed Tappan Zee Bridge Replacement. In this Opinion, we conclude that the proposed action is likely to adversely affect, but not likely to jeopardize the continued existence of endangered shortnose sturgeon, the threatened Gulf of Maine (GOM) Distinct Population Segment (DPS) of Atlantic sturgeon, the endangered New York Bight (NYB) DPS of Atlantic sturgeon or the endangered Chesapeake Bay (CB) DPS of Atlantic sturgeon. We also conclude that the proposed action may affect but is not likely to adversely affect North Atlantic right, humpback or fin whales, the Northwest Atlantic DPS of loggerhead sea turtles, or Kemp's ridley, green or leatherback sea turtles.

Our Opinion includes an Incidental Take Statement (ITS). Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. "Otherwise lawful activities" are those actions that meet all State and Federal legal requirements, including any state endangered species laws or regulations, except for the prohibition against taking in ESA Section 9. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited under the ESA provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

The ITS specifies reasonable and prudent measures necessary to minimize and monitor take of shortnose and Atlantic sturgeon. The measures described in the ITS are non-discretionary, and must be undertaken by FHWA so that they become binding conditions for the exemption in section 7(o)(2) to apply. FHWA has a continuing duty to regulate the activity covered by this Incidental Take Statement. If FHWA (1) fails to assume and implement the terms and conditions or (2) fails to require the project sponsor or their contractors to adhere to the terms and conditions of the Incidental Take Statement through enforceable terms that are added to permits and/or contracts as appropriate, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, FHWA or the project sponsor must report the progress of the action and its impact on the species to the NMFS as specified in the Incidental Take Statement [50 CFR §402.14(i)(3)] (See U.S. Fish and Wildlife Service and National Marine Fisheries Service's Joint Endangered Species Act Section 7 Consultation Handbook (1998) at 4-49).

This ITS exempts the following take:

Short Span Bridge Option		
Type of Take	**Shortnose Sturgeon**	**Atlantic Sturgeon**
Capture	3 (juvenile or adult)	3 total: 2 juvenile or subadult NYB DPS, one subadult GOM or CB DPS
Injury	70 (juvenile or adult)	70 total
		64 NYB DPS (juvenile, subadult or adult)
		4 GOM DPS (subadult or adult)
		2 CB DPS (subadult or adult)
Mortality	2 (juvenile or adult)	2 total: 2 juvenile or subadult NYB DPS ***or*** 1 juvenile or subadult NYB DPS and 1 subadult GOM DPS or 1 subadult CB DPS

Long Span Bridge Option		
Type of Take	**Shortnose Sturgeon**	**Atlantic Sturgeon**
Capture	3 (juvenile or adult)	3 total: 2 juvenile or subadult NYB DPS, one subadult GOM or CB DPS
Injury	43 (juvenile or adult)	43 total
		40 NYB DPS (juvenile, subadult or adult)
		2 GOM DPS (subadult or adult)
		1 CB DPS (subadult)
Mortality	2 (juvenile or adult)	2 total: 2 juvenile or subadult NYB DPS ***or*** 1 juvenile or subadult NYB DPS and 1 subadult GOM DPS or 1 subadult CB DPS

This Opinion concludes formal consultation for the proposed action as currently defined. Reinitiation of this consultation is required if: (1) the amount or extent of taking specified in the ITS is exceeded; (2) new information reveals effects of these actions that may affect listed species or critical habitat in a manner or to an extent not previously considered; (3) project activities are subsequently modified in a manner that causes an effect to the listed species that was not considered in this Opinion; or (4) a new species is listed or critical habitat designated that may be affected by the identified action.

Should you have any questions regarding this Opinion please contact Julie Crocker of my staff at (978) 282-8480 or by e-mail (Julie.Crocker@noaa.gov). I look forward to continuing to work with you and your staff during future Section 7 consultations.

Sincerely,

Daniel S. Morris
Acting Regional Administrator

Enclosure

EC: Crocker, F/NER3
Rusanowsky, Chiarella, Boelke - F/NER4
Toni, FHWA
Tomer, ACOE
Knutson, EPA
Kassof, USCG
Wilson, NYDEC

File Code: Sec 7 FHWA Tappan Zee Bridge Replacement
PCTS: F/NER/2012/01752

ENDANGERED SPECIES ACT SECTION 7 CONSULTATION
BIOLOGICAL OPINION

Agency: Federal Highway Administration, New York Division (lead)
Army Corps of Engineers, New York District
U.S. Coast Guard
U.S. Environmental Protection Agency, Region II

Activity: **Tappan Zee Bridge Replacement**
F/NER/2012/01780

Conducted by: NOAA's National Marine Fisheries Service
Northeast Regional Office

Date Issued: 6·22·12

Approved by:

1.0 INTRODUCTION

This constitutes NOAA's National Marine Fisheries Service's (NMFS) biological opinion (Opinion) issued in accordance with section 7 of the Endangered Species Act of 1973, as amended, on the effects of the proposed Tappan Zee Bridge Replacement Project. The U.S. Federal Highway Administration (FHWA) is the lead agency for the proposed bridge replacement. The U.S. Army Corps of Engineers (ACOE) is proposing to authorize components of the bridge replacement under Section 10 of the Rivers and Harbors Act. The ACOE and the U.S. Environmental Protection Agency (EPA) will authorize the transportation and ocean disposal of dredge material under Section 103 of the Marine Protection, Research and Sanctuaries Act. The U.S. Coast Guard (USCG) will authorize the bridge replacement under the General Bridge Act of 1946.

We are basing this Opinion on information provided in a Biological Assessment (BA) dated January 2012, a revised BA dated April 2012, a Draft Environmental Impact Statement (DEIS) dated January 2012, results of the Pile Installation Demonstration Project (PIDP) provided to us through June 2012 and other sources of available information as cited in this Opinion. A complete administrative record of this consultation will be kept on file at the NMFS Northeast Regional Office, Gloucester, Massachusetts.

2.0 BACKGROUND AND CONSULTATION HISTORY

We began coordination with FHWA, the New York Department of Transportation (NYSDOT), the New York State Thruway Authority (NYSTA), and their project team in 2006 regarding the potential replacement of the Tappan Zee Bridge.

In 2006, we worked with the project team on their design of a gillnet sampling study that was undertaken near the bridge site. Work occurred under an Incidental Take Permit issued by NMFS Office of Protected Resources under section 10(a)1(A) of the ESA. Data was collected from April 2007 through May 2008 with additional sampling of oyster beds and submerged aquatic vegetation (SAV) during 2009. We participated in several meetings with FHWA and their project team beginning in 2008.

Beginning in October 2011, we worked with FHWA and the project team regarding the planned PIDP. We completed section 7 consultation on the effects of the PIDP on shortnose sturgeon and three Distinct Population Segments (DPS) of Atlantic sturgeon. This consultation was completed with the issuance of a Biological Opinion on March 7, 2012. The Opinion concluded that the PIDP was likely to adversely affect, but not likely to jeopardize the continued existence of these species.

We have also reviewed and provided comments on a Preliminary PDEIS and the January 2012 DEIS. A meeting was held on December 14, 2011, to continue the coordination of the PIDP and the Project's Biological Assessment and Essential Fish Habitat analyses.

FHWA submitted a BA to us along with a request to initiate section 7 consultation on January 27, 2012. A revised BA was submitted on April 13, 2012; that served as the initiation date for this consultation. FHWA submitted results of the PIDP to us through May 2012. Information supplementing the April BA was submitted on May 31, 2012.

We transmitted a draft Opinion to FHWA, the ACOE and the project team on June 14, 2012. We received comments from FHWA, the project team and ACOE on June 18, 2012. All comments received have been addressed as appropriate.

3.0 DESCRIPTION OF THE PROPOSED ACTION

3.1 Federal Actions

FHWA is funding the bridge replacement project and the USACE, New York District is permitting in-water work associated with the project under Section 10 of the Rivers and Harbors Act and Section 404 of the Clean Water Act. The New York Department of Transportation (NY NYSDOT), the New York State Thruway Authority (NYSTA) and their contractors, will carry out the project. The FHWA is the lead Federal agency for the project for purposes of this ESA consultation and coordination under the National Environmental Policy Act. The USACE and U.S. Environmental Protection Agency (EPA) will authorize the transportation and ocean disposal of dredge material under Section 103 of the Marine Protection, Research and Sanctuaries Act. The US Coast Guard (USCG) will issue a permit under the General Bridge Act of 1946 for construction of the bridge because it crosses navigable waters of the United States.

3.2 Summary of Proposed Action

The proposed project would result in a new bridge crossing of the Hudson River between Rockland and Westchester Counties. A number of design parameters have been considered to develop the location and general configuration of the replacement bridge. Because the project is being progressed as design-build, certain design elements have not yet been finalized, there are options detailed below for some structural characteristics of the bridge.

The replacement bridge would be constructed north of the existing Tappan Zee Bridge. To conform to highway design standards, including widths and grades, there will also be modifications to Interstate 87/287 between approximately Interchange 10 (Route 9W) in Nyack and Interchange 9 (Route 9) in Tarrytown. The location of the proposed bridge is illustrated in Figure 1.

The landings will tie in the new geometry of the proposed bridge with the geometry of the existing roadway. The landings would employ typical highway construction techniques and would be completed on both the Westchester and Rockland sides of the Hudson River upland from the bridge abutments. Construction of the landings would occur throughout the duration of the project. The construction activity for the landings would be staged, as the roadways on both sides would be altered and then maintained for lengthy spans of time before being altered again. The alterations to the landings would consist of changes in roadway grade, elevation, direction, and general configuration.

Beginning at the abutments, the approaches will carry traffic from land to the main span of the bridge. Construction of the approaches would last for approximately three and a half to four years for the short-span alternative, and two and a half to three years for the long-span alternative. The piles, pile caps, piers, and deck that compose this segment of the bridge would be built sequentially so that as a new pile cluster is being constructed, a completed pile cluster would be undergoing further transformation with, for example, the addition of a pile cap. In water work associated with building the approaches involves pile and cofferdam installation.

The main span would stretch between the Westchester and Rockland approaches and span the federal navigation channel. It is the segment of the bridge that would be defined largely by its superstructure design as an arch or cable stayed bridge. Within its substructure, the piers would be more substantial than those of the approaches. All main span work would be done sequentially and in a similar manner as that of the approaches. The piles, pile caps, pylons, and deck construction would last approximately three and a half years. In water work associated with building the approaches involves pile installation.

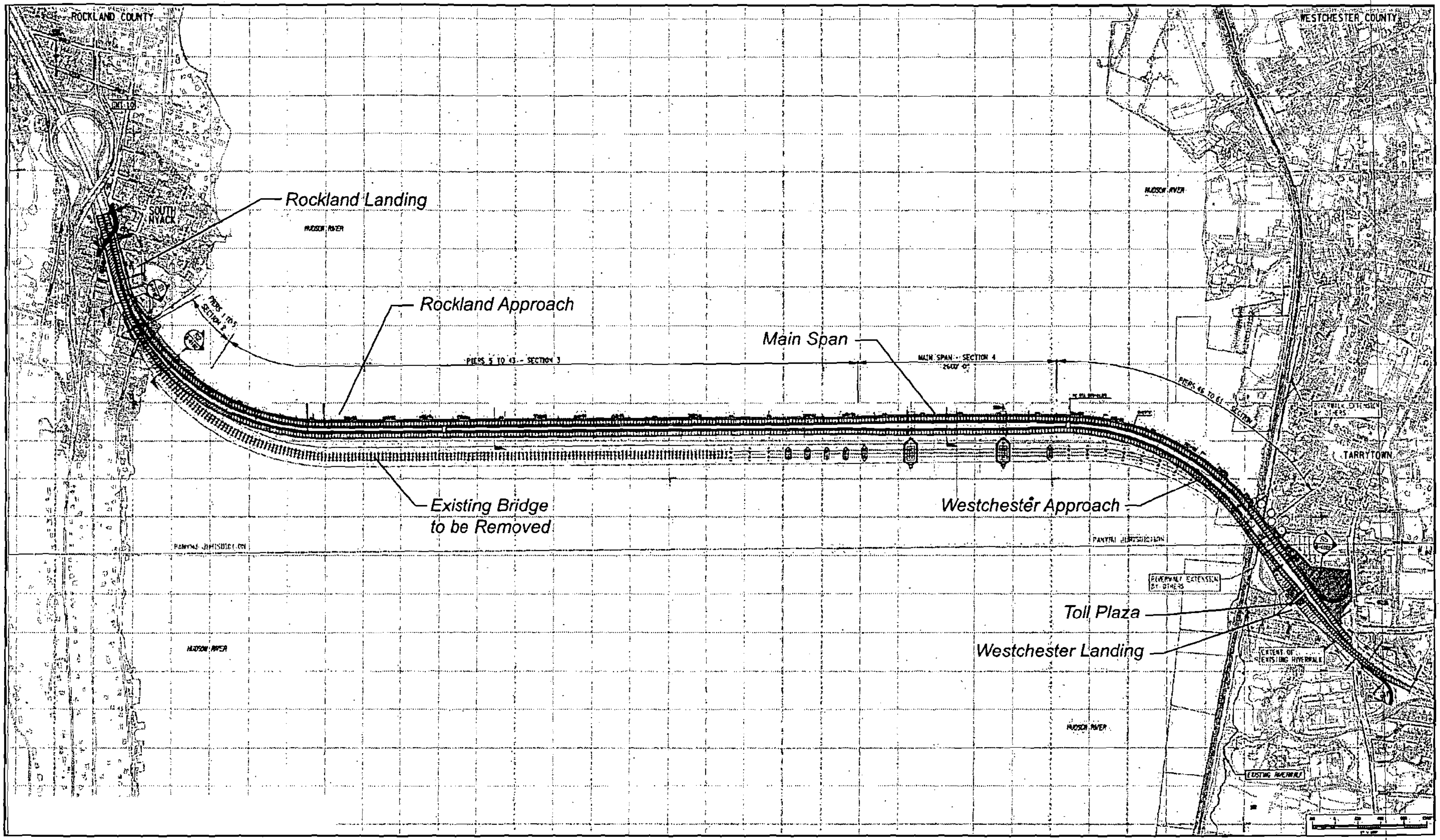
Substructure construction would establish the foundation of the bridge through the processes of pile driving, construction of pile caps, and construction of columns. Superstructure construction would then take place either with a gantry that would move from pier to pier lifting segments from barges below (as in the case of the short-span design option) or with a system of winches to lift prefabricated truss sections (as in the case of the long-span option). In the long span option, a short pier-head truss segment would be lifted atop the next open pier column and secured, and then the span truss is lifted to span the gap between the pier head trusses.

Construction of either option for the new bridge would require a wide range of activities on both sides of the river as well as from within the waterway itself. In addition, due to the lack of available land along the waterfront in the vicinity of the bridge, staging areas at some distance from the construction site would be required. Some bridge components would be pre-fabricated and transported to the site via barge.

To support construction of the main span and bridge approaches, materials, equipment, and crews would be transported from upland staging areas in Westchester and Rockland counties to temporary platforms that would be constructed on the shoreline of the river, as shown in Figure

2. Due to the anticipated draft of the work vessels, dredged channels would be required to provide access to the two work areas in the shallow portion of the river crossing: the Rockland and Westchester approaches.

1.4.12



Figure

Approach Spans, Main Span, and Ancillary Facilities of the Replacement Bridge

1.5.12

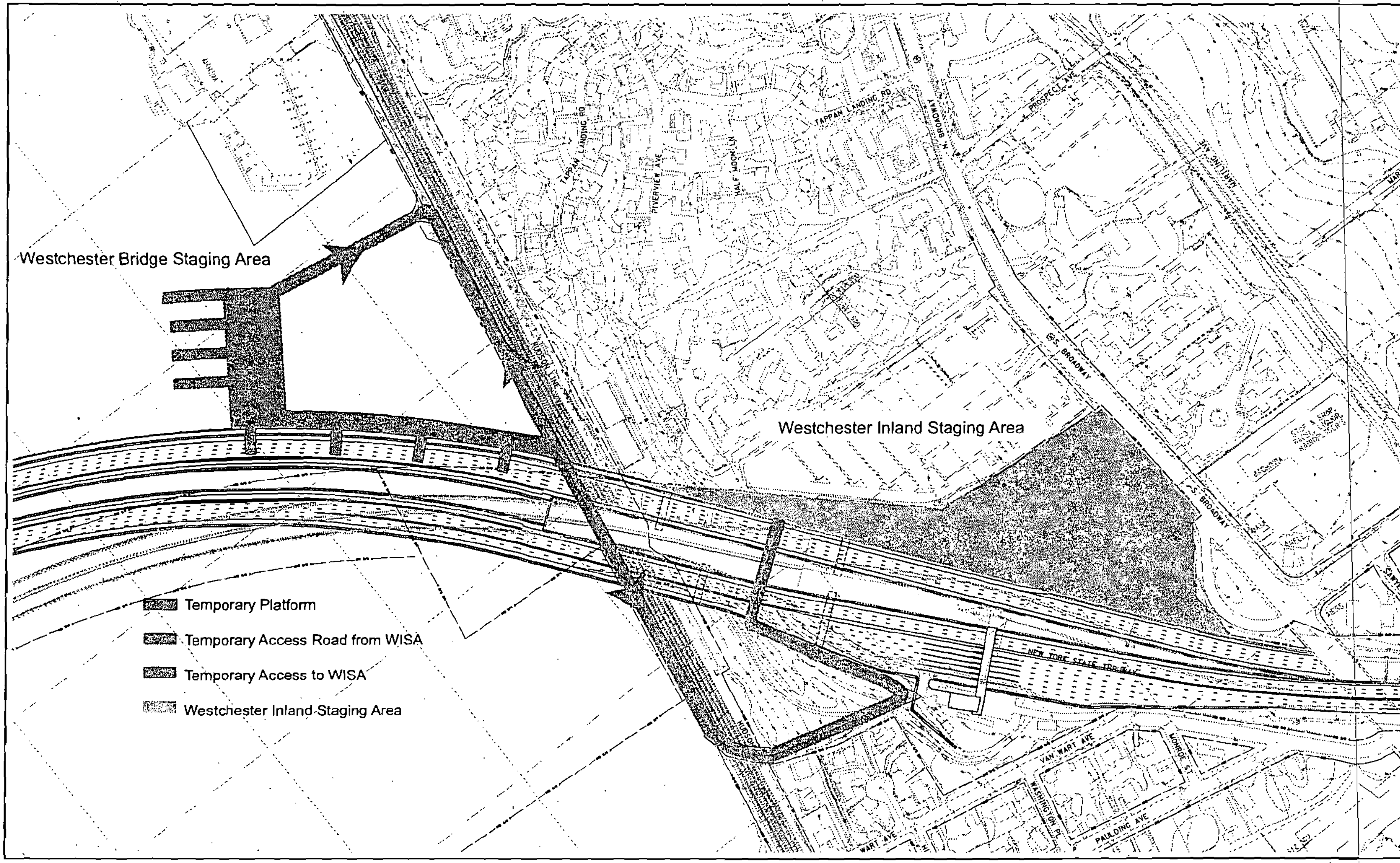


Figure 2
Westchester Landing Construction Access

1.9.12

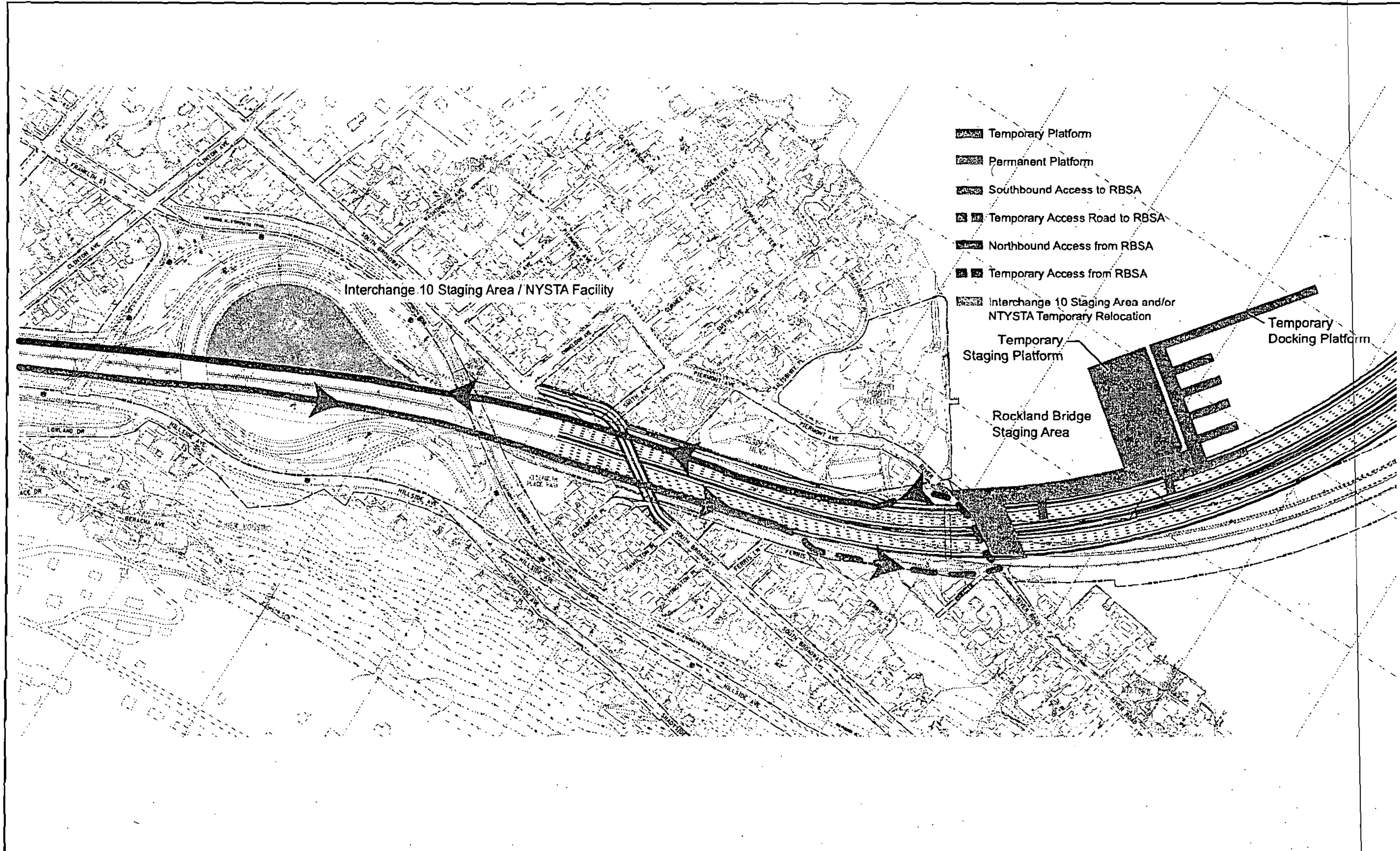


Figure 2

Rockland Landing Construction Access

3.3 Required Environmental Performance Commitments

FHWA will require that certain Environmental Performance Commitments (EPCs) be employed during construction of the substructure. These will become mandatory conditions of any contracts issued for the project and include:

- Driving the largest [3 and 2.4 m (10 and 8 feet)] diameter piles within the first few months of the project thereby limiting the time period of greatest potential impact.

- Using cofferdams and silt curtains, where feasible, to minimize discharge of sediment into the river.

- Using a vibratory pile driver to the extent feasible (i.e., all piles will be vibrated at least to 36.6 m (120 feet) depth or to vibration refusal) particularly for the initial pile segment.

- Using bubble curtain, cofferdams, isolation casings, Gunderboom, or other technologies to achieve a reduction of at least 10 dB of noise attenuation.

- Using the results of the PIDP, which includes the testing of various sound attenuation devices, to inform the project on the effectiveness of BMP technologies for reducing sound levels, and implementing BMPs to achieve maximum sound reduction.

- Limiting the periods of pile driving to no more than 12-hours/day.

- Limiting driving of 8 and 10 foot piles with an impact hammer within Zone C [water depths 5.5-13.7 m (18-45 feet)] to 5 hours per day during the period of spawning migration for shortnose and Atlantic sturgeon (April 1 to August 1).

- Maintaining a corridor where the sound level is below an SEL_{cum} of 187 dB re $1uPa^2 \cdot s$ totaling at least 5,000-ft at all times during impact hammer pile driving. This corridor shall be continuous to the maximum extent possible but at no point shall any contributing section be smaller than 1,500 ft.

- Pile tapping (i.e. a series of minimal energy strikes) for an initial period to cause fish to move from the immediate area.

- Development of a comprehensive monitoring plan. Elements would include:

  - Monitoring water quality parameters such as temperature, salinity, and suspended sediment concentrations in the vicinity of the pile driving.
  - Monitoring fish mortality and inspection of fish for types of injury, as well as a program for determining contaminant levels in dead sturgeon through tissue analysis methods.
  - Monitoring the recovery of the benthic community within the dredged area at the end of the construction period.
  - Supporting the Atlantic and shortnose sturgeon sonic tagging program through coordination with NMFS and NYSDEC. This may include placement of telemetry receivers in the project area.

- Monitoring predation levels by gulls and other piscivorous birds, which would indicate an increased number of dead or dying fish at the surface.
- Preparing a Standard Operating Procedures Manual outlining the monitoring and reporting methods to be implemented during the program.

- In addition, dredging (using a clamshell dredge with an environmental bucket and no barge overflow) would only be conducted during a three-month period from August 1 to November 1 for the three years of the construction period in which dredging would occur, which would minimize the potential for interaction with the dredge and migration effects to sturgeon and other fish species.

- Armoring of the channel to prevent re-suspension of sediment during the movement of construction vessels, installation and removal of cofferdams, and pile driving.

3.4 Construction of the new bridge

There are two options for the Replacement Bridge's approach spans (Short Span and Long Span Options). As shown in Figure 3, construction of the Short Span Option would take approximately 5½ years. The schedule shows both preliminary activities used to support the construction of the project (i.e., dredging and temporary platforms) as well as individual elements of bridge construction (i.e., main span and approaches). Throughout the construction period roadway work would be required at various times. During that time, the approach roadways would be shifted and remain in the new location for an extended period before being shifted again. The dredging would occur in three stages over the 5 ½ year period, and would be conducted during a three-month window between August 1 and November 1. Construction of the main span would consist of approximately 3½ years of construction. Completion of the short span approaches would involve approximately 3½ to 4 years of construction. Demolition of the existing Tappan Zee Bridge would be expected to span approximately 1 year.

Construction of the Long Span Option would last approximately 4½ years (see Figure 4). The construction sequence and schedule would be similar to that of the Short-Span Option with the exception of the construction of the approaches, which would be expected to take approximately 2½ to 3 years.

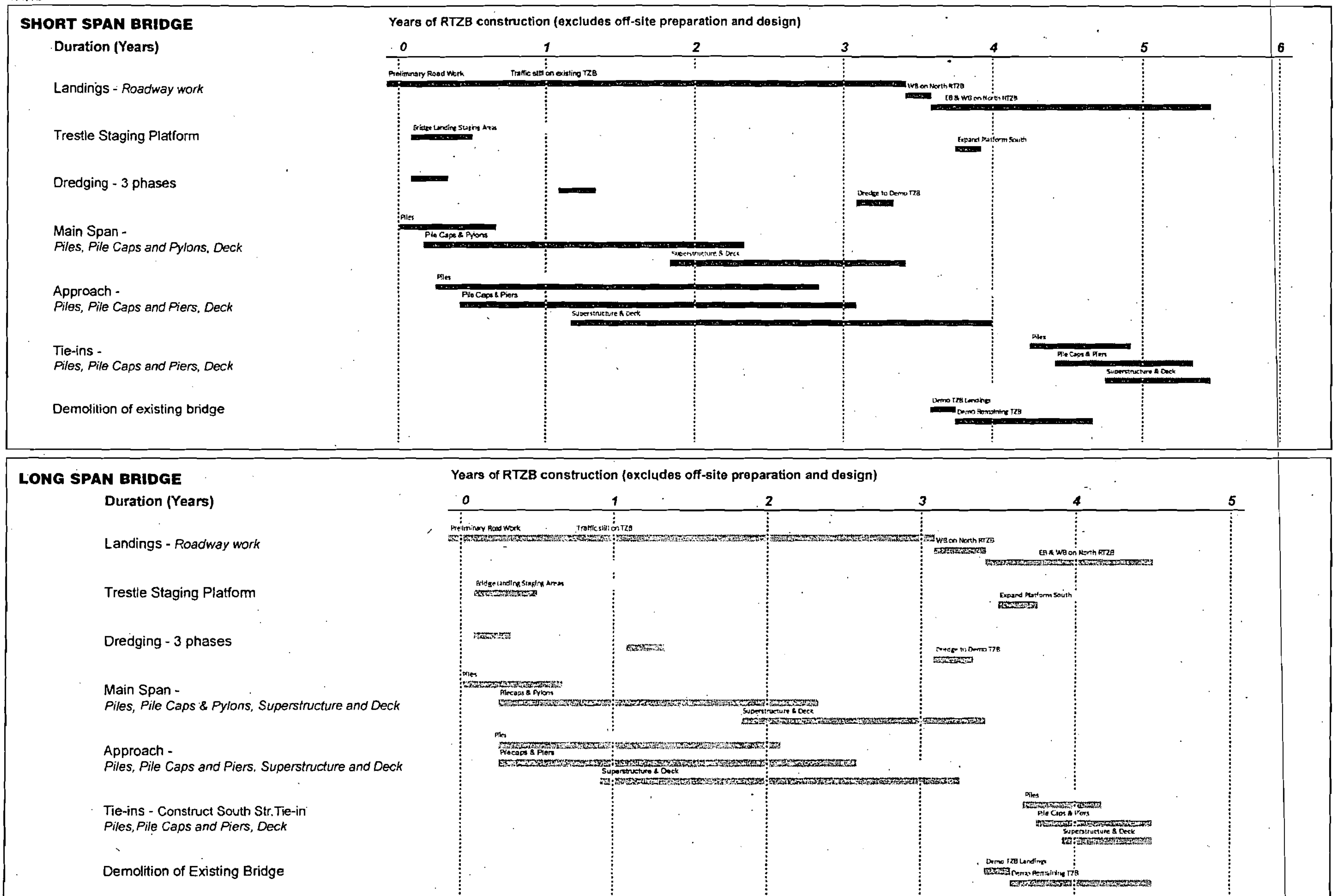


Figure 3.44

Construction Schedules for Short Span and Long Span Option

3.4.1 Waterfront Construction Staging

The shoreline areas near the proposed bridge site are limited by adjacent development. In order to provide space for the docking of vessels, the transfer of materials and personnel, and the preparation of construction elements, temporary platforms and a permanent platform along the Rockland County side would be extended out from the shoreline over the Hudson River (see Figures 3 and 4). The Rockland platforms would protect the shoreline and also enable the continued maintenance of the original Tappan Zee Bridge as well as providing continued support for the NYSTA Dockside Maintenance facility operation. These platforms would provide access to the replacement bridge site via temporary trestles. Their main purposes would be to facilitate delivery of heavy duty bridge elements from an offsite fabrication facility, receive deliveries from the concrete batch plant, receive deliveries (i.e., construction equipment and light duty bridge elements) from the staging areas, and allow for barge-mounted cranes to erect heavy duty bridge elements. Upon completion of construction, the temporary platforms and the piles that support them would be removed.

As the construction of the temporary platforms and access trestles would begin at the shoreline, an access road and work area near the shore would also be constructed. A channel would be dredged specifically to provide tug boat and barge access to the temporary platforms from in-river work sites.

3.4.2 Dredged Access Channel

Since the proposed bridge alignment spans extensive shallows, FHWA has determined it is necessary to dredge an access channel for tugboats and barges to utilize during construction of the approach spans. These vessels would be used for the installation of cofferdams, pile driving, the construction of pile caps and bridge piers, and the erection of bridge decks and other superstructure components.

As shown in Figure 5, dredging would be conducted in three stages between August 1 and November 1 over a 4-year period. An environmental bucket dredge will be used with no barge overflow allowed. The purpose of the first two dredging stages (Years 1 and 2) would be to provide access for bridge construction, while the final dredging stage (Year 4) would provide access for demolition of portions of the existing bridge allowing for completion of the remaining portions of the new structure.

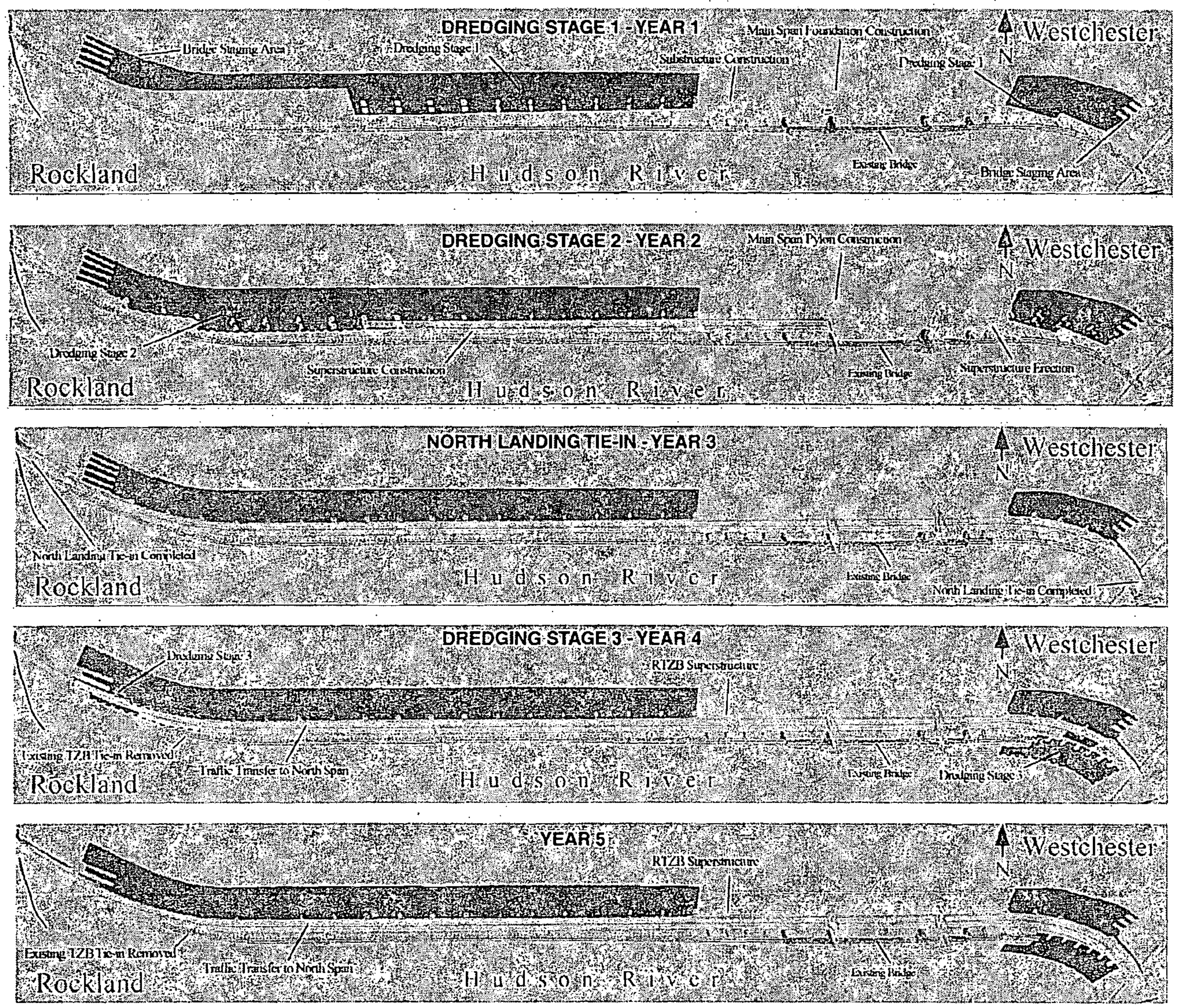
Based on an analysis of the types, number, size and operation of vessels that would operate in the access channel during construction, it was determined that a clear draft of at least 3.6 m (12 feet) would be required within the access channel. To avoid the potential for grounding of vessels, an additional two feet would be added to provide a working channel depth of 4.3 m (14 feet) at the lowest observed water level, which occurs during the Spring Neap Tide. The lowest observed water level is referred to as Mean Low Low Water (MLLW).

Table 1 shows the amount of material to be dredged during each stage for the two bridge design options. For either design option, the channel width would measure approximately 145 to 161 m (475 to 530 feet), and it would extend approximately 2,133 m (7,000 feet) from the Rockland County side into deeper waters and 610 m (2,000) feet from the Tarrytown access trestle into deeper waters. Because the long span alternative would occupy a wider footprint, a slightly larger area must be dredged for that alternative. It is estimated that approximately 1.28 and 1.33 million cubic meters (1.68 and 1.74 million cubic yards) of sediment would be dredged for the short and long span options, respectively.

Table 1. Dredging Quantities for the Replacement Bridge Alternatives

Construction Stage	Short Span		Long Span	
	Quantity (million CY)	Percent of Total	Quantity (million CY)	Percent of Total
Stage 1	1.08	64%	1.12	64%
Stage 2	0.42	25%	0.43	25%
Stage 3	0.18	11%	0.19	11%
Total	1.68	100%	1.74	100%

Notes:
CY = cubic yards
Dredging for bridge demolition (Stage 3) includes that portion of the bridge which must be removed to complete the Replacement Bridge Alternative tie-in.



Note: Long Span Option is depicted, Short Span Option will be similar

Figure 5
Dredging Sequence, Years 1 to 5

3.4.3 Armoring of River Bottom in Dredged Access Channel

To minimize any adverse effects from the re-suspension of the fine sediment material due to movement of vessels, particularly tugboats, within the dredged channel, a layer of sand and gravel (referred to as "armor") would be placed at the bottom of the channel following dredging. FHWA determined the sediments in the vicinity of the area to be dredged are highly susceptible to resuspension into the water column. Without "armoring," prop scour from working tugboats in the channel would result in the generation of suspended sediment at rates several orders of magnitude greater than what would occur from the dredging operation itself.

The installation of the sand and gravel would take place as soon as the dredging for that section of the channel was successfully completed, forming a protective layer to keep sediment from further disturbance. The sand and gravel materials would be delivered by barges or scows, and would be placed within the channel by barge-mounted cranes. The materials would not be removed after the project completion, since they would become fully buried by the gradual deposition of river sediments over time once construction was completed. The dredging depth required assumes that two feet of sand and gravel armor is placed on the bottom. In total, the channel would be dredged to a depth corresponding to 4.9 m (16 feet) below MLLW to allow for the required 14 ft of clear draft and 2 ft of armoring.

3.4.4 Transport and Disposal of Dredged Material

During each three-month period when dredging is occurring, dredged materials would be collected from the bottom of the river by barge-mounted cranes and placed into hopper scows, which have a capacity of approximately 1,911 cubic meters (2,500 cubic yards). To ensure that the scows do not exceed the maximum allowable draft of the river work zone, they would be limited to 80 percent of their maximum load, or 1,529 cubic meters (2,000 cubic yards) per load.

Each dredging stage would occur during a 90-day period. During that period, it is estimated that dredging would occur up to 75 of the 90 days, with two dredges operating at a time. During the busiest dredging stage, Stage 1, up to 11,468 cubic meters (15,000 cubic yards) of materials would be dredged each day. Table 2 presents the estimated daily volumes of materials removed for each dredging stage for the two replacement bridge alternatives.

Construction Stage	**Short Span Daily Volume (cubic yards)**	**Long Span Daily Volume (cubic yards)**
Stage 1	14,600	15,000
Stage 2	5,700	5,800
Stage 3	2,400	2,600

Table 2. Daily Materials Removal by Construction Stage

After placement in the hopper scows, the next step in the dredge materials handling would depend on the dredge placement option selected.

Certain activities related to the project are left to the discretion of the contractor. One of these would be the ultimate transport and disposal of dredge spoils from construction of the access channel. FHWA has identified two likely options for dredge disposal; use of the HARS site or at an upland site. Both options are described below. FHWA believes that it is most likely that the contractor will use the HARS rather than an upland disposal site based on cost, schedule, logistics and the avoidance of impacts to the surrounding residential communities on the Rockland and/or Westchester shorelines.

3.4.4.1 Use of the HARS

The HARS is located 5.6 km (3.5 miles) east of Sandy Hook, NJ (see Figure 6). The HARS is overseen by the USACE and the U.S. EPA. This site was historically used for ocean disposal of dredged material and a variety of waste products, including some contaminated materials. Today, the site is being remediated through a program to cap those historic sediments with cleaner sediments dredged from Mid-Atlantic waters, primarily New York Harbor, which meet certain criteria established by the Ocean Dumping Act.

Disposal at HARS requires a permit from the USACE. To receive the permit, materials must be suitable for remediation, in that they meet certain criteria related to contaminants based on sediment toxicity and bioaccumulation tests. In addition, in accordance with 40 CFR §227.16, the EPA must evaluate alternative disposal options before permitting placement of dredged material at the HARS, and must find that there are no practicable alternative locations and methods of disposal or recycling available. FHWA has prepared documentation outlining their determination that there are no practicable alternatives locations for the placement of the dredged material at the HARS site.

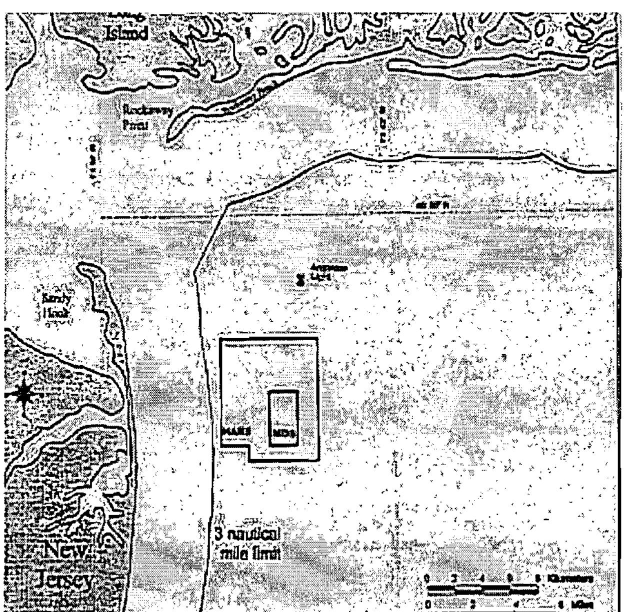


Figure 6. Location of the HARS dredge disposal site.

FHWA is proceeding with sampling and analysis of the dredged material in support of the application for a permit under Section 103 of the Marine, Protection, Research, and Sanctuaries Act of 1972. If approved, the dredged materials from the Tappan Zee Hudson River Crossing Project placed at the HARS would be transferred from the hopper scows to larger capacity [up to 3,440 cubic meters (4,500 cubic yards)] ocean scows. These vessels have large drafts, typically up to 5.5 m (18 feet), which would be too large to be accommodated in the dredged construction channel. Therefore, materials would be transferred from the hopper scows to the ocean scows in deeper water areas of the Hudson River. The ocean scows would then travel to the HARS, where materials would be placed at the site in accordance with the permit conditions for that placement.

3.4.4.2 Upland Disposal

If the permit application for the use of HARS is denied in whole or part, the contractor would be required to dispose of the dredged material at an approved facility in accordance with all applicable laws and regulations. Dredged material would be transferred directly to a truck or to a barge and then to a truck or rail, for ultimate disposal at a permitted upland facility.

3.4.5 Substructure Construction

Substructure construction would vary as a function of water depth and sediment conditions at each location. Work on the foundations can be categorized into three segments referred to as Zone A, Zone B, and Zone C (see Figures 7 and 8). Pile installation would typically be performed one row of piles at a time. The actual pile driving is done one pile at a time. As shown in Table 3, a total of 1,326 piles for Piers 1 to 57 would be required for the Short Span Option. Table 4 includes similar information for the Long Span Option at Piers 1 thru 32. The Long Span Option would require 836 piles. In terms of the largest piles, the number of the 3-m (10-foot) piles would be the same (50) for either option. The greatest difference between the two options would be the number of smaller 1.2-m (4-foot) piles with the Short Span Option requiring approximately 346 more piles than the Long Span Option. The Long Span Option would also require 104 less 1.8-m (6-foot) piles and 40 less 2.4-m (8-foot) piles for a total difference of 490 piles. Under either option, the driving of the largest piles [2.4- and 3-m) (8- and 10-foot)] would only occur for a few months in the first year of construction.

Table 3. Pile Driving, Short Span Option

Pier No.	Substructure Zone	Pile Size (diameter ft)	No. of Piles Within each Pier	Total No. of Piles
1-3	A1	6	4	24
4-8	B1	6	6	60
9 – 14	B1	4	20	240
15-32	B1	4	20	720
33-35	B1	8	4	24
36-43	C	8	4	64
44-45	C	10	25	50
46-50	C	6	6	60
51-57	B2	6	6	84
Total				**1,326**

Table 4. Pile Driving, Long Span Option

Pier No.	Substructure Zone	Pile Size (diameter ft)	No. of Piles Within each Pier	Total No. of Piles
1-2	A1	6	4	16
3	A1	6	6	12
4	B1	6	6	12
5-17	B1	4	25	614
18-21	B1	8	4	32
22-23	C	8	4	16
24-25	C	10	25	50
26-28	C	6	6	36
29-30	B2	6	6	24
31-32	A2	6	6	24
Total				**836**

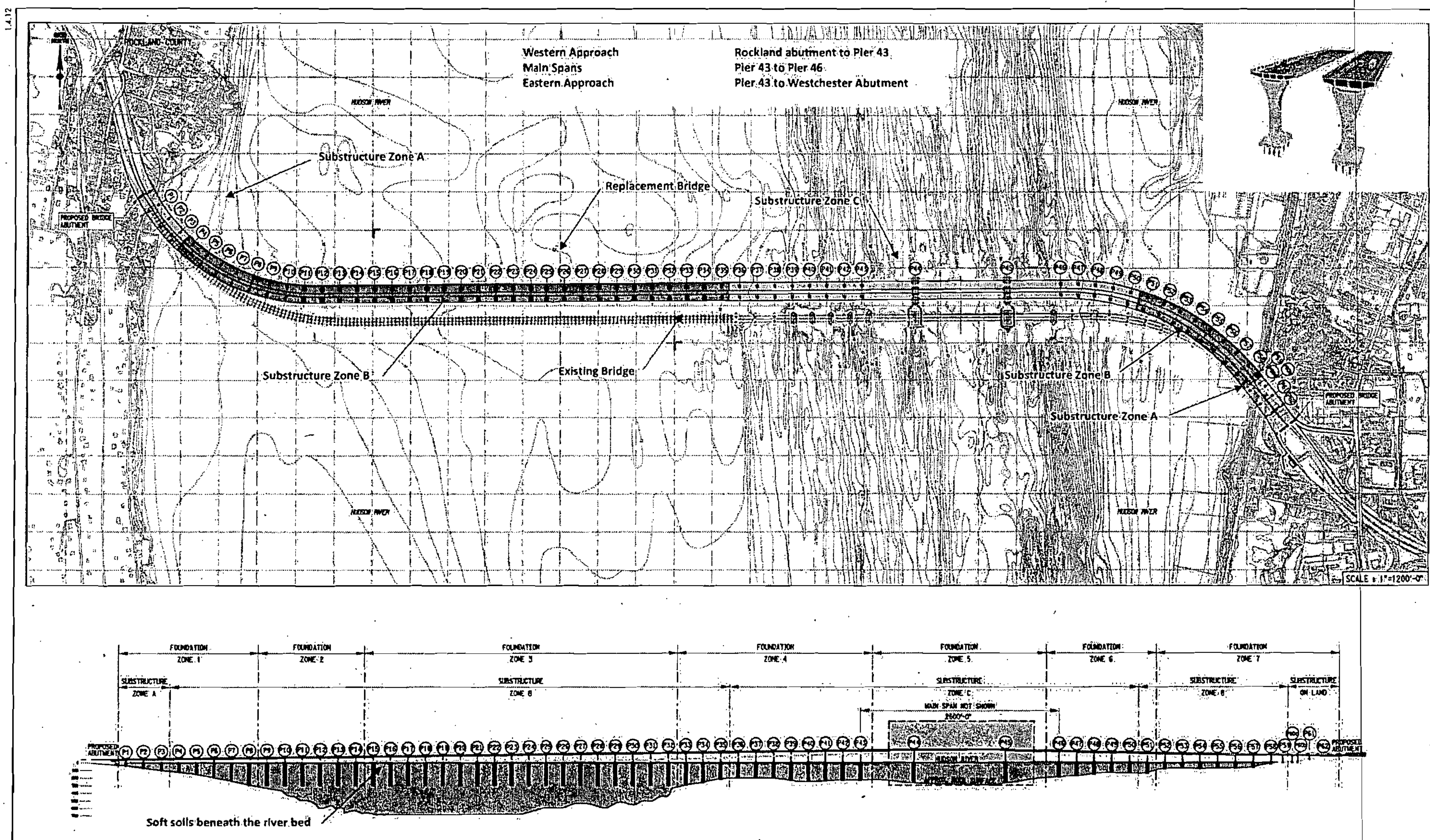


Figure 7
Construction Zones for Short Span Option

1.4.12

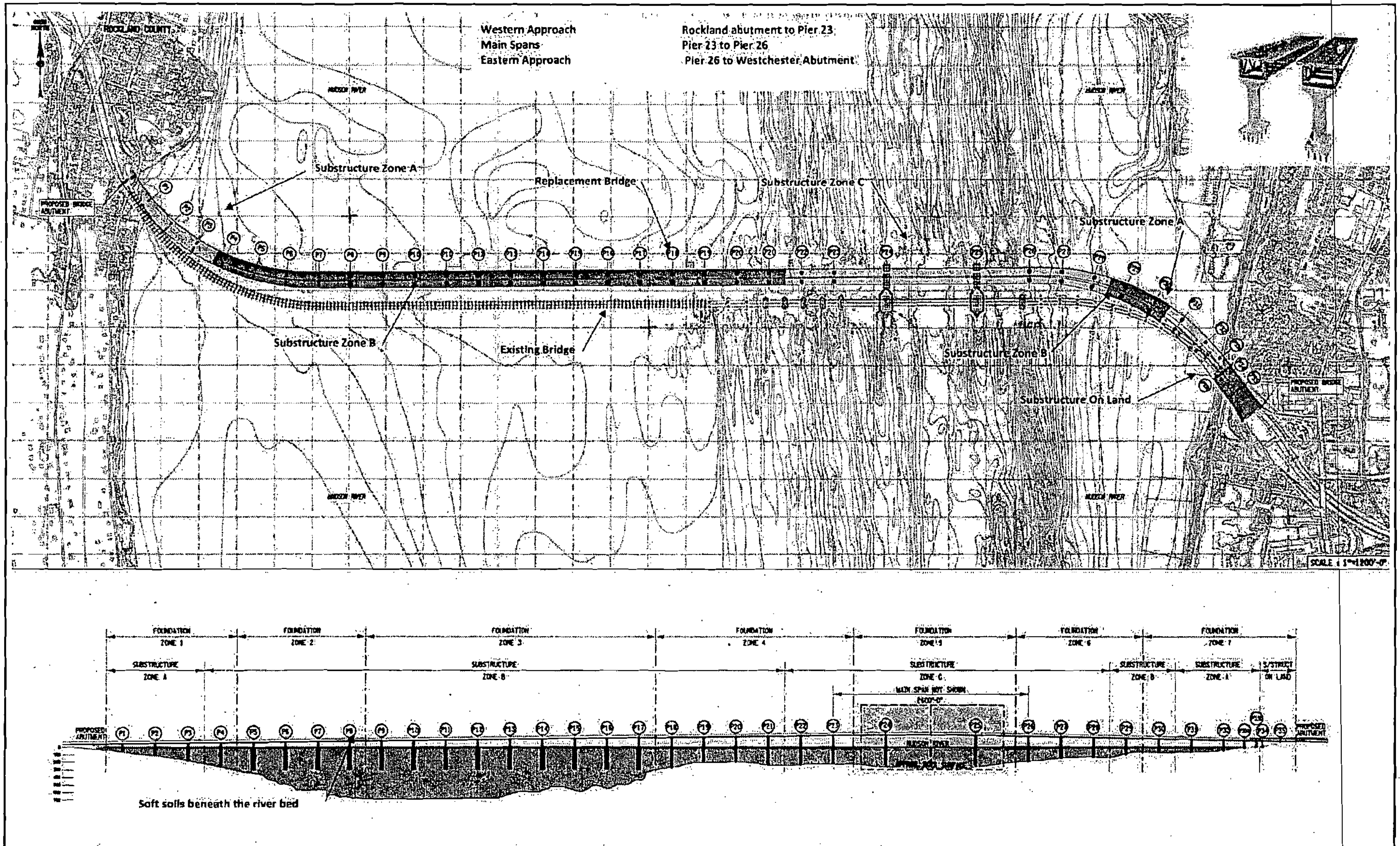


Figure 8
Construction Zones for Long Span Option

3.4.5.1 Foundation Zone A

The two areas of shallowest water depth extend from the shorelines on the Rockland and Westchester sides of the Hudson. These areas, where the water measures less than 2.1 m (7 feet) in depth, are labeled as Zone A. The area adjacent to the Rockland shoreline is labeled Zone A1, while the area adjacent to the Westchester shoreline is Zone A2. Zone A substructure elements would be constructed within cofferdams from adjacent temporary trestle platforms. These cofferdams would be constructed prior to pile driving the bridge foundation piles. The cofferdam would remain flooded during pile installation but would be dewatered prior to installation of the pile caps.

3.4.5.1.1 Cofferdams

A cofferdam is a watertight chamber designed to facilitate construction in an area that would otherwise be underwater. In this case, the cofferdams would be composed of interlocking sheet piles extending into the riverbed a distance of up to 6.1 m (20 feet). Cofferdams will be vibrated in place which will also act to minimize hydroacoustic effects. Upon completion of the cofferdam, foundation piles would be driven into the riverbed.

3.4.5.1.2 Pile installation

A 300-ton crawler crane would suspend the 45.7-m (150-foot) pile sections and support the pile driving hammer during operation. Prior to pile driving, a template to guide piles would be placed within the cofferdam to ensure that they are in position and to hold them when pile driving is not taking place. A quick, low-noise, moderate-energy vibratory hammer would be used to install much of the length of the pile, after which a high efficiency hydraulic impact hammer suspended from cranes operating on the two temporary shoreline access trestles would be used to apply force to the tops of the piles so as to deliver the piles more deeply into the riverbed. The use of vibratory hammers for the entire driving operation is not possible due to the excessive depths to bedrock. Once all piles are driven, the template and its supports would be transitioned to the next cofferdam.

3.4.5.1.3 Pile caps

Upon completion of pile installation, a tremie seal, which braces the bottom of the sheet pile cofferdam and provides a seal at the base of the cofferdam to allow for dewatering of the cofferdam, would be poured and the cofferdam would be dewatered. River water recovered during dewatering of the cofferdams would be routed to tanks to settle out any suspended sediments (or a water filtration system as necessary) and discharged back to the Hudson River in accordance with conditions issued by the NYSDEC under the Section 401 water quality certification for the project. As NYSDEC is requiring a 24 hour settling period for discharge of barge decant water, it is expected that this would be a maximum settling period requirement for river water recovered during dewatering of the cofferdams.

After dewatering of the cofferdam, the interior of the piles would be excavated and a tremie concrete plug would be poured into the hollowed pile to prevent water infiltration. The pile itself would be dewatered down to the plug, reinforcing steel installed, and the pile would be filled with concrete. Prior to the installation of the pile cap, pier reinforcement, post tensioning ducts, and pile reinforcement would be secured. A pile cap, which is a reinforced concrete slab constructed atop a cluster of foundations piles, would then be constructed to form a single structural element that would allow for even distribution of the weight that the piles bear, avoiding over stressing any individual component. These slabs would also provide a larger area for the construction of the columns that they will support.

3.4.5.2 Foundation Zone B

The water depths in Zone B range from 1.5 to 5.5 m (5 to 18 feet), and the zone is characterized by a relatively deep soft-soil profile. Zones B1 (close to the Rockland shoreline) and B2 (close to the Westchester shoreline) are located adjacent to Zones A1 and A2 and are closer to the centerline of the river. Work performed for substructure construction in Zone B would take place in cofferdams, but would be completed from barges and support vessels.

3.4.5.2.1 Pile Installation

Piles, which would be transported in two pieces to Zone B by barge, would measure between 76.2 and 91.4 m (250 and 300 feet). Pile driving would begin immediately upon completion of the cofferdam construction. A 300-ton crawler crane would lift the pile sections. A pile-driving rig would supply a hammer suspended from the barge mounted crane. The template would be positioned to guide the lower pile section into proper position before the pile would be allowed to delve into the soft stratum under its own weight. The depth achieved in this manner would be considerable, and should the application of further pressure be called for, a vibratory hammer would be used to drive the remainder of the pile into place. Upon the placement of the lower segment of the pile, preparations to begin welding the two segments together will commence. In order for the two segments to be joined, the upper segment would be hovered over the lower until the automated welding process was complete. Upon the completion and inspection of the welding, the remaining length of the conjoined pile would be driven to required depth or specified penetration resistance with a hydraulic hammer. The soil within the pile would be excavated to a depth of approximately 120 ft and transported to an off-site disposal facility in order to create space for the tremie plug, steel reinforcing cage and concrete pour. Cofferdams will be dewatered following the installation of the piles.

3.4.5.2.2 Pile caps

The construction process of pile caps in Zone B would be similar to that of Zone A. One difference would be that a granular fill material would be distributed inside of the cofferdam to enable the tremie seal to be poured to its planned elevation prior to dewatering. This granular material would remain after the removal of the cofferdam.

3.4.5.3 Foundation Zone C

Foundation Zone C lies between Zones B1 and B2, connecting the two approaches from both sides of the river. This zone is defined by the greatest water depths, which range from 5.5 to 13.7 m (18 to 45 feet). Construction in this zone would encompass the construction of the main span as well as that of both approaches.

The first substructure construction activity in Zone C would be the installation of the foundation piles. In this zone, due to the greater depths than Zones A or B, cofferdam construction would follow the pile installation, thus requiring that the cofferdam be constructed around the installed pile to create a dry environment in which to construct the tremie seal. The cofferdam in Zone C would be constructed using a different method than that utilized in Zones A and B. This alternative method, the "hanging cofferdam method", would begin with the installation of a temporary support structure above the foundation piles on which the cofferdam would be assembled. The cofferdam components would then be pieced together and suspended from the support structure. Once the hanging cofferdam is assembled it is lowered over the pile cluster. No pile driving will be needed for installation of the hanging cofferdams in zone C. After the placement of the cofferdam, divers would seal the gaps between the cofferdam floor and the piles, then the tremie slab would be poured onto the cofferdam floor to seal the cofferdam for dewatering and pile cap construction.

3.4.5.4 Construction of Bridge Superstructure

Completion of the bridge superstructure would include piers, columns, pylons (for a cable-stayed option), bridge deck, roadway finishes, lighting, and the shared use path. Much of the material would be pre-fabricated at various locations and delivered to the project site via barge. At the construction site, these elements would be lifted into place by gantries and cranes operating on barges, the temporary work platforms, or completed portions of the structure.

3.5 Existing Bridge Demolition

The existing Tappan Zee Bridge contains five segments: causeway, east trestle, east deck truss, west deck truss, and main spans. The demolition of the existing bridge will be performed in two stages. The first stage will include partial demolition to allow for construction of the new bridge, and the second stage will occur after the completion of the new bridge. No blasting or underwater detonations for removal of the existing structure would occur.

3.5.1 Causeway and East Trestle Spans

The causeway is a simple span construction composed of 166 spans measuring 15.2 m (50 feet), with the exception of one 30.5-m (100-foot) span. The east trestle is comprised of six spans. Within its simple span construction, the causeway contains a stringer and deck superstructure and a substructure of concrete columns and footings on timber piles. Initially, the deck and stringers would be lifted out and placed onto awaiting barges. Then, the protective dolphins would be cut so as to offer unrestricted access for pier removal. Columns and footings would either be cut with diamond wire or broken by pneumatic hammers. Finally, the timber piles forming the causeway foundation would be cut to just below the mud line. All materials would be transported to an appropriate permitted off-site disposal facility, and a turbidity curtain would be utilized to ensure that demolition debris would not be dispersed. Side-scan sonar surveys would be performed in order to verify that all generated debris would be removed from the river. Debris will be removed with crane/bucket if necessary.

3.5.2 Deck Truss Spans

The deck truss spans, including 13 east deck, 7 west deck, and all approach truss spans, each contain a deck slab, steel trusses, and concrete piers supported on buoyant foundations or caissons. The deck slabs would be removed and transported off-site by an awaiting barge. A channel would then be dredged in Stage 3 (see above) to provide access to the trusses near the Westchester shoreline, and steelwork would either be removed by barge-mounted crane or a crane mounted on an adjacent in-tact span. Caisson-supported piers would be demolished using the same process as in the causeway and east trestle spans, and would then be removed just below the mud line through excavation and using diamond cutting wire devices or pneumatic hammers. Steel H piles would remain below the mud line. Turbidity curtains surrounding areas where in-water work was ongoing and netting to contain debris would also be used in this stage.

3.5.3 Main Span

The main span stretches 735.2 m (2,412 feet) and is structurally formed by a through truss above a deck supported by four latticework piers on buoyant foundations, ice deflectors around the two central piers, and pre-stressed concrete beams on 76 cm (30-inch) diameter steel piles. Initially, the main span deck slab panels would be lifted and removed off-site by barge. Then, the entire suspended span would be lowered onto a barge via a strand jack or winch system. Conventional barge-mounted cranes would then deconstruct the anchor span steelwork piece by piece and the ice-breaker and fender structures protecting the main span piers would be demolished by divers and barge-mounted cranes. The pier steelwork would also be removed piece by piece, and the buoyant caissons would be flooded, cut and removed in pieces. Following main span demolition, a barge-mounted crane operated clam shell bucket would clear the river bottom of debris. Side-scan sonar surveys would verify that all debris and concrete were removed from the river.

3.6 Action Area

The action area is defined in 50 CFR 402.02 as "all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action." The action area includes the project footprint where work to construct the new bridge and remove the old bridge will take place, including dredging and armoring of the river bottom. The action area also includes the area of the river where increased underwater noise levels and changes in water quality will be experienced. The action area also includes the likely dredge disposal site (HARS) and the transit route that barges will use to access the site. The HARS is located approximately 4 miles (3.4 nautical miles) east of Highlands, New Jersey and about 9 miles south of Rockaway, Long Island. It comprises about 20 square miles within the apex of the New York Bight[1] that includes the approximately 3-square-mile Mud Dump Site (MDS). We anticipate that all effects of the action will occur within this geographic area. See Figure 1 for a map of the bridge location. Figure 6 is a map of the HARS site.

[1] The New York Bight is a region defined as ranging from Cape Cod, MA, to Cape May, NJ, and includes Buzzard's Bay, Long Island Sound, New York Harbor and the New Jersey shore (http://web2.uconn.edu/seagrantnybight/).

4.0 SPECIES THAT ARE NOT LIKELY TO BE ADVERSELY AFFECTED BY THE PROPOSED ACTION

Sei (*Balaenoptera borealis*) whales occur in deep water throughout their range, typically over the continental slope or in basins situated between banks (NMFS 2011). Sperm whales (*Physter macrocephalus*) occur on the continental shelf edge, over the continental slope, and into mid-ocean regions. Sei and sperm whales do not occur in the action area.

We have determined that while the following species may be present in the action area, the actions being considered in the Opinion are not likely to adversely affect the following species: leatherback (*Dermochelys coriacea*), Kemp's ridley (*Lepidochelys kempi*) and green (*Chelonia mydas*) sea turtles; the Northwest Atlantic DPS of loggerhead sea turtle (*Caretta caretta*); North Atlantic right whales (*Eubalaena glacialis*), humpback whales (*Megaptera novaeangliae*), and fin whales (*Balaenoptera physalus*). All of these species are listed as threatened or endangered species under the ESA. Below, we present our rationale for this determination.

4.1 Presence of Whales and Sea Turtles in the Action Area

The large whales and sea turtles noted above do not occur in the Hudson River and therefore would not be exposed to any effects of bridge construction. However, these species may be present at the HARS site or along portions of the vessel transit route. Here, we consider effects to these species.

Right, fin and humpback whales are seasonally present off the coast of New York and New Jersey but are typically found in deep offshore waters. Sightings and satellite tracking data along the east coast indicate that endangered large whales rarely venture into bays, harbors, or inlets (70 FR 35849, June 25, 2005, NMFS 2007, 72 FR 57104, October 5, 2007). As such, we do not expect that any of these species would be present along the transit route through New York Harbor. However, given the HARS offshore location, these whale species may be present at the disposal site and along the offshore portion of the transit route. Right whales are most likely to occur in this area from November – April; humpback whales are most likely to be present in the spring, summer and fall. Acoustic monitoring data from coastal New Jersey indicates that individuals from all three of these whale species may occur in the coastal waters off New York and New Jersey throughout the year (NJDEP 2010). The project will use the HARS site for dredged material disposal between August 1 and November 1; right, humpback and fin whales could be present at the site or along the transit route during this time of year. Whales in this area are expected to be migrating and may also be foraging if suitable forage is present.

Sea turtles are seasonally present in waters off the coast of New York and New Jersey. Sea turtles arrive in the mid-Atlantic from southern overwintering area in May and typically begin migrating southward by mid-November. Satellite tracking studies of sea turtles in New York waters found that foraging turtles mainly occurred in areas where the water depth was between approximately 16 and 49 feet (Ruben and Morreale 1999). This depth was interpreted not to be as much an upper physiological depth limit for turtles, as a natural limiting depth where light and food are most suitable for foraging turtles (Morreale and Standora 1990). Depths at the HARS site range from 46-138 feet. We expect sea turtles to be present at the HARS site between May and November, with the highest number of individuals present between June and October. Sea turtles in this area are likely to be migrating or foraging.

For the species of whales and sea turtles that may occur at the HARS site and along portions of the transit route, we have considered effects of disposal activities (see section 4.2) and effects of vessel operations (see section 4.3) and have determined that all effects will be insignificant and discountable. The rationale for our determination is presented in Section 4.2 and Section 4.3 below.

4.2 Effects of disposal of dredged material at HARS on whales and sea turtles

Potential effects of dredged material disposal include: (1) increased turbidity; (2) exposure to contaminants; and, (3) impacts to benthic resources.

4.2.1 Turbidity

During the discharge of sediment at a disposal site, suspended sediment levels have been reported as high as 500.0 mg/l within 250 feet of the disposal vessel and decreasing to background levels (i.e., 15.0-100.0 mg/l depending on location and sea conditions) within 1,000-6,500 feet (ACOE 1983). In the BA, FHWA indicates that at the HARS, total suspended solids near the center of the dredged material placement plume body have been observed to reach near background levels in 35 to 45 minutes (Battele 1994 in USACE and USEPA 2009).

TSS is most likely to affect sea turtles or whales if a plume causes a barrier to normal behaviors or if sediment settles on the bottom and affects benthic prey. As whales and sea turtles are both highly mobile, individuals are likely to be able to avoid any sediment plume that is present and any effect on their movements or behavior is likely to be insignificant.

Right whales feed on copepods (Horwood 2002; Kenney 2002). Humpback and fin whales feed on krill as well as small schooling fish (*e.g.*, sand lance, herring, and mackerel) (Aguilar 2002; Clapham 2002). Leatherback sea turtles feed on jellyfish. Green sea turtles feed on sea grasses and macroalgae. Loggerhead turtles feed on benthic invertebrates such as gastropods, mollusks and crustaceans. Kemp's ridleys primarily feed on crabs, with a preference for portunid crabs including blue crabs.

The TSS levels expected (up to 500 mg/L) are below those shown to have an adverse effect on fish (580.0 mg/L for the most sensitive species, with 1,000 mg/L more typical; see summary of scientific literature in Burton 1993) and benthic communities (590.0 mg/L (EPA 1986)); therefore, effects to whale and sea turtle prey from increased turbidity is extremely unlikely; effects to listed whales and sea turtles will be discountable.

4.2.2 Effects to the Benthic Environment

Disposal operations can also affect foraging animals by burying benthic prey. Direct impacts to fish or other mobile species during placement of the dredged material at the HARS would be expected to be minimal due to the small contact footprint of the fluidized sediments as they leave the barge (typically 50 foot by 100 foot). Given the small area impacted by each disposal event, mobile species are expected to be able to avoid the falling sediment and would not be subject to burial. The only species that are likely to be buried are immobile benthic organisms. Sea grasses and macroalgae that green sea turtles forage on are not present at the HARS. The species that whales and leatherback sea turtles forage on are mobile and not likely to be vulnerable to burial. Some species of mollusks and gastropods that loggerheads feed on have limited mobility and could be buried during disposal operations.

The loss of potential benthic prey species would be minimized spatially and temporally through use of a grid system for the placement of dredged material. Some buried animals will be able to unbury themselves. Areas where dredged material will be placed are expected to be recolonized by individuals from nearby similar habitats. Because the characteristics of the sediment from the project would be similar to those in and around the HARS, benthic invertebrates would be expected to quickly recolonize the cells used for the placement of this material. Thus, any reduction in benthic prey at the HARS site will be temporary and limited to the small area where dredged material will be placed. Right, humpback and fin whales and green, Kemp's ridley and leatherback sea turtles will not have any reduction in prey. The potential loss of prey for loggerhead sea turtles will be extremely small, as only a fraction of the benthic species that loggerheads prey on will be affected, and those losses will occur in a very small area. Effects to foraging loggerhead sea turtles will be insignificant.

4.2.3 Contaminants

In order to be eligible for ocean disposal, material must meet stringent criteria as required by the Clean Water Act and Section 103 of the Marine Protection, Research, and Sanctuaries Act of 1972 (as described in the EPA/ACOE joint testing guidelines, available at http://water.epa.gov/type/oceb/oceandumping/dredgedmaterial/upload/gbook.pdf; last accessed May 10, 2012). By law and regulation, the significant adverse effects of dredged material disposal activities must be contained within the designated or selected disposal site and even those impacts must not degrade the area's overall ecological health. The HARS is required to have and is managed under a dredged material monitoring and management plan that assesses the health and well-being of the site and surrounding environment. Monitoring of the disposal site is a part of this plan, which is designed to ensure that any degradation of resources or alteration in seafloor characteristics are identified and results in actions by permitting agencies (USEPA 2004).

The testing of dredged material is overseen by EPA and the ACOE. Sediments are tested for possible contamination prior to any planned dredging to ensure that proposed dredging and the dredge material disposal are conducted in a way that minimizes the potential pathways for contaminant exposure. EPA and the ACOE have jointly developed comprehensive testing procedures, which may include physical, chemical and biological tests, to evaluate dredged material placed into ocean waters. Additional, more stringent criteria apply to material disposed of at the HARS.

Laboratory and evaluation methods that apply to dredged material proposed for ocean disposal in accordance with the Marine Protection, Research and Sanctuaries Act (MPRSA) are published in the 1991 USEPA/USACE guidance document entitled "Ecological Evaluation for Dredged Material Proposed for Ocean Disposal in the Marine Environment". An overview of the Dredged Material Testing Framework is contained in EPA's Ocean Dumping Program Update (1996). Only material that is determined to be "Category 1" material is allowed to be disposed at the HARS. Category 1 material does not show acute toxicity or potential bioaccumulation. As described by EPA, "the acute toxicity of a sediment is determined by quantifying the mortality of appropriately sensitive organisms that are put into contact with the sediment, under either field or laboratory conditions, for a specified period." Also, bioacummulation is described as, "the accumulation of contaminants in the tissues of organisms through any route, including respiration, ingestion, or direct contact with contaminated sediment or water" (EPA 1996). The regulations require that bioaccumulation be considered as part of the environmental evaluation of dredged material proposed for ocean dumping. This consideration involves predicting whether there will be a cause-and-effect relationship between an animal's presence in the area influenced by the dredged material and an environmentally important elevation of its tissue content or body burden of contaminants above that in similar animals not influenced by the disposal of the dredged material."

In addition to the national guidelines, EPA Region 2 and USACE New York District developed a regional implementation manual for New York/New Jersey Harbor entitled "Guidance for Performing Tests on Dredged Material Proposed for Ocean Disposal." This regional manual lists specific contaminants of concern, species approved for use in biological tests, required Quality Assurance /Quality Control and test acceptability parameters, and other pertinent information.

In addition to the Category 1 guidelines, there are specific guidelines that material must achieve in order to be disposed of at the HARS. The HARS' Testing Evaluation Framework includes testing that considers bioaccumulation, bioassay toxicity tests and water column tests. The methodology was developed by ACOE and EPA and has been peer reviewed.

Two sediment-sampling programs were conducted in 2006 and 2008 to gather data about the physical and chemical characteristics of Hudson River sediments at the bridge site (FHWA 2012). Both programs used vibracore samplers to obtain 4-inch-diameter sediment cores from 38 locations. Except where the vibracore device encountered refusal at shallower depths, each vibracore was driven to a depth of at least 6 feet. A total of 156 samples from 38 cores were submitted for sediment chemistry analyses, including Semivolatile Organic Compounds (SVOCs)-base/neutral fraction, pesticides, Polycyclic Aromatic Hydrocarbons (PAHs) and metals. A subset of 17 samples from 10 cores were analyzed for dioxins.

PCBs, Total PAH, mercury, dioxin/furan TEQ, Total DDT, DDD and DDE, arsenic, copper, and cadmium were detected in some samples with concentrations decreasing within 2 to 4 feet of the surface. FHWA compared results from the 2006/2008 sediment sampling to results found for historic Hudson River sampling conducted by Llanso *et al.* (2003). In general, levels of contaminants such as metals, pesticides, and PCBs in the sediment samples collected within the study area are similar to average levels found elsewhere in the Hudson River.

In order for the dredged material to be disposed of at the HARS, it must be tested in accordance with the ACOE and EPA procedures for suitability. Material that can be disposed of at the HARS is specifically selected for its low potential to introduce toxins into the marine environment and for purposes of capping contaminated sediments. Material will not be allowed to be disposed of at HARS that would be acutely or chronically toxic to any aquatic species. Further, the material must not present a risk of bioaccumulation; that is, even if it is not acutely or chronically toxic, it must not increase the potential for bioaccumulation of toxins in higher trophic level species (such as whales or sea turtles) that may prey upon benthic organisms present at the HARS. Because any material that is disposed of at HARS will not be acutely or chronically toxic to aquatic life and will not increase the risk of bioaccumulation, effects to whales and sea turtles of dredged material from the bridge site at HARS will be insignificant and discountable.

4.3 Effects of transport of dredged material to HARS on whales and sea turtles

An ACOE approved Dredged Material Inspector (DMI) is present on board all trips to the HARS. The DMI also serves as a marine mammal/sea turtle observer and monitors for the presence of marine mammals, including large whales, along the transit route and at the disposal site. Disposal of material is prohibited if a marine mammal or sea turtle is seen by the DMI. This requirement is included as a condition in all permits authorizing the use of the HARS.

Although little is known about sea turtle and whale reactions to vessel traffic, these species are thought to be able to avoid injury from slower-moving vessels since the animal has more time to maneuver and avoid the vessel. Vessels will only travel at a speed of less than ten knots while transiting to and from the HARS site.

Large whales, particularly right whales, are vulnerable to injury and mortality from ship strikes. Ship strikes are more likely to occur and more likely to result in serious injury or mortality when vessels are traveling at speeds greater than ten knots. Because the barge will be traveling at speeds below this, the risk of a strike is reduced. The presence of an experienced endangered species observer on board the disposal vessel who can advise the vessel operator to slow the vessel or maneuver safely when listed species are spotted will further reduce the potential for interaction with vessels. Given the low speed that the dredge disposal vessel will operate at and the use of an observer to look out for whales, it is extremely unlikely that any whales will be hit by the dredge vessel. Similarly, we expect that sea turtles will be able to avoid the disposal vessel and that the presence of an observer will further reduce the likelihood of any vessel strikes. Therefore, effects of vessel operations on sea turtles and large whales are discountable.

5.0 STATUS OF LISTED SPECIES IN THE ACTION AREA

This section presents biological and ecological information relevant to formulating the Biological Opinion. Information on species' life history, its habitat and distribution, and other factors necessary for its survival are included to provide background for analyses in later sections of this opinion. We have determined that the actions being considered in the Opinion may adversely affect the following listed species:

Common name	Scientific name	ESA Status
Shortnose sturgeon	Acipenser brevirostrum	Endangered
GOM DPS of Atlantic sturgeon	*Acipenser oxyrinchus oxyrinchus*	Threatened
New York Bight DPS of Atlantic sturgeon	*Acipenser oxyrinchus oxyrinchus*	Endangered
Chesapeake Bay DPS of Atlantic sturgeon	*Acipenser oxyrinchus oxyrinchus*	Endangered

5.1 Shortnose Sturgeon

This section reviews the status of the species rangewide as well as the status of the species in the Hudson River.

5.1.1 Shortnose sturgeon life history

Shortnose sturgeon are benthic fish that mainly occupy the deep channel sections of large rivers. They feed on a variety of benthic and epibenthic invertebrates including mollusks, crustaceans (amphipods, isopods), insects, and oligochaete worms (Vladykov and Greeley 1963; Dadswell 1979 *in* NMFS 1998). Shortnose sturgeon have similar lengths at maturity (45-55 cm fork length) throughout their range, but, because sturgeon in southern rivers grow faster than those in northern rivers, southern sturgeon mature at younger ages (Dadswell *et al.* 1984). Shortnose sturgeon are long-lived (30-40 years) and, particularly in the northern extent of their range, mature at late ages. In the north, males reach maturity at 5 to 10 years, while females mature between 7 and 13 years. Based on limited data, females spawn every three to five years while males spawn approximately every two years. The spawning period is estimated to last from a few days to several weeks. Spawning begins from late winter/early spring (southern rivers) to mid to late spring (northern rivers)[2] when the freshwater temperatures increase to 8-9°C. Several published reports have presented the problems facing long-lived species that delay sexual maturity (Crouse *et al.* 1987; Crowder *et al.* 1994; Crouse 1999). In general, these reports concluded that animals that delay sexual maturity and reproduction must have high annual survival as juveniles through adults to ensure that enough juveniles survive to reproductive maturity and then reproduce enough times to maintain stable population sizes.

Total instantaneous mortality rates (Z) are available for the Saint John River (0.12 - 0.15; ages 14-55; Dadswell 1979), Upper Connecticut River (0.12; Taubert 1980b), and Pee Dee-Winyah River (0.08-0.12; Dadswell *et al.* 1984). Total instantaneous natural mortality (M) for shortnose sturgeon in the lower Connecticut River was estimated to be 0.13 (T. Savoy, Connecticut Department of Environmental Protection, personal communication). There is no recruitment information available for shortnose sturgeon because there are no commercial fisheries for the species. Estimates of annual egg production for this species are difficult to calculate because females do not spawn every year (Dadswell *et al.* 1984). Further, females may abort spawning attempts, possibly due to interrupted migrations or unsuitable environmental conditions (NMFS 1998). Thus, annual egg production is likely to vary greatly in this species. Fecundity estimates have been made and range from 27,000 to 208,000 eggs/female and a mean of 11,568 eggs/kg body weight (Dadswell *et al.* 1984).

At hatching, shortnose sturgeon are blackish-colored, 7-11mm long and resemble tadpoles (Buckley and Kynard 1981). In 9-12 days, the yolk sac is absorbed and the sturgeon develops into larvae which are about 15mm total length (TL; Buckley and Kynard 1981). Sturgeon larvae are believed to begin downstream migrations at about 20mm TL. Dispersal rates differ at least regionally, laboratory studies on Connecticut River larvae indicated dispersal peaked 7-12 days after hatching in comparison to Savannah River larvae that had longer dispersal rates with multiple, prolonged peaks, and a low level of downstream movement that continued throughout the entire larval and early juvenile period (Parker 2007). Synder (1988) and Parker (2007) considered individuals to be juvenile when they reached 57mm TL. Laboratory studies demonstrated that larvae from the Connecticut River made this transformation on day 40 while

2 For purposes of this consultation, Northern rivers are considered to include tributaries of the Chesapeake Bay northward to the St. John River in Canada. Southern rivers are those south of the Chesapeake Bay.

Savannah River fish made this transition on day 41 and 42 (Parker 2007).

The juvenile phase can be subdivided in to young of the year (YOY) and immature/ sub-adults. YOY and sub-adult habitat use differs and is believed to be a function of differences in salinity tolerances. Little is known about YOY behavior and habitat use, though it is believed that they are typically found in channel areas within freshwater habitats upstream of the salt wedge for about one year (Dadswell *et al.* 1984, Kynard 1997). One study on the stomach contents of YOY revealed that the prey items found corresponded to organisms that would be found in the channel environment (amphipods) (Carlson and Simpson 1987). Sub-adults are typically described as age one or older and occupy similar spatio-temporal patterns and habitat-use as adults (Kynard 1997). Though there is evidence from the Delaware River that sub-adults may overwinter in different areas than adults and do not form dense aggregations like adults (ERC Inc. 2007). Sub-adults feed indiscriminately; typical prey items found in stomach contents include aquatic insects, isopods, and amphipods along with large amounts of mud, stones, and plant material (Dadswell 1979, Carlson and Simpson 1987, Bain 1997).

In populations that have free access to the total length of a river (e.g., no dams within the species' range in a river: Saint John, Kennebec, Altamaha, Savannah, Delaware and Merrimack Rivers), spawning areas are located at the farthest upstream reach of the river (NMFS 1998). In the northern extent of their range, shortnose sturgeon exhibit three distinct movement patterns. These migratory movements are associated with spawning, feeding, and overwintering activities. In spring, as water temperatures reach between 7-9.7°C (44.6-49.5°F), pre-spawning shortnose sturgeon move from overwintering grounds to spawning areas. Spawning occurs from mid/late March to mid/late May depending upon location and water temperature. Sturgeon spawn in upper, freshwater areas and feed and overwinter in both fresh and saline habitats. Shortnose sturgeon spawning migrations are characterized by rapid, directed and often extensive upstream movement (NMFS 1998).

Shortnose sturgeon are believed to spawn at discrete sites within their natal river (Kieffer and Kynard 1996). In the Merrimack River, males returned to only one reach during a four year telemetry study (Kieffer and Kynard 1996). Squires (1982) found that during the three years of the study in the Androscoggin River, adults returned to a 1-km reach below the Brunswick Dam and Kieffer and Kynard (1996) found that adults spawned within a 2-km reach in the Connecticut River for three consecutive years. Spawning occurs over channel habitats containing gravel, rubble, or rock-cobble substrates (Dadswell *et al.* 1984; NMFS 1998). Additional environmental conditions associated with spawning activity include decreasing river discharge following the peak spring freshet, water temperatures ranging from 8 - 15° (46.4-59°F), and bottom water velocities of 0.4 to 0.8 m/sec (Dadswell *et al.* 1984; Hall *et al.* 1991, Kieffer and Kynard 1996, NMFS 1998). For northern shortnose sturgeon, the temperature range for spawning is 6.5-18.0°C (Kieffer and Kynard in press). Eggs are separate when spawned but become adhesive within approximately 20 minutes of fertilization (Dadswell *et al.* 1984). Between 8° (46.4°F) and 12°C (53.6°F), eggs generally hatch after approximately 13 days. The larvae are photonegative, remaining on the bottom for several days. Buckley and Kynard (1981) found week old larvae to be photonegative and form aggregations with other larvae in concealment.

Adult shortnose sturgeon typically leave the spawning grounds soon after spawning. Non-spawning movements include rapid, directed post-spawning movements to downstream feeding areas in spring and localized, wandering movements in summer and winter (Dadswell *et al.* 1984; Buckley and Kynard 1985; O'Herron *et al.* 1993). Kieffer and Kynard (1993) reported that post-spawning migrations were correlated with increasing spring water temperature and river discharge. Young-of-the-year shortnose sturgeon are believed to move downstream after hatching (Dovel 1981) but remain within freshwater habitats. Older juveniles or sub-adults tend to move downstream in fall and winter as water temperatures decline and the salt wedge recedes and move upstream in spring and feed mostly in freshwater reaches during summer.

Juvenile shortnose sturgeon generally move upstream in spring and summer and move back downstream in fall and winter; however, these movements usually occur in the region above the saltwater/freshwater interface (Dadswell *et al.* 1984; Hall *et al.* 1991). Non-spawning movements include wandering movements in summer and winter (Dadswell *et al.* 1984; Buckley and Kynard 1985; O'Herron *et al.* 1993). Kieffer and Kynard (1993) reported that post-spawning migrations were correlated with increasing spring water temperature and river discharge. Adult sturgeon occurring in freshwater or freshwater/tidal reaches of rivers in summer and winter often occupy only a few short reaches of the total length (Buckley and Kynard 1985). Summer concentration areas in southern rivers are cool, deep, thermal refugia, where adult and juvenile shortnose sturgeon congregate (Flourney *et al.* 1992; Rogers *et al.* 1994; Rogers and Weber 1995; Weber 1996).

While shortnose sturgeon do not undertake the significant marine migrations seen in Atlantic sturgeon, telemetry data indicates that shortnose sturgeon do make localized coastal migrations. This is particularly true within certain areas such as the Gulf of Maine (GOM) and among rivers in the Southeast. Interbasin movements have been documented among rivers within the GOM and between the GOM and the Merrimack, between the Connecticut and Hudson rivers, the Delaware River and Chesapeake Bay, and among the rivers in the Southeast.

The temperature preference for shortnose sturgeon is not known (Dadswell *et al.* 1984) but shortnose sturgeon have been found in waters with temperatures as low as 2 to 3°C (35.6-37.4°F) (Dadswell *et al.* 1984) and as high as 34°C (93.2°F) (Heidt and Gilbert 1978). However, water temperatures above 28°C (82.4°F) are thought to adversely affect shortnose sturgeon. In the Altamaha River, water temperatures of 28-30°C (82.4-86°F) during summer months create unsuitable conditions and shortnose sturgeon are found in deep cool water refuges. Dissolved oxygen (DO) also seems to play a role in temperature tolerance, with increased stress levels at higher temperatures with low DO versus the ability to withstand higher temperatures with elevated DO (Niklitchek 2001).

Shortnose sturgeon are known to occur at a wide range of depths. A minimum depth of 0.6m (approximately 2 feet) is necessary for the unimpeded swimming by adults. Shortnose sturgeon are known to occur at depths of up to 30m (98.4 ft) but are generally found in waters less than 20m (65.5 ft) (Dadswell *et al.* 1984; Dadswell 1979). Shortnose sturgeon have also demonstrated tolerance to a wide range of salinities. Shortnose sturgeon have been documented in freshwater (Taubert 1980; Taubert and Dadswell 1980) and in waters with salinity of 30 parts-per-thousand (ppt) (Holland and Yeverton 1973; Saunders and Smith 1978). Mcleave *et al.*

(1977) reported adults moving freely through a wide range of salinities, crossing waters with differences of up to 10ppt within a two hour period. The tolerance of shortnose sturgeon to increasing salinity is thought to increase with age (Kynard 1996). Shortnose sturgeon typically occur in the deepest parts of rivers or estuaries where suitable oxygen and salinity values are present (Gilbert 1989); however, shortnose sturgeon forage on vegetated mudflats and over shellfish beds in shallower waters when suitable forage is present.

5.1.2 Status and Trends of Shortnose Sturgeon Rangewide

Shortnose sturgeon were listed as endangered on March 11, 1967 (32 FR 4001), and the species remained on the endangered species list with the enactment of the ESA in 1973. Although the original listing notice did not cite reasons for listing the species, a 1973 Resource Publication, issued by the US Department of the Interior, stated that shortnose sturgeon were "in peril...gone in most of the rivers of its former range [but] probably not as yet extinct" (USDOI 1973). Pollution and overfishing, including bycatch in the shad fishery, were listed as principal reasons for the species' decline. In the late nineteenth and early twentieth centuries, shortnose sturgeon commonly were taken in a commercial fishery for the closely related and commercially valuable Atlantic sturgeon (*Acipenser oxyrinchus*). More than a century of extensive fishing for sturgeon contributed to the decline of shortnose sturgeon along the east coast. Heavy industrial development during the twentieth century in rivers inhabited by sturgeon impaired water quality and impeded these species' recovery; possibly resulting in substantially reduced abundance of shortnose sturgeon populations within portions of the species' ranges (e.g., southernmost rivers of the species range: Santilla, St. Marys and St. Johns Rivers). A shortnose sturgeon recovery plan was published in December 1998 to promote the conservation and recovery of the species (see NMFS 1998). Shortnose sturgeon are listed as "vulnerable" on the IUCN Red List.

Although shortnose sturgeon are listed as endangered range-wide, in the final recovery plan NMFS recognized 19 separate populations occurring throughout the range of the species. These populations are in New Brunswick Canada (1); Maine (2); Massachusetts (1); Connecticut (1); New York (1); New Jersey/Delaware (1); Maryland and Virginia (1); North Carolina (1); South Carolina (4); Georgia (4); and Florida (2). NMFS has not formally recognized distinct population segments (DPS)[3] of shortnose sturgeon under the ESA. Although genetic information within and among shortnose sturgeon occurring in different river systems is largely unknown, life history studies indicate that shortnose sturgeon populations from different river systems are substantially reproductively isolated (Kynard 1997) and, therefore, should be considered discrete. The 1998 Recovery Plan indicates that while genetic information may reveal that interbreeding does not occur between rivers that drain into a common estuary, at this time, such river systems are considered a single population compromised of breeding subpopulations (NMFS 1998).

Studies conducted since the issuance of the Recovery Plan have provided evidence that suggests

3 The definition of species under the ESA includes any subspecies of fish, wildlife, or plants, and any distinct population segment of any species of vertebrate fish or wildlife which interbreeds when mature. To be considered a DPS, a population segment must meet two criteria under NMFS policy. First, it must be discrete, or separated, from other populations of its species or subspecies. Second, it must be significant, or essential, to the long-term conservation status of its species or subspecies. This formal legal procedure to designate DPSs for shortnose sturgeon has not been undertaken.

that years of isolation between populations of shortnose sturgeon have led to morphological and genetic variation. Walsh *et al.* (2001) examined morphological and genetic variation of shortnose sturgeon in three rivers (Kennebec, Androscoggin, and Hudson). The study found that the Hudson River shortnose sturgeon population differed markedly from the other two rivers for most morphological features (total length, fork length, head and snout length, mouth width, interorbital width and dorsal scute count, left lateral scute count, right ventral scute count). Significant differences were found between fish from Androscoggin and Kennebec rivers for interorbital width and lateral scute counts which suggests that even though the Androscoggin and Kennebec rivers drain into a common estuary, these rivers support largely discrete populations of shortnose sturgeon. The study also found significant genetic differences among all three populations indicating substantial reproductive isolation among them and that the observed morphological differences may be partly or wholly genetic.

Grunwald *et al.* (2002) examined mitochondrial DNA (mtDNA) from shortnose sturgeon in eleven river populations. The analysis demonstrated that all shortnose sturgeon populations examined showed moderate to high levels of genetic diversity as measured by haplotypic diversity indices. The limited sharing of haplotypes and the high number of private haplotypes are indicative of high homing fidelity and low gene flow. The researchers determined that glaciation in the Pleistocene Era was likely the most significant factor in shaping the phylogeographic pattern of mtDNA diversity and population structure of shortnose sturgeon. The Northern glaciated region extended south to the Hudson River while the southern non-glaciated region begins with the Delaware River. There is a high prevalence of haplotypes restricted to either of these two regions and relatively few are shared; this represents a historical subdivision that is tied to an important geological phenomenon that reflects historical isolation. Analyses of haplotype frequencies at the level of individual rivers showed significant differences among all systems in which reproduction is known to occur. This implies that although higher level genetic stock relationships exist (i.e., southern vs. northern and other regional subdivisions), shortnose sturgeon appear to be discrete stocks, and low gene flow exists between the majority of populations.

Waldman *et al.* (2002) also conducted mtDNA analysis on shortnose sturgeon from 11 river systems and identified 29 haplotypes. Of these haplotypes, 11 were unique to northern, glaciated systems and 13 were unique to the southern non-glaciated systems. Only 5 were shared between them. This analysis suggests that shortnose sturgeon show high structuring and discreteness and that low gene flow rates indicated strong homing fidelity.

Wirgin *et al.* (2005) also conducted mtDNA analysis on shortnose sturgeon from 12 rivers (St. John, Kennebec, Androscoggin, Upper Connecticut, Lower Connecticut, Hudson, Delaware, Chesapeake Bay, Cooper, Peedee, Savannah, Ogeechee and Altamaha). This analysis suggested that most population segments are independent and that genetic variation among groups was high.

The best available information demonstrates differences in life history and habitat preferences between northern and southern river systems and given the species' anadromous breeding habits, the rare occurrence of migration between river systems, and the documented genetic differences between river populations, it is unlikely that populations in adjacent river systems interbreed with any regularity. This likely accounts for the failure of shortnose sturgeon to repopulate river systems from which they have been extirpated, despite the geographic closeness of persisting populations. This characteristic of shortnose sturgeon also complicates recovery and persistence of this species in the future because, if a river population is extirpated in the future, it is unlikely that this river will be recolonized. Consequently, this Opinion will treat the nineteen separate populations of shortnose sturgeon as subpopulations (one of which occurs in the action area) for the purposes of this analysis.

Historically, shortnose sturgeon are believed to have inhabited nearly all major rivers and estuaries along nearly the entire east coast of North America. The range extended from the St John River in New Brunswick, Canada to the Indian River in Florida. Today, only 19 populations remain ranging from the St. Johns River, Florida (possibly extirpated from this system) to the Saint John River in New Brunswick, Canada. Shortnose sturgeon are large, long lived fish species. The present range of shortnose sturgeon is disjunct, with northern populations separated from southern populations by a distance of about 400 km. Population sizes vary across the species' range. From available estimates, the smallest populations occur in the Cape Fear (~8 adults; Moser and Ross 1995) in the south and Merrimack and Penobscot rivers in the north (~ several hundred to several thousand adults depending on population estimates used; M. Kieffer, United States Geological Survey, personal communication; Dionne 2010), while the largest populations are found in the Saint John (~18, 000; Dadswell 1979) and Hudson Rivers (~61,000; Bain *et al.* 1998). As indicated in Kynard 1996, adult abundance is less than the minimum estimated viable population abundance of 1000 adults for 5 of 11 surveyed northern populations and all natural southern populations. Kynard 1996 indicates that all aspects of the species' life history indicate that shortnose sturgeon should be abundant in most rivers. As such, the expected abundance of adults in northern and north-central populations should be thousands to tens of thousands of adults. Expected abundance in southern rivers is uncertain, but large rivers should likely have thousands of adults. The only river systems likely supporting populations of these sizes are the St John, Hudson and possibly the Delaware and the Kennebec, making the continued success of shortnose sturgeon in these rivers critical to the species as a whole. While no reliable estimate of the size of either the total species population rangewide, or the shortnose sturgeon population in the Northeastern United States exists, nearly all rivers are thought to have populations below carrying capacity.

Based on the best available information (Bowers-Altman *et al.* 2012 in draft) trends in abundance for shortnose sturgeon in Northeast Rivers demonstrate the majority of populations are stable (i.e., Delaware, Hudson, Connecticut, Merrimack). The Kennebec River Complex is the only population in the Northeast that shows an increasing trend in abundance. In the Southeast, abundance trends for many riverine populations are unknown due to lack of data (i.e., Chowan, Tar Pamlico, Neuse, New, North, Santee, Santee-Cooper system, Satilla, St. Mary's, and St. John's). The Winyah Bay Complex, Cooper, Savannah, Ogeechee, and Altamaha Rivers show stable trends in abundance. The only riverine population in the Southeast demonstrating increasing trends in abundance is the ACE Basin. The species overall is considered to be stable.

5.1.3 Threats to shortnose sturgeon recovery rangewide

The Shortnose Sturgeon Recovery Plan (NMFS 1998) identifies habitat degradation or loss (resulting, for example, from dams, bridge construction, channel dredging, and pollutant discharges) and mortality (resulting, for example, from impingement on cooling water intake screens, dredging and incidental capture in other fisheries) as principal threats to the species' survival.

Several natural and anthropogenic factors continue to threaten the recovery of shortnose sturgeon. Shortnose sturgeon continue to be taken incidentally in fisheries along the east coast and are probably targeted by poachers throughout their range (Dadswell 1979; Dovel *et al.* 1992; Collins *et al.* 1996). In-water or nearshore construction and demolition projects may interfere with normal shortnose sturgeon migratory movements and disturb sturgeon concentration areas. Unless appropriate precautions are made, internal damage and/or death may result from blasting projects with powerful explosives. Hydroelectric dams may affect shortnose sturgeon by restricting habitat, altering river flows or temperatures necessary for successful spawning and/or migration and causing mortalities to fish that become entrained in turbines. Maintenance dredging of Federal navigation channels and other areas can adversely affect or jeopardize shortnose sturgeon populations. Hydraulic dredges can lethally take sturgeon by entraining sturgeon in dredge dragarms and impeller pumps. Mechanical dredges have also been documented to lethally take shortnose sturgeon. In addition to direct effects, dredging operations may also impact shortnose sturgeon by destroying benthic feeding areas, disrupting spawning migrations, and filling spawning habitat with resuspended fine sediments. Shortnose sturgeon are susceptible to impingement on cooling water intake screens at power plants. Electric power and nuclear power generating plants can affect sturgeon by impinging larger fish on cooling water intake screens and entraining larval fish. The operation of power plants can have unforeseen and extremely detrimental impacts to riverine habitat which can affect shortnose sturgeon. For example, the St. Stephen Power Plant near Lake Moultrie, South Carolina was shut down for several days in June 1991 when large mats of aquatic plants entered the plant's intake canal and clogged the cooling water intake gates. Decomposing plant material in the tailrace canal coupled with the turbine shut down (allowing no flow of water) triggered a low dissolved oxygen water condition downstream and a subsequent fish kill. The South Carolina Wildlife and Marine Resources Department reported that twenty shortnose sturgeon were killed during this low dissolved oxygen event.

Contaminants, including toxic metals, polychlorinated aromatic hydrocarbons (PAHs), pesticides, and polychlorinated biphenyls (PCBs) can have substantial deleterious effects on aquatic life including production of acute lesions, growth retardation, and reproductive impairment (Cooper 1989; Sinderman 1994). Ultimately, toxins introduced to the water column become associated with the benthos and can be particularly harmful to benthic organisms (Varanasi 1992) like sturgeon. Heavy metals and organochlorine compounds are known to accumulate in fat tissues of sturgeon, but their long term effects are not yet known (Ruelle and Henry 1992; Ruelle and Kennlyne 1993). Available data suggests that early life stages of fish are more susceptible to environmental and pollutant stress than older life stages (Rosenthal and Alderdice 1976).

Although there is scant information available on the levels of contaminants in shortnose sturgeon tissues, some research on other related species indicates that concern about the effects of contaminants on the health of sturgeon populations is warranted. Detectible levels of chlordane, DDE (1,1-dichloro-2, 2-bis(p-chlorophenyl)ethylene), DDT (dichlorodiphenyl-trichloroethane), and dieldrin, and elevated levels of PCBs, cadmium, mercury, and selenium were found in pallid sturgeon tissue from the Missouri River (Ruelle and Henry 1994). These compounds were found in high enough levels to suggest they may be causing reproductive failure and/or increased physiological stress (Ruelle and Henry 1994). In addition to compiling data on contaminant levels, Ruelle and Henry also determined that heavy metals and organochlorine compounds (i.e. PCBs) accumulate in fat tissues. Although the long term effects of the accumulation of contaminants in fat tissues is not yet known, some speculate that lipophilic toxins could be transferred to eggs and potentially inhibit egg viability. In other fish species, reproductive impairment, reduced egg viability, and reduced survival of larval fish are associated with elevated levels of environmental contaminants including chlorinated hydrocarbons. A strong correlation that has been made between fish weight, fish fork length, and DDE concentration in pallid sturgeon livers indicates that DDE increases proportionally with fish size (NMFS 1998).

Contaminant analysis was conducted on two shortnose sturgeon from the Delaware River in the fall of 2002. Muscle, liver, and gonad tissue were analyzed for contaminants (ERC 2002). Sixteen metals, two semivolatile compounds, three organochlorine pesticides, one PCB Aroclor, as well as polychlorinated dibenzo-p-dioxins (PCDDs), and polychlorinated dibenzofurans (PCDFs) were detected in one or more of the tissue samples. Levels of aluminum, cadmium, PCDDs, PCDFs, PCBs, DDE (an organochlorine pesticide) were detected in the "adverse affect" range. It is of particular concern that of the above chemicals, PCDDs, DDE, PCBs and cadmium, were detected as these have been identified as endocrine disrupting chemicals. Contaminant analysis conducted in 2003 on tissues from a shortnose sturgeon from the Kennebec River revealed the presence of fourteen metals, one semivolatile compound, one PCB Aroclor, Polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) in one or more of the tissue samples. Of these chemicals, cadmium and zinc were detected at concentrations above an adverse effect concentration reported for fish in the literature (ERC 2003). While no directed studies of chemical contamination in shortnose sturgeon have been undertaken, it is evident that the heavy industrialization of the rivers where shortnose sturgeon are found is likely adversely affecting this species.

During summer months, especially in southern areas, shortnose sturgeon must cope with the physiological stress of water temperatures that may exceed 28°C. Flourney *et al.*(1992) suspected that, during these periods, shortnose sturgeon congregate in river regions which support conditions that relieve physiological stress (i.e., in cool deep thermal refuges). In southern rivers where sturgeon movements have been tracked, sturgeon refrain from moving during warm water conditions and are often captured at release locations during these periods (Flourney *et al.* 1992; Rogers and Weber 1994; Weber 1996). The loss and/or manipulation of these discrete refuge habitats may limit or be limiting population survival, especially in southern river systems.

Pulp mill, silvicultural, agricultural, and sewer discharges, as well as a combination of non-point source discharges, which contain elevated temperatures or high biological demand, can reduce dissolved oxygen levels. Shortnose sturgeon are known to be adversely affected by dissolved oxygen levels below 5 mg/L. Shortnose sturgeon may be less tolerant of low dissolved oxygen levels in high ambient water temperatures and show signs of stress in water temperatures higher than 28°C (82.4°F) (Flourney *et al.* 1992). At these temperatures, concomitant low levels of dissolved oxygen may be lethal.

5.1.4 Status of Shortnose Sturgeon in the Hudson River

The action area is limited to the reach of the Hudson River and the New York Bight where direct and indirect effects of the Tappan Zee bridge replacement project will be experienced, as described in the "Action Area" section above. Shortnose sturgeon in the Gulf of Maine are known to make nearshore coastal migrations between rivers; 71% of shortnose sturgeon tagged in the Penobscot River made regular seasonal movements out of the river, with some fish spending up to a year outside of the river. These types of nearshore coastal movements have only been documented twice in the New York Bight (two fish have been documented to move between the Connecticut and Hudson rivers). Regular coastal between-river movements have only been documented in areas with shared estuaries or when rivers are in close geographic proximity. At this time, the available tagging and tracking information indicates that Hudson River shortnose sturgeon are not making regular movements outside of the Hudson River. The documented movements of two Hudson River fish outside of the river since the mid-1990s is thought to be a reflection of the rarity of these types of movements. Any occurrence of Hudson River fish outside of the river is likely to be extremely rareAs such, we do not expect shortnose sturgeon to occur in portions of the action area outside of the Hudson River. No shortnose sturgeon are expected to occur at the HARS site or along the transit route south of New York Harbor. This section discusses the available information related to the presence and status of shortnose sturgeon in the Hudson River.

Shortnose sturgeon were first observed in the Hudson River by early settlers who captured them as a source of food and documented their abundance (Bain *et al.* 1998). Shortnose sturgeon in the Hudson River were documented as abundant in the late 1880s (Ryder 1888 in Hoff 1988). Prior to 1937, a few fishermen were still commercially harvesting shortnose sturgeon in the Hudson River; however, fishing pressure declined as the population decreased. During the late 1800s and early 1900s, the Hudson River served as a dumping ground for pollutants that lead to major oxygen depletions and resulted in fish kills and population reductions. During this same time there was a high demand for shortnose sturgeon eggs (caviar), leading to overharvesting. Water pollution, overfishing, and the commercial Atlantic sturgeon fishery are all factors that may have contributed to the decline of shortnose sturgeon in the Hudson River (Hoff 1988).

In the 1930s, the New York State Biological Survey launched the first scientific analysis that documented the distribution, age, and size of mature shortnose sturgeon in the Hudson River (see Bain *et al.* 1998). In the 1970s, scientific sampling resumed precipitated by the lack of biological data and concerns about the impact of electric generation facilities on fishery resources (see Bain *et al.* 1998). The current population of shortnose sturgeon has been documented by studies conducted throughout the entire range of shortnose sturgeon in the Hudson River (see: Dovel 1979, Hoff *et al.* 1988, Geoghegan *et al.* 1992, Bain *et al.* 1998, Bain *et al.* 2000, Dovel *et al.* 1992).

Several population estimates were conducted throughout the 1970s and 1980s (Dovel 1979; Dovel 1981; Dovel *et al.* 1992). Most recently, Bain *et al.* (1998) conducted a mark recapture study from 1994 through 1997 focusing on the shortnose sturgeon active spawning stock. Utilizing targeted and dispersed sampling methods, 6,430 adult shortnose sturgeon were captured and 5,959 were marked; several different abundance estimates were generated from this sampling data using different population models. Abundance estimates generated ranged from a low of 25, 255 to a high of 80,026; though 61,057 is the abundance estimate from this dataset and modeling exercise that is typically used. This estimate includes spawning adults estimated to comprise 93% of the entire population or 56,708, non-spawning adults accounting for 3% of the population and juveniles 4% (Bain *et al.* 2000). Bain *et al.* (2000) compared the spawning population estimate with estimates by Dovel *et al.* (1992) concluding an increase of approximately 400% between 1979 and 1997. Although fish populations dominated by adults are not common for most species, there is no evidence that this is atypical for shortnose sturgeon (Bain *et al.* 1998).

Woodland and Secor (2007) examined the Bain *et al.* (1998, 2000, 2007) estimates to try and identify the cause of the major change in abundance. Woodland and Secor (2007) concluded that the dramatic increase in abundance was likely due to improved water quality in the Hudson River which allowed for high recruitment during years when environmental conditions were right, particularly between 1986-1991. These studies provide the best information available on the current status of the Hudson River population and suggests that the population is relatively healthy, large, and particular in habitat use and migratory behavior (Bain *et al.* 1998).

Shortnose sturgeon have been documented in the Hudson River from upper Staten Island (RM -3 (rkm -4.8)) to the Troy Dam (RM 155 (rkm 249.5); for reference, the Tappan Zee Bridge is located at RM 27 (rkm 43) (Bain *et al.* 2000, ASA 1980-2002). Prior to the construction of the Troy Dam in 1825, shortnose sturgeon are thought to have used the entire freshwater portion of the Hudson River (NYHS 1809). Spawning fish congregated at the base of Cohoes Falls where the Mohawk River emptied into the Hudson. In recent years (since 1999), shortnose sturgeon have been documented below the Tappan Zee Bridge from June through December (ASA 1999-2002; Dynegy 2003). While shortnose sturgeon presence below the Tappan Zee Bridge had previously been thought to be rare (Bain *et al.* 2000), increasing numbers of shortnose sturgeon have been documented in this area over the last several years (ASA 1999-2002; Dynegy 2003) suggesting that the range of shortnose sturgeon is extending downstream. Shortnose sturgeon were documented as far south as the Manhattan/Staten Island area in June, November and December 2003 (Dynegy 2003).

From late fall to early spring, adult shortnose sturgeon concentrate in a few overwintering areas. Reproductive activity the following spring determines overwintering behavior. The largest overwintering area is just south of Kingston, NY, near Esopus Meadows (RM 86-94, rkm 139-152) (Dovel *et al.* 1992). The fish overwintering at Esopus Meadows are mainly spawning adults. Recent capture data suggests that these areas may be expanding (Hudson River 1999-2002, Dynegy 2003). Captures of shortnose sturgeon during the fall and winter from Saugerties to Hyde Park (greater Kingston reach), indicate that additional smaller overwintering areas may be present (Geoghegan *et al.* 1992). Both Geoghegan *et al.* (1992) and Dovel *et al.* (1992) also confirmed an overwintering site in the Croton-Haverstraw Bay area (RM 33.5 – 38,rkm 54-61). The Tappan Zee Bridge is located approximately 11km (6.5 miles) south of the southern extent of this overwintering area, which is near rkm 54 (RM 33.5). Fish overwintering in areas below Esopus Meadows are mainly thought to be pre-spawning adults. Typically, movements during overwintering periods are localized and fairly sedentary.

In the Hudson River, males usually spawn at approximately 3-5 years of age while females spawn at approximately 6-10 years of age (Dadswell *et al.* 1984; Bain *et al.* 1998). Males may spawn annually once mature and females typically spawn every 3 years (Dovel *et al.* 1992). Mature males feed only sporadically prior to the spawning migration, while females do not feed at all in the months prior to spawning.

In approximately late March through mid-April, when water temperatures are sustained at 8°-9° C (46.4-48.2°F) for several days[4], reproductively active adults begin their migration upstream to the spawning grounds that extend from below the Federal Dam at Troy to about Coeymans, NY (rkm 245-212 (RM 152-131) (Dovel *et al.* 1992). The spawning grounds are located more than 169 km (109 miles) upstream from the Tappan Zee Bridge. Spawning typically occurs at water temperatures between 10-18°C (50-64.4°F) (generally late April-May) after which adults disperse quickly down river into their summer range. Dovel *et al.* (1992) reported that spawning fish tagged at Troy were recaptured in Haverstraw Bay in early June. The broad summer range occupied by adult shortnose sturgeon extends from approximately rkm 38 to rkm 177 (RM 23.5-110). The Tappan Zee Bridge (at rkm 43) is located within the broad summer range.

There is scant data on actual collection of early life stages of shortnose sturgeon in the Hudson River. During a mark recapture study conducted from 1976-1978, Dovel *et al.* (1979) captured larvae near Hudson, NY (rkm 188, RM 117) and young of the year were captured further south near Germantown (RM 106, rkm 171). Between 1996 and 2004, approximately 10 small shortnose sturgeon were collected each year as part of the Falls Shoals Survey (FSS) (ASA 2007). Based upon basic life history information for shortnose sturgeon it is known that eggs adhere to solid objects on the river bottom (Buckley and Kynard 1981; Taubert 1980) and that eggs and larvae are expected to be present within the vicinity of the spawning grounds (rkm 245-212, RM 152-131) for approximately four weeks post spawning (i.e., at latest through mid-June). Shortnose sturgeon larvae in the Hudson River generally range in size from 15 to 18 mm (0.6-0.7 inches) TL at hatching (Pekovitch 1979). Larvae gradually disperse downstream after hatching, entering the tidal river (Hoff *et al.* 1988). Larvae or fry are free swimming and typically concentrate in deep channel habitat (Taubert and Dadswell 1980; Bath *et al.* 1981; Kieffer ad Kynard 1993). Given that fry are free swimming and foraging, they typically disperse downstream of spawning/rearing areas. Larvae can be found upstream of the salt wedge in the Hudson River estuary and are most commonly found in deep waters with strong currents, typically in the channel (Hoff *et al.* 1988; Dovel *et al.* 1992). Larvae are not tolerant of saltwater and their occurrence within the estuary is limited to freshwater areas. The transition from the larval to juvenile stage generally occurs in the first summer of life when the fish grows to approximately 2 cm (0.8 in) TL and is marked by fully developed external characteristics (Pekovitch 1979).

Similar to non-spawning adults, most juveniles occupy the broad region of Haverstraw Bay (rkm 55-64.4) RM 34-40 by late fall and early winter(Dovel *et al.* 1992; Geoghegan *et al.* 1992); the

4 Based on information from the USGS gage in Albany (gage no. 01359139), in 2002 water temperatures reached 8°C on April 10 and 15°C on April 20; 2003 - 8°C on April 14 and 15°C on May 19; 2004 - 8°C on April 17 and 15°C on May 11. In 2011, the most recent year on record, water temperatures reached 8°C on April 11 and reached 15°C on May 19.

Tappan Zee Bridge is located 12 km downstream of the southern edge of the bay. Migrations from the summer foraging areas to the overwintering grounds are triggered when water temperatures fall to 8°C (46.4°F) (NMFS 1998), typically in late November[5]. Juveniles are distributed throughout the mid-river region during the summer and move back into the Haverstraw Bay region during the late fall (Bain *et al.* 1998; Geoghegan *et al.* 1992; Haley 1998).

Shortnose sturgeon are bottom feeders and juveniles may use the protuberant snout to "vacuum" the river bottom. Curran & Ries (1937) described juvenile shortnose sturgeon from the Hudson River as having stomach contents of 85-95% mud intermingled with plant and animal material. Other studies found stomach contents of adults were solely food items, implying that feeding is more precisely oriented. The ventral protrusable mouth and barbells are adaptations for a diet of small live benthic animals. Juveniles feed on smaller and somewhat different organisms than adults. Common prey items are aquatic insects (chironomids), isopods, and amphipods. Unlike adults, mollusks do not appear to be an important part of the diet of juveniles (Bain 1997). As adults, their diet shifts strongly to mollusks (Curran & Ries 1937).

The Hudson River supports the largest population of shortnose sturgeon in the U.S. The population has experienced a tremendous increase since the mid-1970s, with some estimates indicating that the population has increased by over 400%. This improvement is thought to have been aided by regulatory mechanisms, including protections provided by the Federal and State ESA listing, as well as improvements in water quality. Additionally, restrictions, and later the prohibition, on fishing for Atlantic sturgeon in New York waters is likely to have reduced the number of shortnose sturgeon mortalities, as this species is thought to have been caught as bycatch in fisheries targeting Atlantic sturgeon. The closure of the state shad fishery, which resulted in the capture, injury and mortality of shortnose sturgeon, is also likely to contribute to continued improvements in the status of shortnose sturgeon in the Hudson River. Based on the best available information, we consider that the Hudson River population of shortnose sturgeon is currently stable at high numbers; this trend is expected to continue into the future.

5.2 Atlantic Sturgeon

The section below describes the Atlantic sturgeon listing, provides life history information that is relevant to all DPSs of Atlantic sturgeon and then provides information specific to the status of each DPS of Atlantic sturgeon. Below, we also provide a description of which Atlantic sturgeon DPSs likely occur in the action area and provide information on the use of the action area by Atlantic sturgeon.

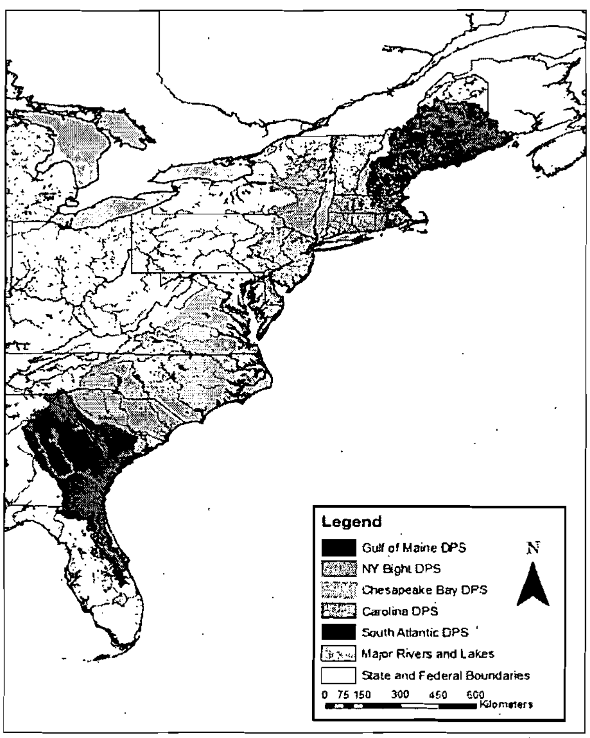
The Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) is a subspecies of sturgeon distributed along the eastern coast of North America from Hamilton Inlet, Labrador, Canada to Cape Canaveral, Florida, USA (Scott and Scott, 1988; ASSRT, 2007; T. Savoy, CT DEP, pers.

5 In 2002, water temperatures at the USGS gage at Hastings-on-Hudson (No. 01376304; the farthest downstream gage on the river) fell to 8°C on November 23. In 2003, water temperatures at this gage fell to 8°C on November 29; In 2010, water temperatures at the USGS gage at West Point, NY (No. 01374019; currently the farthest downstream gage on the river) fell to 8°C on November 23.

comm.). NMFS has delineated U.S. populations of Atlantic sturgeon into five DPSs[6] (77 FR 5880 and 77 FR 5914). These are: the Gulf of Maine, New York Bight, Chesapeake Bay, Carolina, and South Atlantic DPSs (see Figure 9). The results of genetic studies suggest that natal origin influences the distribution of Atlantic sturgeon in the marine environment (Wirgin and King, 2011). However, genetic data as well as tracking and tagging data demonstrate sturgeon from each DPS and Canada occur throughout the full range of the subspecies. Therefore, sturgeon originating from any of the 5 DPSs can be affected by threats in the marine, estuarine and riverine environment that occur far from natal spawning rivers.

On February 6, 2012, we published notice in the *Federal Register* that we were listing the New York Bight, Chesapeake Bay, Carolina, and South Atlantic DPSs as "endangered," and the Gulf of Maine DPS as "threatened" (77 FR 5880 and 77 FR 5914). The effective date of the listings was April 6, 2012. The DPSs do not include Atlantic sturgeon spawned in Canadian rivers. Therefore, Canadian spawned fish are not included in the listings.

Figure 9. Map Depicting the Boundaries of the five Atlantic sturgeon DPSs



6 To be considered for listing under the ESA, a group of organisms must constitute a "species." A "species" is defined in section 3 of the ESA to include "any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate fish or wildlife which interbreeds when mature."

As described below, individuals originating from three of the five listed DPSs may occur in the action area. Information general to all Atlantic sturgeon as well as information specific to each of the relevant DPSs, is provided below.

5.2.1 Atlantic sturgeon life history

Atlantic sturgeon are long lived (approximately 60 years), late maturing, estuarine dependent, anadromous[7] fish (Bigelow and Schroeder, 1953; Vladykov and Greeley 1963; Mangin, 1964; Pikitch *et al.*, 2005; Dadswell, 2006; ASSRT, 2007).

The life history of Atlantic sturgeon can be divided up into five general categories as described in the table below (developed from information in ASSRT 2007).

Age Class	**Size**	**Description**
Egg		Fertilized or unfertilized
Larvae		Negative photo-taxic, nourished by yolk sac
Young of Year (YOY)	**0.3 grams <41 cm TL**	Fish that are > 3 months and < one year; capable of capturing and consuming live food
Sub-adults	**>41 cm and <150 cm TL**	Fish that are at least age 1 and are not sexually mature
Adults	**>150 cm TL**	Sexually mature fish

Table 5. Descriptions of Atlantic sturgeon life history stages.

They are a relatively large fish, even amongst sturgeon species (Pikitch *et al.*, 2005). Atlantic sturgeons are bottom feeders that suck food into a ventrally-located protruding mouth (Bigelow and Schroeder, 1953). Four barbels in front of the mouth assist the sturgeon in locating prey (Bigelow and Schroeder, 1953). Diets of adult and migrant subadult Atlantic sturgeon include mollusks, gastropods, amphipods, annelids, decapods, isopods, and fish such as sand lance (Bigelow and Schroeder, 1953; ASSRT, 2007; Guilbard *et al.*, 2007; Savoy, 2007). Juvenile Atlantic sturgeon feed on aquatic insects, insect larvae, and other invertebrates (Bigelow and

7 Anadromous refers to a fish that is born in freshwater, spends most of its life in the sea, and returns to freshwater to spawn (NEFSC FAQ's, available at http://www.nefsc.noaa.gov/faq/fishfaq1a.html, modified June 16, 2011)

Schroeder, 1953; ASSRT, 2007; Guilbard *et al.*, 2007).

Rate of maturation is affected by water temperature and gender. In general: (1) Atlantic sturgeon that originate from southern systems grow faster and mature sooner than Atlantic sturgeon that originate from more northern systems; (2) males grow faster than females; (3) fully mature females attain a larger size (i.e. length) than fully mature males; and (4) the length of Atlantic sturgeon caught since the mid-late 20th century have typically been less than 3 meters (m) (Smith *et al.*, 1982; Smith *et al.*, 1984; Smith, 1985; Scott and Scott, 1988; Young *et al.*, 1998; Collins *et al.*, 2000; Caron *et al.*, 2002; Dadswell, 2006; ASSRT, 2007; Kahnle *et al.*, 2007; DFO, 2011). The largest recorded Atlantic sturgeon was a female captured in 1924 that measured approximately 4.26 m (Vladykov and Greeley, 1963). Dadswell (2006) reported seeing seven fish of comparable size in the St. John River estuary from 1973 to 1995. Observations of large-sized sturgeon are particularly important given that egg production is correlated with age and body size (Smith *et al.*, 1982; Van Eenennaam *et al.*, 1996; Van Eenennaam and Doroshov, 1998; Dadswell, 2006). However, while females are prolific with egg production ranging from 400,000 to 4 million eggs per spawning year, females spawn at intervals of 2-5 years (Vladykov and Greeley, 1963; Smith *et al.*, 1982; Van Eenennaam *et al.*, 1996; Van Eenennaam and Doroshov, 1998; Stevenson and Secor, 1999; Dadswell, 2006). Given spawning periodicity and a female's relatively late age to maturity, the age at which 50 percent of the maximum lifetime egg production is achieved is estimated to be 29 years (Boreman, 1997). Males exhibit spawning periodicity of 1-5 years (Smith, 1985; Collins *et al.*, 2000; Caron *et al.*, 2002). While long-lived, Atlantic sturgeon are exposed to a multitude of threats prior to achieving maturation and have a limited number of spawning opportunities once mature.

Water temperature plays a primary role in triggering the timing of spawning migrations (ASMFC, 2009). Spawning migrations generally occur during February-March in southern systems, April-May in Mid-Atlantic systems, and May-July in Canadian systems (Murawski and Pacheco, 1977; Smith, 1985; Bain, 1997; Smith and Clugston, 1997; Caron *et al.*, 2002). Male sturgeon begin upstream spawning migrations when waters reach approximately 6° C (43° F) (Smith *et al.*, 1982; Dovel and Berggren, 1983; Smith, 1985; ASMFC, 2009), and remain on the spawning grounds throughout the spawning season (Bain, 1997). Females begin spawning migrations when temperatures are closer to 12° C to 13° C (54° to 55° F) (Dovel and Berggren, 1983; Smith, 1985; Collins *et al.*, 2000), make rapid spawning migrations upstream, and quickly depart following spawning (Bain, 1997).

The spawning areas in most U.S. rivers have not been well defined. However, the habitat characteristics of spawning areas have been identified based on historical accounts of where fisheries occurred, tracking and tagging studies of spawning sturgeon, and physiological needs of early life stages. Spawning is believed to occur in flowing water between the salt front of estuaries and the fall line of large rivers, when and where optimal flows are 46-76 cm/s and depths are 3-27 m (Borodin, 1925; Dees, 1961; Leland, 1968; Scott and Crossman, 1973; Crance, 1987; Shirey *et al.* 1999; Bain *et al.*, 2000; Collins *et al.*, 2000; Caron *et al.* 2002; Hatin *et al.* 2002; ASMFC, 2009). Sturgeon eggs are deposited on hard bottom substrate such as cobble, coarse sand, and bedrock (Dees, 1961; Scott and Crossman, 1973; Gilbert, 1989; Smith and Clugston, 1997; Bain *et al.* 2000; Collins *et al.*, 2000; Caron *et al.*, 2002; Hatin *et al.*, 2002; Mohler, 2003; ASMFC, 2009), and become adhesive shortly after fertilization (Murawski and

Pacheco, 1977; Van den Avyle, 1983; Mohler, 2003). Incubation time for the eggs increases as water temperature decreases (Mohler, 2003). At temperatures of 20° and 18° C, hatching occurs approximately 94 and 140 hours, respectively, after egg deposition (ASSRT, 2007).

Larval Atlantic sturgeon (i.e. less than 4 weeks old, with total lengths (TL) less than 30 mm; Van Eenennaam *et al.* 1996) are assumed to undertake a demersal existence and inhabit the same riverine or estuarine areas where they were spawned (Smith *et al.*, 1980; Bain *et al.*, 2000; Kynard and Horgan, 2002; ASMFC, 2009). Studies suggest that age-0 (i.e., young-of-year), age-1, and age-2 juvenile Atlantic sturgeon occur in low salinity waters of the natal estuary (Haley, 1999; Hatin *et al.*, 2007; McCord *et al.*, 2007; Munro *et al.*, 2007) while older fish are more salt tolerant and occur in higher salinity waters as well as low salinity waters (Collins *et al.*, 2000). Atlantic sturgeon remain in the natal estuary for months to years before emigrating to open ocean as subadults (Holland and Yelverton, 1973; Dovel and Berggen, 1983; Waldman *et al.*, 1996; Dadswell, 2006; ASSRT, 2007).

After emigration from the natal estuary, subadults and adults travel within the marine environment, typically in waters less than 50 m in depth, using coastal bays, sounds, and ocean waters (Vladykov and Greeley, 1963; Murawski and Pacheco, 1977; Dovel and Berggren, 1983; Smith, 1985; Collins and Smith, 1997; Welsh *et al.*, 2002; Savoy and Pacileo, 2003; Stein *et al.*, 2004; USFWS, 2004; Laney *et al.*, 2007; Dunton *et al.*, 2010; Erickson *et al.*, 2011; Wirgin and King, 2011). Tracking and tagging studies reveal seasonal movements of Atlantic sturgeon along the coast. Satellite-tagged adult sturgeon from the Hudson River concentrated in the southern part of the Mid-Atlantic Bight at depths greater than 20 m during winter and spring, and in the northern portion of the Mid-Atlantic Bight at depths less than 20 m in summer and fall (Erickson *et al.*, 2011). Shirey (Delaware Department of Fish and Wildlife, unpublished data reviewed in ASMFC, 2009) found a similar movement pattern for juvenile Atlantic sturgeon based on recaptures of fish originally tagged in the Delaware River. After leaving the Delaware River estuary during the fall, juvenile Atlantic sturgeon were recaptured by commercial fishermen in nearshore waters along the Atlantic coast as far south as Cape Hatteras, North Carolina from November through early March. In the spring, a portion of the tagged fish re-entered the Delaware River estuary. However, many fish continued a northerly coastal migration through the Mid-Atlantic as well as into southern New England waters where they were recovered throughout the summer months. Movements as far north as Maine were documented. A southerly coastal migration was apparent from tag returns reported in the fall. The majority of these tag returns were reported from relatively shallow near shore fisheries with few fish reported from waters in excess of 25 m (C. Shirey, Delaware Department of Fish and Wildlife, unpublished data reviewed in ASMFC, 2009). Areas where migratory Atlantic sturgeon commonly aggregate include the Bay of Fundy (e.g., Minas and Cumberland Basins), Massachusetts Bay, Connecticut River estuary, Long Island Sound, New York Bight, Delaware Bay, Chesapeake Bay, and waters off of North Carolina from the Virginia/North Carolina border to Cape Hatteras at depths up to 24 m (Dovel and Berggren, 1983; Dadswell *et al.*, 1984; Johnson *et al.*, 1997; Rochard *et al.*, 1997; Kynard *et al.*, 2000; Eyler *et al.*, 2004; Stein *et al.*, 2004; Wehrell, 2005; Dadswell, 2006; ASSRT, 2007; Laney *et al.*, 2007). These sites may be used as foraging sites and/or thermal refuge.

5.2.2 Determination of DPS Composition in the Action Area

As explained above, the range of all 5 DPSs overlaps and extends from Canada through Cape Canaveral, Florida. We have considered the best available information to determine from which DPSs individuals in the action area are likely to have originated. We have determined that Atlantic sturgeon in the action area likely originate from three of the five DPSs at the following frequencies: Gulf of Maine 6%; NYB 92%; and, Chesapeake Bay 2%. These percentages are based on genetic sampling of individuals (n=39) captured within the Hudson River and therefore, represent the best available information on the likely genetic makeup of individuals occurring in the action area. The genetic assignments have a plus/minus 5% confidence interval; however, for purposes of section 7 consultation we have selected the reported values above, which approximate the mid-point of the range, as a reasonable indication of the likely genetic makeup of Atlantic sturgeon in the action area. These assignments and the data from which they are derived are described in detail in Damon-Randall *et al.* (2012a).

5.2.3 Distribution and Abundance

Atlantic sturgeon underwent significant range-wide declines from historical abundance levels due to overfishing in the mid to late 19th century when a caviar market was established (Scott and Crossman, 1973; Taub, 1990; Kennebec River Resource Management Plan, 1993; Smith and Clugston, 1997; Dadswell, 2006; ASSRT, 2007). Abundance of spawning-aged females prior to this period of exploitation was predicted to be greater than 100,000 for the Delaware, and at least 10,000 females for other spawning stocks (Secor and Waldman, 1999; Secor, 2002). Historical records suggest that Atlantic sturgeon spawned in at least 35 rivers prior to this period. Currently, only 16 U.S. rivers are known to support spawning based on available evidence (i.e., presence of young-of-year or gravid Atlantic sturgeon documented within the past 15 years) (ASSRT, 2007). While there may be other rivers supporting spawning for which definitive evidence has not been obtained (e.g., in the Penobscot and York Rivers), the number of rivers supporting spawning of Atlantic sturgeon are approximately half of what they were historically. In addition, only four rivers (Kennebec, Hudson, Delaware, James) are known to currently support spawning from Maine through Virginia where historical records support there used to be fifteen spawning rivers (ASSRT, 2007). Thus, there are substantial gaps in the range between Atlantic sturgeon spawning rivers amongst northern and mid-Atlantic states which could make recolonization of extirpated populations more difficult.

There are no current, published population abundance estimates for any of the currently known spawning stocks. Therefore, there are no published abundance estimates for any of the five DPSs of Atlantic sturgeon. An estimate of 863 mature adults per year (596 males and 267 females) was calculated for the Hudson River based on fishery-dependent data collected from 1985-1995 (Kahnle *et al.*, 2007). An estimate of 343 spawning adults per year is available for the Altamaha River, GA, based on fishery-independent data collected in 2004 and 2005 (Schueller and Peterson, 2006). Using the data collected from the Hudson River and Altamaha River to estimate the total number of Atlantic sturgeon in either subpopulation is not possible, since mature Atlantic sturgeon may not spawn every year (Vladykov and Greeley, 1963; Smith, 1985; Van Eenennaam *et al.*, 1996; Stevenson and Secor, 1999; Collins *et al.* 2000; Caron *et al.*, 2002), the age structure of these populations is not well understood, and stage to stage survival is unknown. In other words, the information that would allow us to take an estimate of annual spawning adults and expand that estimate to an estimate of the total number of individuals (e.g., yearlings, subadults, and adults) in a population is lacking. The ASSRT presumed that the Hudson and Altamaha rivers had the most robust of the remaining U.S. Atlantic sturgeon spawning populations and concluded that the other U.S. spawning populations were likely less than 300 spawning adults per year (ASSRT, 2007).

It is possible, however, to estimate the total number of adults in some other rivers based on the number of mature adults in the Hudson River. We have calculated an estimate of total mature adults and a proportion of subadults for four of the five DPSs. The technique used to obtain these estimates is explained fully in Damon-Randall 2012(b) and is summarized briefly below. We used this method because for these four DPSs, there are: (1) no total population estimates available; (2) with the exception of the Hudson River, no estimates of the number of mature adults; and, (3) no information from directed population surveys which could be used to generate an estimate of the number of spawning adults, total adult population or total DPS population.

Kahnle *et al.* (2007) estimated the number of total mature adults per year in the Hudson River using data from surveys in the 1980s to mid-1990s and based on mean harvest by sex divided by sex specific exploitation rate. While this data is over 20 years old, it is currently the best available data on the abundance of Hudson River origin Atlantic sturgeon. The sex ratio of spawners is estimated to be approximately 70% males and 30% females. As noted above, Kahnle *et al.* (2007) estimated a mean annual number of mature adults at 596 males and 267 females.

We were able to use this estimate of the adult population in the Hudson River and the rate at which Atlantic sturgeon from the Hudson River are intercepted in certain Northeast commercial fisheries[8] to estimate the number of adults in other spawning rivers. As noted above, the method used is summarized below and explained fully in Damon-Randall 2012(b).

Given the geographic scope of commercial fisheries as well as the extensive marine migrations of Atlantic sturgeon, fish originating from nearly all spawning rivers are believed to be intercepted by commercial fisheries. An estimate of the number of Atlantic sturgeon captured in certain fisheries authorized by NMFS under Federal FMPs in the Northeast is available (NEFSC 2011). This report indicates that based on observed interactions with Atlantic sturgeon in sink gillnet and otter trawl fisheries from 2006-2010, on average 3,118 Atlantic sturgeon are captured in these fisheries each year. Information in the Northeast Fisheries Observer Program (NEFOP) database, indicates that 25% of captured Atlantic sturgeon are adults (determined as length greater than 150 cm) and 75% are subadults (determined as length less than 150cm). By applying the mixed stock genetic analysis of individuals[9] sampled by the NEFOP and At Sea Monitoring Program (see Damon-Randall *et al.* 2012a) to the bycatch estimate, we can determine an estimate of the number of Hudson River Atlantic sturgeon that are intercepted by these fisheries on an annual basis.

[8] Bycatch information was obtained from a report prepared by NMFS' Northeast Fisheries Science Center (NEFSC 2012).
[9] Based on the best available information, we expect that 46% of Atlantic sturgeon captured in Northeast commercial fisheries originate from the New York Bight DPS and that 91% of those individuals originate from the Hudson River (see Damon-Randall *et al.* 2012a and Wirgin and King 2011).

Given the number of observed Hudson River origin Atlantic sturgeon adults taken as bycatch, we can calculate what percentage of Hudson River origin Atlantic sturgeon mature adults these represent. This provides an interception rate. We assume that fish originating in any river in any DPS are equally likely to be intercepted by the observed commercial fisheries; therefore, we can use this interception rate to estimate the number of Atlantic sturgeon in the other rivers of origin. This type of back calculation allows us to use the information we have for the Hudson River and fill in significant data gaps present for the other rivers. Using this method, we have estimated the total adult populations for three DPSs (Gulf of Maine, Chesapeake Bay, and South Atlantic) as follows. We are not able to use this method to calculate an adult population estimate for the Carolina DPS. Based on the results of the genetic mixed stock analysis, fish originating from the Carolina DPS do not appear in the Northeast Fisheries Observer Program (NEFOP) observer dataset and based on this, as well as genetics information on fish captured in other coastal sampling programs in the Northeast[10] are assumed to not be intercepted in Northeast fisheries. Given the proportion of adults to subadults in the observer database (ratio of 1:3), we can also estimate a number of subadults originating from each DPS. However, this can not be considered an estimate of the total number of subadults because it would only consider those subadults that are of a size vulnerable to captured in commercial sink gillnet and otter trawl gear in the marine environment and are present in the marine environment.

Table 6: Summary of Calculated Population Estimates

DPS	Estimated Mature Adult Population	Estimated Subadults of Size vulnerable to capture in commercial fisheries
GOM	166	498
NYB (Hudson River and Delaware River)	950	2,850
CB	329	987

5.2.4 *Threats faced by Atlantic sturgeon throughout their range*

Atlantic sturgeon are susceptible to over exploitation given their life history characteristics (e.g., late maturity, dependence on a wide-variety of habitats). Similar to other sturgeon species (Vladykov and Greeley, 1963; Pikitch *et al.*, 2005), Atlantic sturgeon experienced range-wide declines from historical abundance levels due to overfishing (for caviar and meat) and impacts to habitat in the 19th and 20th centuries (Taub, 1990; Smith and Clugston, 1997; Secor and Waldman, 1999).

Based on the best available information, NMFS has concluded that unintended catch of Atlantic sturgeon in fisheries, vessel strikes, poor water quality, water availability, dams, lack of regulatory mechanisms for protecting the fish, and dredging are the most significant threats to Atlantic sturgeon (77 FR 5880 and 77 FR 5914; February 6, 2012). While all of the threats are not necessarily present in the same area at the same time, given that Atlantic sturgeon subadults and adults use ocean waters from the Labrador, Canada to Cape Canaveral, FL, as well as

[10] We reviewed genetics information available for 701 individuals sampled in a variety of coastal sampling programs from Maine to Virginia. Only two fish were identified as Carolina DPS origin (collected in central Long Island Sound) and no fish in the NEFOP database (n=89 for genetic samples) were identified as Carolina DPS origin.

estuaries of large rivers along the U.S. East Coast, activities affecting these water bodies are likely to impact more than one Atlantic sturgeon DPS. In addition, given that Atlantic sturgeon depend on a variety of habitats, every life stage is likely affected by one or more of the identified threats.

An ASMFC interstate fishery management plan for sturgeon (Sturgeon FMP) was developed and implemented in 1990 (Taub, 1990). In 1998, the remaining Atlantic sturgeon fisheries in U.S. state waters were closed per Amendment 1 to the Sturgeon FMP. Complementary regulations were implemented by NMFS in 1999 that prohibit fishing for, harvesting, possessing or retaining Atlantic sturgeon or its parts in or from the Exclusive Economic Zone in the course of a commercial fishing activity.

Commercial fisheries for Atlantic sturgeon still exist in Canadian waters (DFO, 2011). Sturgeon belonging to one or more of the DPSs may be harvested in the Canadian fisheries. In particular, the Bay of Fundy fishery in the Saint John estuary may capture sturgeon of U.S. origin given that sturgeon from the Gulf of Maine and the New York Bight DPSs have been incidentally captured in other Bay of Fundy fisheries (DFO, 2010; Wirgin and King, 2011). Because Atlantic sturgeon are listed under Appendix II of the Convention on International Trade in Endangered Species (CITES), the U.S. and Canada are currently working on a conservation strategy to address the potential for captures of U.S. fish in Canadian directed Atlantic sturgeon fisheries and of Canadian fish incidentally in U.S. commercial fisheries. At this time, there are no estimates of the number of individuals from any of the DPSs that are captured or killed in Canadian fisheries each year.

Based on geographic distribution, most U.S. Atlantic sturgeon that are intercepted in Canadian fisheries are likely to originate from the Gulf of Maine DPS, with a smaller percentage from the New York Bight DPS.

Bycatch in U.S. waters is a significant threat faced by all 5 DPSs. At this time, we have an estimate of the number of Atlantic sturgeon captured and killed in sink gillnet and otter trawl fisheries authorized by Federal FMPs (NMFS NEFSC 2011) in the Northeast Region but do not have a similar estimate for Southeast fisheries. We also do not have an estimate of the number of Atlantic sturgeon captured or killed in state fisheries. At this time, we are not able to quantify the effects of other significant threats (e.g., vessel strikes, poor water quality, water availability, dams, and dredging) in terms of habitat impacts or loss of individuals. While we have some information on the number of mortalities that have occurred in the past in association with certain activities (e.g., mortalities in the Delaware and James rivers that are thought to be due to vessel strikes), we are not able to use those numbers to extrapolate effects throughout one or more DPS. This is because of (1) the small number of data points and, (2) lack of information on the percent of incidences that the observed mortalities represent.

As noted above, the NEFSC prepared an estimate of the number of encounters of Atlantic sturgeon in fisheries authorized by Northeast FMPs (NEFSC 2011). The analysis prepared by the NEFSC estimates that from 2006 through 2010 there were 2,250 to 3,862 encounters per year in observed gillnet and trawl fisheries, with an average of 3,118 encounters. Mortality rates in gillnet gear are approximately 20%, with the exception of monkfish gear which has a higher mortality rate of approximately 27%. Mortality rates in otter trawl gear are believed to be lower at approximately 5%. Comparing the estimated annual average mortalities to the adult population estimates for each of the DPSs encountered in Northeast fisheries, we estimate that at least 4% of adults from each DPS are being killed as a result of interactions with fisheries authorized by Northeast FMPs each year.

5.3 Gulf of Maine DPS

The Gulf of Maine DPS includes the following: all anadromous Atlantic sturgeons that are spawned in the watersheds from the Maine/Canadian border and, extending southward, all watersheds draining into the Gulf of Maine as far south as Chatham, MA. Within this range, Atlantic sturgeon historically spawned in the Androscoggin, Kennebec, Merrimack, Penobscot, and Sheepscot Rivers (ASSRT, 2007). Spawning still occurs in the Kennebec and Androscoggin Rivers, and it is possible that it still occurs in the Penobscot River as well. Spawning in the Androscoggin River was just recently confirmed by the Maine Department of Marine Resources when they captured a larval Atlantic sturgeon during the 2011 spawning season below the Brunswick Dam. There is no evidence of recent spawning in the remaining rivers. In the 1800s, construction of the Essex Dam on the Merrimack River at river kilometer (rkm) 49 blocked access to 58 percent of Atlantic sturgeon habitat in the river (Oakley, 2003; ASSRT, 2007). However, the accessible portions of the Merrimack seem to be suitable habitat for Atlantic sturgeon spawning and rearing (i.e., nursery habitat) (Keiffer and Kynard, 1993). Therefore, the availability of spawning habitat does not appear to be the reason for the lack of observed spawning in the Merrimack River. Studies are on-going to determine whether Atlantic sturgeon are spawning in these rivers. Atlantic sturgeons that are spawned elsewhere continue to use habitats within all of these rivers as part of their overall marine range (ASSRT, 2007). The movement of subadult and adult sturgeon between rivers, including to and from the Kennebec River and the Penobscot River, demonstrates that coastal and marine migrations are key elements of Atlantic sturgeon life history for the Gulf of Maine DPS as well as likely throughout the entire range (ASSRT, 2007; Fernandes, *et al.*, 2010).

Bigelow and Schroeder (1953) surmised that Atlantic sturgeon likely spawned in Gulf of Maine Rivers in May-July. More recent captures of Atlantic sturgeon in spawning condition within the Kennebec River suggest that spawning more likely occurs in June-July (Squiers *et al.*, 1981; ASMFC, 1998; NMFS and USFWS, 1998). Evidence for the timing and location of Atlantic sturgeon spawning in the Kennebec River includes: (1) the capture of five adult male Atlantic sturgeon in spawning condition (i.e., expressing milt) in July 1994 below the (former) Edwards Dam; (2) capture of 31 adult Atlantic sturgeon from June 15,1980, through July 26,1980, in a small commercial fishery directed at Atlantic sturgeon from the South Gardiner area (above Merrymeeting Bay) that included at least 4 ripe males and 1 ripe female captured on July 26,1980; and, (3) capture of nine adults during a gillnet survey conducted from 1977-1981, the majority of which were captured in July in the area from Merrymeeting Bay and upriver as far as Gardiner, ME (NMFS and USFWS, 1998; ASMFC 2007). The low salinity values for waters above Merrymeeting Bay are consistent with values found in other rivers where successful Atlantic sturgeon spawning is known to occur.

Several threats play a role in shaping the current status of Gulf of Maine DPS Atlantic sturgeon. Historical records provide evidence of commercial fisheries for Atlantic sturgeon in the

Kennebec and Androscoggin Rivers dating back to the 17th century (Squiers *et al.*, 1979). In 1849, 160 tons of sturgeon was caught in the Kennebec River by local fishermen (Squiers *et al.*, 1979). Following the 1880's, the sturgeon fishery was almost non-existent due to a collapse of the sturgeon stocks. All directed Atlantic sturgeon fishing as well as retention of Atlantic sturgeon by catch has been prohibited since 1998. Nevertheless, mortalities associated with bycatch in fisheries occurring in state and federal waters still occurs. In the marine range, Gulf of Maine DPS Atlantic sturgeon are incidentally captured in federal and state managed fisheries, reducing survivorship of subadult and adult Atlantic sturgeon (Stein *et al.*, 2004; ASMFC 2007). As explained above, we have estimates of the number of subadults and adults that are killed as a result of bycatch in fisheries authorized under Northeast FMPs. At this time, we are not able to quantify the impacts from other threats or estimate the number of individuals killed as a result of other anthropogenic threats. Habitat disturbance and direct mortality from anthropogenic sources are the primary concerns.

Riverine habitat may be impacted by dredging and other in-water activities, disturbing spawning habitat and also altering the benthic forage base. Many rivers in the Gulf of Maine DPS have navigation channels that are maintained by dredging. Dredging outside of Federal channels and in-water construction occurs throughout the Gulf of Maine DPS. While some dredging projects operate with observers present to document fish mortalities, many do not. To date we have not received any reports of Atlantic sturgeon killed during dredging projects in the Gulf of Maine region; however, as noted above, not all projects are monitored for interactions with fish. At this time, we do not have any information to quantify the number of Atlantic sturgeon killed or disturbed during dredging or in-water construction projects are also not able to quantify any effects to habitat.

Connectivity is disrupted by the presence of dams on several rivers in the Gulf of Maine region, including the Penobscot and Merrimack Rivers. While there are also dams on the Kennebec, Androscoggin and Saco Rivers, these dams are near the site of natural falls and likely represent the maximum upstream extent of sturgeon occurrence even if the dams were not present. Because no Atlantic sturgeon occur upstream of any hydroelectric projects in the Gulf of Maine region, passage over hydroelectric dams or through hydroelectric turbines is not a source of injury or mortality in this area. The extent that Atlantic sturgeon are affected by operations of dams in the Gulf of Maine region is currently unknown; however, the documentation of an Atlantic sturgeon larvae downstream of the Brunswick Dam in the Androscoggin River suggests that Atlantic sturgeon spawning may be occurring in the vicinity of at least that project and therefore, may be affected by project operations. The range of Atlantic sturgeon in the Penobscot River is limited by the presence of the Veazie and Great Works Dams. Together these dams prevent Atlantic sturgeon from accessing approximately 29 km of habitat, including the presumed historical spawning habitat located downstream of Milford Falls, the site of the Milford Dam. While removal of the Veazie and Great Works Dams is anticipated to occur in the near future, the presence of these dams is currently preventing access to significant habitats within the Penobscot River. While Atlantic sturgeon are known to occur in the Penobscot River, it is unknown if spawning is currently occurring or whether the presence of the Veazie and Great Works Dams affects the likelihood of spawning occurring in this river. The Essex Dam on the Merrimack River blocks access to approximately 58% of historically accessible habitat in this river. Atlantic sturgeon occur in the Merrimack River but spawning has not been documented.

Like the Penobscot, it is unknown how the Essex Dam affects the likelihood of spawning occurring in this river.

Gulf of Maine DPS Atlantic sturgeon may also be affected by degraded water quality. In general, water quality has improved in the Gulf of Maine over the past decades (Lichter *et al.* 2006; EPA, 2008). Many rivers in Maine, including the Androscoggin River, were heavily polluted in the past from industrial discharges from pulp and paper mills. While water quality has improved and most discharges are limited through regulations, many pollutants persist in the benthic environment. This can be particularly problematic if pollutants are present on spawning and nursery grounds as developing eggs and larvae are particularly susceptible to exposure to contaminants.

There are no empirical abundance estimates for the Gulf of Maine DPS. The Atlantic sturgeon SRT (2007) presumed that the Gulf of Maine DPS was comprised of less than 300 spawning adults per year, based on abundance estimates for the Hudson and Altamaha River riverine populations of Atlantic sturgeon. Surveys of the Kennebec River over two time periods, 1977-1981 and 1998-2000, resulted in the capture of nine adult Atlantic sturgeon (Squiers, 2004). However, since the surveys were primarily directed at capture of shortnose sturgeon, the capture gear used may not have been selective for the larger-sized, adult Atlantic sturgeon; several hundred subadult Atlantic sturgeon were caught in the Kennebec River during these studies. As explained above, we have estimated that there is an annual mean of 166 mature adult Atlantic sturgeon in the GOM DPS.

Summary of the Gulf of Maine DPS

Spawning for the Gulf of Maine DPS is known to occur in two rivers (Kennebec and Androscoggin) and possibly in a third. Spawning may be occurring in other rivers, such as the Sheepscot or Penobscot, but has not been confirmed. There are indications of increasing abundance of Atlantic sturgeon belonging to the Gulf of Maine DPS. Atlantic sturgeon continue to be present in the Kennebec River; in addition, they are captured in directed research projects in the Penobscot River, and are observed in rivers where they were unknown to occur or had not been observed to occur for many years (e.g., the Saco, Presumpscot, and Charles rivers). These observations suggest that abundance of the Gulf of Maine DPS of Atlantic sturgeon is sufficient such that recolonization to rivers historically suitable for spawning may be occurring. However, despite some positive signs, there is not enough information to establish a trend for this DPS.

Some of the impacts from the threats that contributed to the decline of the Gulf of Maine DPS have been removed (e.g., directed fishing), or reduced as a result of improvements in water quality and removal of dams (e.g., the Edwards Dam on the Kennebec River in 1999). There are strict regulations on the use of fishing gear in Maine state waters that incidentally catch sturgeon. In addition, there have been reductions in fishing effort in state and federal waters, which most likely would result in a reduction in bycatch mortality of Atlantic sturgeon. A significant amount of fishing in the Gulf of Maine is conducted using trawl gear, which is known to have a much lower mortality rate for Atlantic sturgeon caught in the gear compared to sink gillnet gear (ASMFC, 2007). Atlantic sturgeon from the GOM DPS are not commonly taken as bycatch in areas south of Chatham, MA, with only 8 percent (e.g., 7 of the 84 fish) of interactions observed in the Mid Atlantic/Carolina region being assigned to the Gulf of Maine DPS (Wirgin and King, 2011). Tagging results also indicate that Gulf of Maine DPS fish tend to remain within the waters of the Gulf of Maine and only occasionally venture to points south. However, data on Atlantic sturgeon incidentally caught in trawls and intertidal fish weirs fished in the Minas Basin area of the Bay of Fundy (Canada) indicate that approximately 35 percent originated from the Gulf of Maine DPS (Wirgin *et al.*, in draft).

As noted previously, studies have shown that in order to rebuild, Atlantic sturgeon can only sustain low levels of bycatch and other anthropogenic mortality (Boreman, 1997; ASMFC, 2007; Kahnle *et al.*, 2007; Brown and Murphy, 2010). NMFS has determined that the Gulf of Maine DPS is at risk of becoming endangered in the foreseeable future throughout all of its range (i.e., is a threatened species) based on the following: (1) significant declines in population sizes and the protracted period during which sturgeon populations have been depressed; (2) the limited amount of current spawning; and, (3) the impacts and threats that have and will continue to affect recovery.

5.4 New York Bight DPS

The New York Bight DPS includes the following: all anadromous Atlantic sturgeon spawned in the watersheds that drain into coastal waters from Chatham, MA to the Delaware-Maryland border on Fenwick Island. Within this range, Atlantic sturgeon historically spawned in the Connecticut, Delaware, Hudson, and Taunton Rivers (Murawski and Pacheco, 1977; Secor, 2002; ASSRT, 2007). Spawning still occurs in the Delaware and Hudson Rivers, but there is no recent evidence (within the last 15 years) of spawning in the Connecticut and Taunton Rivers (ASSRT, 2007). Atlantic sturgeon that are spawned elsewhere continue to use habitats within the Connecticut and Taunton Rivers as part of their overall marine range (ASSRT, 2007; Savoy, 2007; Wirgin and King, 2011).

The Hudson River and Estuary extend 504 kilometers from the Atlantic Ocean to Lake Tear of-the-Clouds in the Adirondack Mountains (Dovel and Berggren, 1983). The estuary is 246 km long, beginning at the southern tip of Manhattan Island (rkm 0) and running north to the Troy Dam (rkm 246) near Albany (Sweka *et al.*, 2007). All Atlantic sturgeon habitats are believed to occur below the dam. Therefore, presence of the dam on the river does not restrict access of Atlantic sturgeon to necessary habitats (e.g., for spawning, rearing, foraging, over wintering) (NMFS and USFWS, 1998; ASSRT, 2007).

Use of the river by Atlantic sturgeon has been described by several authors. Briefly, spawning likely occurs in multiple sites within the river from approximately rkm 56 to rkm 182 (Dovel and Berggren, 1983; Van Eenennaam *et al.*, 1996; Kahnle *et al.*, 1998; Bain *et al.*, 2000). Selection of sites in a given year may be influenced by the position of the salt wedge (Dovel and Berggren, 1983; Van Eenennaam *et al.*, 1996; Kahnle *et al.*, 1998). The area around Hyde Park (approximately rkm134) has consistently been identified as a spawning area through scientific studies and historical records of the Hudson River sturgeon fishery (Dovel and Berggren, 1983; Van Eenennaam *et al.*, 1996; Kahnle *et al.*, 1998; Bain *et al.*, 2000). Habitat conditions at the Hyde Park site are described as freshwater year round with bedrock, silt and clay substrates and waters depths of 12-24 m (Bain *et al.*, 2000). Bain *et al.* (2000) also identified a spawning site at rkm 112 based on tracking data. The rkm 112 site, located to one side of the river, has clay, silt and sand substrates, and is approximately 21-27 m deep (Bain *et al.*, 2000).

Young-of-year (YOY) have been recorded in the Hudson River between rkm 60 and rkm 148, which includes some brackish waters; however, larvae must remain upstream of the salt wedge because of their low salinity tolerance (Dovel and Berggren, 1983; Kahnle *et al.*, 1998; Bain *et al.*, 2000). Catches of immature sturgeon (age 1 and older) suggest that juveniles utilize the estuary from the Tappan Zee Bridge through Kingston (rkm 43- rkm 148) (Dovel and Berggren, 1983; Bain *et al.*, 2000). Seasonal movements are apparent with juveniles occupying waters from rkm 60 to rkm 107 during summer months and then moving downstream as water temperatures decline in the fall, primarily occupying waters from rkm 19 to rkm 74 (Dovel and Berggren, 1983; Bain *et al.*, 2000). Based on river-bottom sediment maps (Coch, 1986) most juvenile sturgeon habitats in the Hudson River have clay, sand, and silt substrates (Bain *et al.*, 2000). Newburgh and Haverstraw Bays in the Hudson River are areas of known juvenile sturgeon concentrations (Sweka *et al.*, 2007). Sampling in spring and fall revealed that highest catches of juvenile Atlantic sturgeon occurred during spring in soft-deep areas of Haverstraw Bay even though this habitat type comprised only 25% of the available habitat in the Bay (Sweka *et al.*, 2007). Overall, 90% of the total 562 individual juvenile Atlantic sturgeon captured during the course of this study (14 were captured more than once) came from Haverstraw Bay (Sweka *et al.*, 2007). At around 3 years of age, Hudson River juveniles exceeding 70 cm total length begin to migrate to marine waters (Bain *et al.*, 2000).

In general, Hudson River Atlantic sturgeons mature at approximately 11 to 21 years of age (Dovel and Berggren, 1983; ASMFC 1998; Young *et al.* 1998). A sample of 94 pre-spawning adult Atlantic sturgeon from the Hudson River was comprised of males 12 to 19 years old, and females that were 14 to 36 years old (Van Eenennaam *et al.*, 1996). The majority of males were 13 to 16 years old while the majority of females were 16 to 20 years old (Van Eenennaam *et al.*, 1996). These data are consistent with the findings of Stevenson and Secor (1999) who noted that, amongst a sample of Atlantic sturgeon collected from the Hudson River fishery from 1992-1995, growth patterns indicated males grew faster and, thus, matured earlier than females. The spawning season for Hudson River Atlantic sturgeon extends from late spring to early summer (Dovel and Berggren, 1983; Van Eenennaam *et al.*, 1996).

The abundance of the Hudson River Atlantic sturgeon riverine population prior to the onset of expanded exploitation in the 1800's is unknown but, has been conservatively estimated at 10,000 adult females (Secor, 2002). Current abundance is likely at least one order of magnitude smaller than historical levels (Secor, 2002; ASSRT, 2007; Kahnle *et al.*, 2007). As described above, an estimate of the mean annual number of mature adults (863 total; 596 males and 267 females) was calculated for the Hudson River riverine population based on fishery-dependent data collected from 1985-1995 (Kahnle *et al.*, 2007). Kahnle *et al.* (1998; 2007) also showed that the level of fishing mortality from the Hudson River Atlantic sturgeon fishery during the period of 1985-1995 exceeded the estimated sustainable level of fishing mortality for the riverine population and may have led to reduced recruitment. All available data on abundance of juvenile Atlantic sturgeon in the Hudson River Estuary indicate a substantial drop in production of young since the mid 1970's (Kahnle *et al.*, 1998). A decline appeared to occur in the mid to late 1970's followed by a secondary drop in the late 1980's (Kahnle *et al.*, 1998; Sweka *et al.*, 2007; ASMFC, 2010). Catch-per-unit-effort data suggests that recruitment has remained depressed relative to catches of juvenile Atlantic sturgeon in the estuary during the mid-late 1980's (Sweka *et al.*, 2007; ASMFC, 2010). In examining the CPUE data from 1985-2007, there are significant fluctuations during this time. There appears to be a decline in the number of juveniles between the late 1980s and early 1990s and while the CPUE is generally higher in the 2000s as compared to the 1990s, given the significant annual fluctuation it is difficult to discern any trend. Despite the CPUEs from 2000-2007 being generally higher than those from 1990-1999, they are low compared to the late 1980s. There is currently not enough information regarding any life stage to establish a trend for the Hudson River population.

In the Delaware River and Estuary, Atlantic sturgeon occur from the mouth of the Delaware Bay to the fall line near Trenton, NJ, a distance of 220 km (NMFS and USFWS, 1998; Simpson, 2008). As is the case in the Hudson River, all historical Atlantic sturgeon habitats appear to be accessible in the Delaware (NMFS and USFWS, 1998; ASSRT, 2007). Recent multi-year studies have provided new information on the use of habitats by Atlantic sturgeon within the Delaware River and Estuary (Brundage, 2007; Simpson, 2008; Brundage and O'Herron, 2009; Fisher, 2009; Calvo *et al.*, 2010; Fox and Breece, 2010).

Historical records from the 1830's indicate Atlantic sturgeon may have spawned as far north as Bordentown, just below Trenton, NJ (Pennsylvania Commission of Fisheries, 1897). Cobb (1899) and Borden (1925) reported spawning occurring between rkm 77 and 130 (Delaware City, DE to Chester City, PA). Based on recent tagging and tracking studies carried out from 2009-2011, Breece (2011) reports likely spawning locations at rkm 120-150 and rkm 170-190. Mature adults have been tracked in these areas at the time of year when spawning is expected to occur and movements have been consistent with what would be expected from spawning adults. Based on tagging and tracking studies, Simpson (2008) suggested that spawning habitat also exists from Tinicum Island (rkm 136) to the fall line in Trenton, NJ (rkm 211). To date, eggs and larvae have not been documented to confirm that actual spawning is occurring in these areas. However, as noted below, the presence of young of the year in the Delaware River provides confirmation that spawning is still occurring in this river.

Sampling in 2009 that targeted YOY resulted in the capture of more than 60 YOY in the Marcus Hook anchorage (rkm 127) area during late October-late November 2009 (Fisher, 2009; Calvo *et al.*, 2010). Twenty of the YOY from one study and six from the second study received acoustic tags that provided information on habitat use by this early life stage (Calvo *et al.*, 2010; Fisher, 2011). YOY used several areas from Deepwater (rkm 105) to Roebling (rkm 199) during late fall to early spring. Some remained in the Marcus Hook area while others moved upstream, exhibiting migrations in and out of the area during winter months (Calvo *et al.*, 2010; Fisher, 2011). At least one YOY spent some time downstream of Marcus Hook (Calvo *et al.*, 2010; Fisher, 2011). Downstream detections from May to August between Philadelphia (rkm 150) and New Castle (rkm 100) suggest non-use of the upriver locations during the summer months (Fisher, 2011). By September 2010, only 3 of 20 individuals tagged by DE DNREC persisted with active tags (Fisher, 2011). One of these migrated upstream to the Newbold Island and Roebling area (rkm 195), but was back down in the lower tidal area within 3 weeks and was last detected at Tinicum Island (rkm 141) when the transmitter expired in October (Fisher, 2011). The other two remained in the Cherry Island Flats (rkm 113) and Marcus Hook Anchorage area (rkm130) until their tags transmissions also ended in October (Fisher, 2011).

The Delaware Estuary is known to be a congregation area for sturgeon from multiple DPSs. Generally, non-natal late stage juveniles (sometimes also referred to as subadults) immigrate into the estuary in spring, establish home range in the summer months in the river, and emigrate from the estuary in the fall (Fisher, 2011). Subadults tagged and tracked by Simpson (2008) entered the lower Delaware Estuary as early as mid-March but, more typically, from mid-April through May. Tracked sturgeon remained in the Delaware Estuary through the late fall departing in November (Simpson, 2008). Previous studies have found a similar movement pattern of upstream movement in the spring-summer and downstream movement to overwintering areas in the lower estuary or nearshore ocean in the fall-winter (Brundage and Meadows, 1982; Lazzari *et al.*, 1986; Shirey *et al.*, 1997; 1999; Brundage and O'Herron, 2009; Brundage and O'Herron in Calvo *et al.*, 2010).

Brundage and O'Herron (in Calvo *et al.* (2010)) tagged 26 juvenile Atlantic sturgeon, including 6 young of the year. For non YOY fish, most detections occured in the lower tidal Delaware River from the middle Liston Range (rkm 70) to Tinicum Island (rkm 141). For non YOY fish, these researchers also detected a relationship between the size of individuals and the movement pattern of the fish in the fall. The fork length of fish that made defined movements to the lower bay and ocean averaged 815 mm (range 651-970 mm) while those that moved towards the bay but were not detected below Liston Range averaged 716 mm (range 505-947 mm), and those that appear to have remained in the tidal river into the winter averaged 524 mm (range 485-566 mm) (Calvo *et al.*, 2010). During the summer months, concentrations of Atlantic sturgeon have been located in the Marcus Hook (rkm 123-129) and Cherry Island Flats (rkm 112-118) regions of the river (Simpson, 2008; Calvo *et al.*, 2010) as well as near Artificial Island (Simpson, 2008). Sturgeon have also been detected using the Chesapeake and Delaware Canal (Brundage, 2007; Simpson, 2008).

Adult Atlantic sturgeon captured in marine waters off of Delaware Bay in the spring were tracked in an attempt to locate spawning areas in the Delaware River, (Fox and Breece, 2010). Over the period of two sampling seasons (2009-2010) four of the tagged sturgeon were detected in the Delaware River. The earliest detection was in mid-April while the latest departure occurred in mid-June (Fox and Breece, 2010). The sturgeon spent relatively little time in the river each year, generally about 4 weeks, and used the area from New Castle, DE (rkm 100) to Marcus Hook (rkm 130) (Fox and Breece, 2010). A fifth sturgeon tagged in a separate study was also tracked and followed a similar timing pattern but traveled farther upstream (to rkm 165) before exiting the river in early June (Fox and Breece, 2010).

There is no abundance estimate for the Delaware River population of Atlantic sturgeon. Harvest records from the 1800's indicate that this was historically a large population with an estimated 180,000 adult females prior to 1890 (Secor and Waldman, 1999; Secor, 2002). Sampling in 2009 to target young-of- the year (YOY) Atlantic sturgeon in the Delaware River (i.e., natal sturgeon) resulted in the capture of 34 YOY, ranging in size from 178 to 349 mm TL (Fisher, 2009) and the collection of 32 YOY Atlantic sturgeon in a separate study (Brundage and O'Herron in Calvo *et al.*, 2010). Genetics information collected from 33 of the 2009 year class YOY indicates that at least 3 females successfully contributed to the 2009 year class (Fisher, 2011). Therefore, while the capture of YOY in 2009 provides evidence that successful spawning is still occurring in the Delaware River, the relatively low numbers suggest the existing riverine population is limited in size.

Several threats play a role in shaping the current status and trends observed in the Delaware River and Estuary. In-river threats include habitat disturbance from dredging, and impacts from historical pollution and impaired water quality. A dredged navigation channel extends from Trenton seaward through the tidal river (Brundage and O'Herron, 2009), and the river receives significant shipping traffic. Vessel strikes have been identified as a threat in the Delaware River; however, at this time we do not have information to quantify this threat or its impact to the population or the New York Bight DPS. Similar to the Hudson River, there is currently not enough information to determine a trend for the Delaware River population.

Summary of the New York Bight DPS
Atlantic sturgeon originating from the New York Bight DPS spawn in the Hudson and Delaware rivers. While genetic testing can differentiate between individuals originating from the Hudson or Delaware river the available information suggests that the straying rate is high between these rivers. There are no indications of increasing abundance for the New York Bight DPS (ASSRT, 2009; 2010). Some of the impact from the threats that contributed to the decline of the New York Bight DPS have been removed (e.g., directed fishing) or reduced as a result of improvements in water quality since passage of the Clean Water Act (CWA). In addition, there have been reductions in fishing effort in state and federal waters, which may result in a reduction in bycatch mortality of Atlantic sturgeon. Nevertheless, areas with persistent, degraded water quality, habitat impacts from dredging, continued bycatch in state and federally-managed fisheries, and vessel strikes remain significant threats to the New York Bight DPS.

In the marine range, New York Bight DPS Atlantic sturgeon are incidentally captured in federal and state managed fisheries, reducing survivorship of subadult and adult Atlantic sturgeon (Stein *et al.*, 2004; ASMFC 2007). As explained above, currently available estimates indicate that at least 4% of adults may be killed as a result of bycatch in fisheries authorized under Northeast FMPs. Based on mixed stock analysis results presented by Wirgin and King (2011), over 40 percent of the Atlantic sturgeon bycatch interactions in the Mid Atlantic Bight region were sturgeon from the New York Bight DPS. Individual-based assignment and mixed stock analysis of samples collected from sturgeon captured in Canadian fisheries in the Bay of Fundy indicated that approximately 1-2% were from the New York Bight DPS. At this time, we are not able to quantify the impacts from other threats or estimate the number of individuals killed as a result of other anthropogenic threats.

Riverine habitat may be impacted by dredging and other in-water activities, disturbing spawning habitat and also altering the benthic forage base. Both the Hudson and Delaware rivers have navigation channels that are maintained by dredging. Dredging is also used to maintain channels in the nearshore marine environment. Dredging outside of Federal channels and in-water construction occurs throughout the New York Bight region. While some dredging projects operate with observers present to document fish mortalities many do not. We have reports of one Atlantic sturgeon entrained during hopper dredging operations in Ambrose Channel, New Jersey. At this time, we do not have any information to quantify the number of Atlantic sturgeon killed or disturbed during dredging or in-water construction projects are also not able to quantify any effects to habitat.

In the Hudson and Delaware Rivers, dams do not block access to historical habitat. The Holyoke Dam on the Connecticut River blocks further upstream passage; however, the extent that Atlantic sturgeon would historically have used habitat upstream of Holyoke is unknown. Connectivity may be disrupted by the presence of dams on several smaller rivers in the New York Bight region. Because no Atlantic sturgeon occur upstream of any hydroelectric projects in the New York Bight region, passage over hydroelectric dams or through hydroelectric turbines is not a source of injury or mortality in this area. The extent that Atlantic sturgeon are affected by operations of dams in the New York Bight region is currently unknown.

New York Bight DPS Atlantic sturgeon may also be affected by degraded water quality. In general, water quality has improved in the Hudson and Delaware over the past decades (Lichter *et al.* 2006; EPA, 2008). Both the Hudson and Delaware rivers, as well as other rivers in the New York Bight region, were heavily polluted in the past from industrial and sanitary sewer discharges. While water quality has improved and most discharges are limited through regulations, many pollutants persist in the benthic environment. This can be particularly problematic if pollutants are present on spawning and nursery grounds as developing eggs and larvae are particularly susceptible to exposure to contaminants.

Vessel strikes occur in the Delaware River. Twenty-nine mortalities believed to be the result of vessel strikes were documented in the Delaware River from 2004 to 2008, and at least 13 of these fish were large adults. Given the time of year in which the fish were observed (predominantly May through July, with two in August), it is likely that many of the adults were migrating through the river to the spawning grounds. Because we do not know the percent of total vessel strikes that the observed mortalities represent, we are not able to quantify the number of individuals likely killed as a result of vessel strikes in the New York Bight DPS.

Studies have shown that to rebuild, Atlantic sturgeon can only sustain low levels of anthropogenic mortality (Boreman, 1997; ASMFC, 2007; Kahnle *et al.*, 2007; Brown and Murphy, 2010). There are no empirical abundance estimates of the number of Atlantic sturgeon in the New York Bight DPS. As explained above, we have estimated that there are an annual mean total of 950 mature adult Atlantic sturgeon in the NYB DPS. NMFS has determined that the New York Bight DPS is currently at risk of extinction due to: (1) precipitous declines in population sizes and the protracted period in which sturgeon populations have been depressed; (2) the limited amount of current spawning; and (3) the impacts and threats that have and will continue to affect population recovery.

5.5 Chesapeake Bay DPS

The Chesapeake Bay DPS includes the following: all anadromous Atlantic sturgeons that are spawned in the watersheds that drain into the Chesapeake Bay and into coastal waters from the Delaware-Maryland border on Fenwick Island to Cape Henry, VA. Within this range, Atlantic sturgeon historically spawned in the Susquehanna, Potomac, James, York, Rappahannock, and Nottoway Rivers (ASSRT, 2007). Based on the review by Oakley (2003), 100 percent of Atlantic sturgeon habitat is currently accessible in these rivers since most of the barriers to passage (i.e. dams) are located upriver of where spawning is expected to have historically occurred (ASSRT, 2007). Spawning still occurs in the James River, and the presence of juvenile and adult sturgeon in the York River suggests that spawning may occur there as well (Musick *et al.*, 1994; ASSRT, 2007; Greene, 2009). However, conclusive evidence of current spawning is only available for the James River. Atlantic sturgeon that are spawned elsewhere are known to use the Chesapeake Bay for other life functions, such as foraging and as juvenile nursery habitat prior to entering the marine system as subadults (Vladykov and Greeley, 1963; ASSRT, 2007; Wirgin *et al.*, 2007; Grunwald *et al.*, 2008).

Several threats play a role in shaping the current status of Chesapeake Bay DPS Atlantic sturgeon. Historical records provide evidence of the large-scale commercial exploitation of Atlantic sturgeon from the James River and Chesapeake Bay in the 19th century (Hildebrand and Schroeder, 1928; Vladykov and Greeley, 1963; ASMFC, 1998; Secor, 2002; Bushnoe *et al.*, 2005; ASSRT, 2007) as well as subsistence fishing and attempts at commercial fisheries as early as the 17th century (Secor, 2002; Bushnoe *et al.*, 2005; ASSRT, 2007; Balazik *et al.*, 2010). Habitat disturbance caused by in-river work such as dredging for navigational purposes is thought to have reduced available spawning habitat in the James River (Holton and Walsh, 1995; Bushnoe *et al.*, 2005; ASSRT, 2007). At this time, we do not have information to quantify this loss of spawning habitat.

Decreased water quality also threatens Atlantic sturgeon of the Chesapeake Bay DPS, especially since the Chesapeake Bay system is vulnerable to the effects of nutrient enrichment due to a relatively low tidal exchange and flushing rate, large surface to volume ratio, and strong stratification during the spring and summer months (Pyzik *et al.*, 2004; ASMFC, 1998; ASSRT, 2007; EPA, 2008). These conditions contribute to reductions in dissolved oxygen levels throughout the Bay. The availability of nursery habitat, in particular, may be limited given the recurrent hypoxia (low dissolved oxygen) conditions within the Bay (Niklitschek and Secor, 2005; 2010). At this time we do not have sufficient information to quantify the extent that degraded water quality effects habitat or individuals in the James River or throughout the Chesapeake Bay.

Vessel strikes have been observed in the James River (ASSRT, 2007). Eleven Atlantic sturgeon were reported to have been struck by vessels from 2005 through 2007. Several of these were mature individuals. Because we do not know the percent of total vessel strikes that the observed mortalities represent, we are not able to quantify the number of individuals likely killed as a result of vessel strikes in the New York Bight DPS.

In the marine and coastal range of the Chesapeake Bay DPS from Canada to Florida, fisheries bycatch in federally and state managed fisheries poses a threat to the DPS, reducing survivorship of subadults and adults and potentially causing an overall reduction in the spawning population (Stein *et al.*, 2004; ASMFC, 2007; ASSRT, 2007).

Summary of the Chesapeake Bay DPS

Spawning for the Chesapeake Bay DPS is known to occur in only the James River. Spawning may be occurring in other rivers, such as the York, but has not been confirmed. There are anecdotal reports of increased sightings and captures of Atlantic sturgeon in the James River. However, this information has not been comprehensive enough to develop a population estimate for the James River or to provide sufficient evidence to confirm increased abundance. Some of the impact from the threats that facilitated the decline of the Chesapeake Bay DPS have been removed (e.g., directed fishing) or reduced as a result of improvements in water quality since passage of the Clean Water Act (CWA). As explained above, we have estimated that there is an annual mean of 329 mature adult Atlantic sturgeon in the Chesapeake Bay DPS. We do not currently have enough information about any life stage to establish a trend for this DPS.

Areas with persistent, degraded water quality, habitat impacts from dredging, continued bycatch in U.S. state and federally-managed fisheries, Canadian fisheries and vessel strikes remain significant threats to the Chesapeake Bay DPS of Atlantic sturgeon. Studies have shown that Atlantic sturgeon can only sustain low levels of bycatch mortality (Boreman, 1997; ASMFC, 2007; Kahnle *et al.*, 2007). The Chesapeake Bay DPS is currently at risk of extinction given (1) precipitous declines in population sizes and the protracted period in which sturgeon populations have been depressed; (2) the limited amount of current spawning; and, (3) the impacts and threats that have and will continue to affect the potential for population recovery.

5.6 Factors Affecting the Survival and Recovery of Shortnose and Atlantic sturgeon in the Hudson River

There are several activities that occur in the Hudson River that affect individual shortnose and Atlantic sturgeon. Impacts of activities that occur within the action area are considered in the "Environmental Baseline" section (Section 6.0, below). Activities that impact sturgeon in the Hudson River but do not necessarily overlap with the action area are discussed below.

5.6.1 Hudson River Power Plants

The mid-Hudson River provides cooling water to four large power plants: Indian Point Nuclear Generating Station, Roseton Generating Station (RM 66, rkm 107), Danskammer Point Generating Station (RM 66, rkm 107), and Bowline Point Generating Station (RM 33, rkm 52.8). All of these stations use once-through cooling. The Lovett Generating Station (RM 42, rkm 67) is no longer operating.

5.6.1.1 Indian Point

IP1 operated from 1962 through October 1974. IP2 and IP3 have been operational since 1973 and 1975, respectively. Since 1963, shortnose and Atlantic sturgeon in the Hudson River have been exposed to effects of this facility. Eggs and early larvae would be the only life stages of sturgeon small enough to be vulnerable to entrainment at the Indian Point intakes (openings in the wedge wire screens are 6mm x 12.5 mm (0.25 inches by 0.5 inches); eggs are small enough to pass through these openings but are not expected to occur in the immediate vicinity of the Indian Point site.

Studies to evaluate the effects of entrainment at IP2 and IP3 occurred from the early 1970s through 1987; with intense daily sampling during the spring of 1981-1987. As reported by the Nuclear Regulatory Commission (NRC) in its Final Environmental Impact Statement considering the proposed relicensing of IP2 and IP3 (NRC 2011), entrainment monitoring reports list no shortnose or Atlantic sturgeon eggs or larvae at IP2 or IP3. Given what is known about these life stages (i.e., no eggs expected to be present in the action area; larvae only expected to be found in the deep channel area away from the intakes) and the intensity of the past monitoring, it is reasonable to assume that this past monitoring provides an accurate assessment of past entrainment of sturgeon early life stages. Based on this, it is unlikely that any entrainment of sturgeon eggs and larvae occurred historically.

NMFS has no information on any monitoring for impingement that may have occurred at the IP1 intakes. Therefore, we are unable to determine whether any monitoring did occur at the IP1 intakes and whether shortnose or Atlantic sturgeon were recorded as impinged at IP1 intakes. Despite this lack of data, given that the IP1 intake is located between the IP2 and IP3 intakes and operates in a similar manner, it is reasonable to assume that some number of shortnose and Atlantic sturgeon were impinged at the IP1 intakes during the time that IP1 was operational. However, based on the information available to NMFS, we are unable to make a quantitative assessment of the likely number of shortnose and Atlantic sturgeon impinged at IP1 during the period in which it was operational.

The impingement of shortnose and Atlantic sturgeon at IP2 and IP3 has been documented (NRC 2011). Impingement monitoring occurred from 1974-1990, and during this time period, 21 shortnose sturgeon were observed impinged at IP2. For Unit 3, 11 impinged shortnose sturgeon were recorded. At Unit 2, 251 Atlantic sturgeon were observed as impinged during this time period, with an annual range of 0-118 individuals (peak number in 1975); at Unit 3, 266 Atlantic sturgeon were observed as impinged, with an annual range of 0-153 individuals (peak in 1976). No monitoring of the intakes for impingement has occurred since 1990.

While models of the current thermal plume are available, it is not clear whether this model accurately represents past conditions associated with the thermal plume. As no information on past thermal conditions are available and no monitoring was done historically to determine if the thermal plume was affecting shortnose or Atlantic sturgeon or their prey, it is not possible to estimate past effects associated with the discharge of heated effluent from the Indian Point facility. No information is available on any past impacts to shortnose sturgeon prey due to impingement or entrainment or exposure to the thermal plume. This is because no monitoring of sturgeon prey in the action area has occurred.

The Indian Point facility may be relicensed in the future; if so, it could operate until 2033 and 2035. NRC is currently considering Entergy's application for a new operating license. NRC's proposed action was the subject of a section 7 consultation with NMFS that concluded in October 2011. In our Biological Opinion, we considered the effects of the continued operation of the facility from the time a new license is issued (2013 and 2015 for Units 2 and 3 respectively) through the 20 year extended operating period (2033 and 2035) on shortnose sturgeon. We determined that the proposed action was likely to adversely affect, but not likely to jeopardize, the continued existence of shortnose sturgeon. As explained in the "Effects of the Action" section of that Opinion, an average of 5 shortnose sturgeon per year are likely to be impinged at Unit 2 during the extended operating period, with a total of no more than 104 shortnose sturgeon over the 20 year period (dead or alive). Additionally, over the 20 year operating period, an additional 6 shortnose sturgeon (dead or alive) are likely to be impinged at the Unit 1 intakes which will provide service water for the operation of Unit 2. At Unit 3, an average of 3 shortnose sturgeon are likely to be impinged per year during the extended operating period, with a total of no more than 58 shortnose sturgeon (dead or alive) taken as a result of the operation of Unit 3 over the 20 year period. This level of take was exempted through an Incidental Take Statement that applies only to the period when the facility operates under a new operating license (September 28, 2013 through September 28, 2033 for Units 1 and 2; December 12, 2015 through December 12, 2035 for Unit 3). It is likely that the operation of Indian Point continues to cause the impingement, and possible mortality, of some number of individual Atlantic sturgeon in the Hudson River; on May 16, 2012, NRC requested reinitiation of the 2011 consultation to consider Atlantic sturgeon. This consultation is currently ongoing.

5.6.1.2 Roseton and Danskammer

In 1998, Central Hudson Gas and Electric Corporation (CHGEC), the operator of the Roseton and Danskammer Point power plants initiated an application with us for an incidental take (ITP) permit under section 10(a)(1)(B) of the ESA.[11] As part of this process CHGEC submitted a Conservation Plan and application for a 10(a)(1)(B) incidental take permit that proposed to minimize the potential for entrainment and impingement of shortnose sturgeon at the Roseton and Danskammer Point power plants. These measures ensure that the operation of these plants will not appreciably reduce the likelihood of the survival and recovery of shortnose sturgeon in the wild. In addition to the minimization measures, a proposed monitoring program was implemented to assess the periodic take of shortnose sturgeon, the status of the species in the project area, and the progress on the fulfillment of mitigation requirements. In December 2000, Dynegy Roseton L.L.C. and Dynegy Danskammer Point L.L.C. were issued incidental take permit no. 1269 (ITP 1269). At the time the ITP was issued, Atlantic sturgeon were not listed under the ESA; therefore, the ITP does not address Atlantic sturgeon.

The ITP exempts the incidental take of 2 shortnose sturgeon at Roseton and 4 at Danskammer Point annually. This incidental take level is based upon impingement data collected from 1972-1998. NMFS determined that this level of take was not likely to appreciably reduce the numbers, distribution, or reproduction of the Hudson River population of shortnose sturgeon in a way that appreciably reduces the ability of shortnose sturgeon to survive and recover in the wild. Since the ITP was issued, the number of shortnose sturgeon impinged has been very low. Dynegy has indicated that this may be due in part to reduced operations at the facilities which results in significantly less water withdrawal and therefore, less opportunity for impingement. While historical monitoring reports indicate that a small number of sturgeon larvae were entrained at Danskammer, no sturgeon larvae have been observed in entrainment samples collected since the ITP was issued. While the ITP does not currently address Atlantic sturgeon, the number of interactions with Atlantic sturgeon at Roseton and Danskammer that have been reported to NMFS since the ITP became effective has been very low.

6.0 ENVIRONMENTAL BASELINE

Environmental baselines for biological opinions include the past and present impacts of all state, federal or private actions and other human activities in the action area, the anticipated impacts of all proposed federal projects in the action area that have already undergone formal or early

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11 CHGEC has since been acquired by Dynegy Danskammer L.L.C. and Dynegy Roseton L.L.C. (Dynegy), thus the current incidental take permit is held by Dynegy. ESA Section 9 prohibits take, among other things, without express authorization through a Section 10 permit or exemption through a Section 7 Incidental Take Statement.

Section 7 consultation, and the impact of state or private actions that are contemporaneous with the consultation in process (50 CFR 402.02). The environmental baseline for this Opinion includes the effects of several activities that may affect the survival and recovery of shortnose and Atlantic sturgeon in the action area.

6.1 Federal Actions that have Undergone Formal or Early Section 7 Consultation

Some of the actions noted below occur only in the Hudson River and some occur in waters outside the river (e.g., Federal fisheries). Actions that occur in the Hudson River may affect shortnose and Atlantic sturgeon. Given the range of shortnose sturgeon, activities outside the Hudson River and upper New York Harbor are only likely to affect Atlantic sturgeon.

6.1.1 Scientific Studies permitted under Section 10 of the ESA

The Hudson River population of shortnose and Atlantic sturgeon have been the focus of a prolonged history of scientific research. In the 1930s, the New York State Biological Survey launched the first scientific sampling study and documented the distribution, age, and size of mature shortnose sturgeon (Bain *et al.* 1998). In the early 1970s, research resumed in response to a lack of biological data and concerns about the impact of electric generation facilities on fishery resources (Hoff 1988). In an effort to monitor relative abundance, population status, and distribution, intensive sampling of shortnose sturgeon in this region has continued throughout the past forty years. Sampling studies targeting other species, including Atlantic sturgeon, also incidentally capture shortnose sturgeon.

There are currently three scientific research permits issued pursuant to Section 10(a)(1)(A) of the ESA that authorize research on sturgeon in the Hudson River. The activities authorized under these permits are presented below.

NYDEC holds a scientific research permit (#16439, which replaces their previously held permit #1547) authorizing the assessment of habitat use, population abundance, reproduction, recruitment, age and growth, temporal and spatial distribution, diet selectivity, and contaminant load of shortnose sturgeon in the Hudson River Estuary from New York Harbor (RKM 0) to Troy Dam (RKM 245). NYDEC is authorized to use gillnets and trawls to capture up to 240 and 2,340 shortnose sturgeon in year one through years three and four and five, respectively. Research activities include: capture; measure, weigh; tag with passive integrated transponder (PIT) tags and Floy tags, if untagged; and sample genetic fin clips. A first subset of fish will also be anesthetized and tagged with acoustic transmitters; a second subset will have fin rays sampled for age and growth analysis; and a third subset will have gastric contents lavaged for diet analysis, as well as blood samples taken for contaminants. The unintentional mortality of nine shortnose sturgeon is anticipated over the five year life of the permit. This permit expires on November 24, 2016.

In April 2012, NYDEC was issued a scientific research permit (#16436) which authorizes the capture, handling and tagging of Atlantic sturgeon in the Hudson River. NYDEC is authorized to capture 1,350 juveniles and 200 adults. The unintentional mortality of two juveniles is anticipated annually over the five year life of the permit. This permit expires on April 5, 2017.

A permit was issued to Dynegy[12] in 2007 (#1580, originally issued as #1254) to evaluate the life history, population trends, and spacio-temporal and size distribution of shortnose sturgeon collected during the annual Hudson River Biological Monitoring Program. Dynegy is authorized to capture up to 82 adults/juveniles annually to measure, weigh, tag, photograph, and collect tissue samples for genetic analyses. Dynegy is also authorized to lethally take up to 40 larvae annually. An application for a new permit to authorize continuation of this sampling program was submitted by Entergy in 2012 and is currently under review. It is anticipated that any new permit issued would authorize takes of shortnose and Atlantic sturgeon.

6.1.2 Federally Authorized Fisheries

NMFS authorizes the operation of several fisheries in the action area under the authority of the Magnuson-Stevens Fishery Conservation Act and through Fishery Management Plans (FMP) and their implementing regulations. The action area includes a portion of NOAA Statistical Area 612. Fisheries that operate in the action area that may affect Atlantic sturgeon include: American lobster, Atlantic bluefish, Atlantic herring, Atlantic mackerel/squid/ butterfish, Atlantic sea scallop, monkfish, northeast multispecies, spiny dogfish, surf clam/ocean quahog and summer flounder/scup/black sea bass. Section 7 consultations have been completed on these fisheries to consider effects to listed whales and sea turtles.

We are in the process of reinitiating consultations that consider fisheries actions that may affect Atlantic sturgeon. Atlantic sturgeon are known to be captured and killed in fisheries operated in the action area; of the fisheries noted above, we expect that interactions may occur in all except American lobster, Atlantic herring and surf clam/ocean quahog. Data in the NEFOP database (see NEFSC 2011) indicates that captures of Atlantic sturgeon in fishing gear has been reported in all months in area 612. At the time of this writing, no Opinions considering effects of federally authorized fisheries on any DPS of Atlantic sturgeon have been completed. As noted in the Status of the Species section above, the NEFSC prepared a bycatch estimate for Atlantic sturgeon captured in sink gillnet and otter trawl fisheries operated from Maine through Virginia. This estimate indicates that, based on data from 2006-2010, annually, an average of 3,118 Atlantic sturgeon are captured in these fisheries with 1,569 in sink gillnet and 1,548 in otter trawls. The mortality rate in sink gillnets is estimated at approximately 20% and the mortality rate in otter trawls is estimated at 5%. Based on this estimate, a total of 391 Atlantic sturgeon are estimated to be killed annually in these fisheries that are prosecuted in the action area. We are currently in the process of determining the effects of this annual loss to each of the DPSs.

6.1.3 Other Research Activities

We have completed ESA section 7 consultation on two other research projects that occur in the action area. The US Fish and Wildlife Service funds an ocean trawl survey carried out by the State of New Jersey; the project is currently funded through May 3, 2014. This federal action was the subject of a consultation completed in May 2012. In the Opinion, we concluded that the action may adversely affect, but was not likely to jeopardize the continued existence of any DPS of Atlantic sturgeon. The ITS exempts the take of 109 Atlantic sturgeon through May 2014. All captured Atlantic sturgeon are expected to be released alive and no lethal take is anticipated.

12 Permit 1580 is issued by NMFS to Dynegy on behalf of "other Hudson River Generators including Entergy Nuclear Indian Point 2, L.L.C., Entergy Nuclear Indian Point 3, L.L.C. and Mirant (now GenOn) Bowline, L.L.C."

We provide funding to the Virginia Institute of Marine Science (VIMS) to carry out the Northeast Area Monitoring and Assessment Program (NEAMAP) Near Shore Trawl Program. In an April 2012 Opinion, we concluded that the 2012 spring and fall surveys may adversely affect, but was not likely to jeopardize the continued existence of any DPS of Atlantic sturgeon. The ITS exempts the take of 32 Atlantic sturgeon through 2012. All captured Atlantic sturgeon are expected to be released alive and no lethal take is anticipated.

6.1.4 HARS site

Background information on the HARS site is provided in sections 3.4.4 and 4.2 above. Over the past century, dredged material from the Port of New York and New Jersey was routinely disposed of at the Mud Dump Site (MDS), which is located within the current HARS site. The EPA formally designated the MDS as an "interim" ocean dredged material disposal site in 1973, and gave it final designation in 1984. On September 29, 1997, EPA under 40 CFR §228, closed MDS and simultaneously re-designated the site and surrounding areas that were used historically as disposal sites for contaminated dredged material as the HARS, and proposed that the site be managed to reduce impacts to acceptable levels (in accordance with 40 CFR §228.1(c)) (62 FR 46142) through remediation with uncontaminated dredged material (Remediation Material).

EPA published final rule 67 FR 62659 on March 17, 2003, to modify the designation of the HARS to establish a HARS-specific worm tissue polychlorinated biphenyl (PCB) criterion of 113 parts per billion (ppb) for use in determining the suitability of proposed dredged material for use as Remediation Material. This amendment to the HARS designation established a pass/fail criterion for evaluating PCBs in worm tissue from bioaccumulation tests performed on dredged material proposed for use at HARS as Remediation Material (USACE and USEPA 2009).

Pursuant to NEPA, EPA Region 2 prepared a Supplement to the Environmental Impact Statement (SEIS) on the Dredged Material Disposal Site Designation for the Designation of the HARS in 1997 (USEPA 1997). EPA prepared a BA that concluded that the closure of the Mud Dump Site and designation of the HARS was not likely to adversely affect loggerhead and kemps ridley sea turtles and humpback and fin whales (USEPA 1997). Special conditions are included in USACE Section 103 permits for placement of Remediation Material at HARS that requires the presence of NMFS approved Endangered Species Observer(s) on disposal scows during their trips to the HARS. The role of these observers is to prevent adverse impacts to endangered or threatened species transiting the area between the proposed dredge site and the HARS. In a letter dated July 30, 1997, we concurred with the EPA's determination and noted that while the BA did not consider right whales, our conclusions also applied to right whales. EPA is in the process of assessing the continued use of the HARS on Atlantic sturgeon and is in the process of preparing a BA and consultation request.

6.1.5 New York Harbor Deepening Project

The Harbor Deepening Project (HDP) was authorized pursuant to the Water Resources Development Act of 2000 and is an ongoing (since 2005) Federal dredging project that will deepen several channels in the Port of New York and New Jersey to a depth of approximately 50 feet below mean low water, thereby enabling the safe navigation and access of the Port by deep draft vessels. The HDP involves deepening channels and management of the dredged material produced by these operations (i.e., several different placement options for the dredged material are and will be utilized: upland sites; the Newark Bay Confined Disposal Facility (NBCDF); HARS; reef sites (i.e., Atlantic Beach artificial reef, New York; Sandy Hook artificial reef, New Jersey); habitat creation and other beneficial uses (e.g., Plumb Beach storm damage reduction, restoration Yellow Bar, Black Wall, and Rulers Bar Islands).

On February 18, 2000, consultation was initiated, with a Biological Opinion (Opinion) issued by us to the ACOE on October 13, 2000. In this Opinion we concluded that the HDP was likely to adversely affect but was not likely to jeopardize the continued existence of loggerhead, Kemp's ridley, leatherback or green sea turtles. The Opinion included an ITS exempting the incidental take of two loggerhead, one green, one Kemp's ridley, or one leatherback for the duration of the deepening, via a hopper dredge, of the Ambrose Channel. Due to the proposed method of dredging (i.e., clamshell bucket dredge or hydraulic cutterhead dredge) and location to unsuitable sea turtle habitat, dredging activities in Anchorage Channel, Bay Ridge Channel, Port Jersey Channel, Kill van Kull, Arthur Kill, and Newark Bay Channels are not expected to result in any lethal or non-lethal take of sea turtles. The ACOE is currently preparing a BA to consider effects of the remaining HDP work on Atlantic sturgeon; we expect consultation to be reinitiated in summer 2012. No interactions with Atlantic sturgeon during the HDP have been observed to date.

6.1.6 Hudson River Navigation Project

The Hudson River navigation project authorizes a channel 600 feet wide, New York City to Kingston narrowing to 400 feet wide to 2,200 feet south of the Mall Bridge (Dunn Memorial Bridge) at Albany with a turning basin at Albany and anchorages near Hudson and Stuyvesant, all with depths of 32 feet in soft material and 34 feet in rock; then 27 feet deep and 400 feet wide to 900 feet south of the Mall Bridge (Dunn Memorial Bridge); then 14 feet deep and generally 400 feet wide, to the Federal Lock at Troy; and then 14 feet deep and 200 feet wide, to the southern limit of the State Barge Canal at Waterford; with widening at bends and widening in front of the cities of Troy and Albany to form harbors 12 feet deep. The total length of the existing navigation project (NYC to Waterford) is about 155 miles. The only portion of the channel that is regularly dredged is the North Germantown and Albany reaches. Dredging is scheduled at times of year when sturgeon are least likely to be in the dredged reaches; no interactions with sturgeon have been observed.

6.1.7 Other Federally Authorized Actions

We have completed several informal consultations on effects of in-water construction activities in the Hudson River and New York Harbor permitted by the ACOE. This includes several dock and pier projects. No interactions with shortnose or Atlantic sturgeon have been reported in association with any of these projects.

We have also completed several informal consultations on effects of private dredging projects permitted by the ACOE. All of the dredging was with a mechanical dredge. No interactions with shortnose or Atlantic sturgeon have been reported in association with any of these projects.

6.2 State or Private Actions within the Action Area

6.2.1 Existing Tappan Zee Bridge

The existing Tappan Zee Bridge was built in the early 1950s and opened to traffic in 1955. Because the bridge was built prior to the enactment of the Endangered Species Act, no ESA consultation occurred. It is likely that the construction of the existing bridge resulted in some disturbance to aquatic communities and may have affected individual shortnose and Atlantic sturgeon. However, we have no information on construction methodologies or aquatic conditions at the time of construction and are not able to speculate on the effects of construction. The construction of the bridge resulted in the placement of structures in the water where there previously were none and resulted in a loss of benthic habitat. However, given the extremely small benthic footprint of the bridge compared with the size of the Hudson River estuary it is unlikely that this loss of habitat has had significant impacts on shortnose or Atlantic sturgeon. The bridge currently carries approximately 134,000 vehicles per day. The existence of the bridge results in storm water runoff that would not occur but for the existence of the bridge. We have no information on the likely effects of runoff on water quality in the Hudson River, but given the volume of stormwater runoff and best management practices that are in place to minimize impacts to the Hudson River, it is unlikely that there are significant impacts to water quality from the continued operation of the existing bridge.

6.2.2 State Authorized Fisheries

Atlantic and shortnose sturgeon may be vulnerable to capture, injury and mortality in fisheries occurring in state waters. The action area includes portions of New York and New Jersey state waters. Information on the number of sturgeon captured or killed in state fisheries is extremely limited and as such, efforts are currently underway to obtain more information on the numbers of sturgeon captured and killed in state water fisheries. We are currently working with the Atlantic States Marine Fisheries Commission (ASMFC) and the coastal states to assess the impacts of state authorized fisheries on sturgeon. We anticipate that some states are likely to apply for ESA section 10(a)(1)(B) Incidental Take Permits to cover their fisheries; however, to date, no applications have been submitted. Below, we discuss the different fisheries authorized by the states and any available information on interactions between these fisheries and sturgeon. Some of these fisheries occur in the Hudson River or lower estuary where both Atlantic and shortnose sturgeon occur (i.e., American eel, shad and river herring, striped bass, croaker and weakfish); other fisheries occur only in marine waters where only Atlantic sturgeon are likely to occur (coastal sharks, horseshoe crabs, American lobster).

American Eel

American eel (*Anguilla rostrata*) is exploited in fresh, brackish and coastal waters from the southern tip of Greenland to northeastern South America. American eel fisheries are conducted primarily in tidal and inland waters. In the Hudson River, eels between 6 and 14 inches long may be kept for bait; no eels may be kept for food (due to potential PCB contamination). Eels are typically caught with hook and line or with eel traps and may also be caught with fyke nets. Sturgeon are not known to interact with the eel fishery.

Atlantic croaker

Atlantic croaker (*Micropogonias undulates*) occur in coastal waters from the Gulf of Maine to Argentina, and are one of the most abundant inshore bottom-dwelling fish along the U.S. Atlantic coast. Fishing for Atlantic croaker may occur in the Hudson River estuary as well as in coastal waters considered as part of the action area. Atlantic croaker are managed under an ASMFC ISFMP (including Amendment 1 in 2005 and Addendum 1 in 2010), but no specific management measures are required. New York currently has no recreational or commercial management measures in place.

Recreational fisheries for Atlantic croaker are likely to use hook and line; commercial fisheries targeting croaker primarily use otter trawls. A review of the NEFOP database indicates that from 2006-2010, 60 Atlantic sturgeon (out of a total of 726 observed interactions) were captured during observed trips where the trip target was identified as croaker. This represents a minimum number of Atlantic sturgeon captured in the croaker fishery during this time period as it only considers observed trips. We do not have an estimate of the total number of Atlantic sturgeon caught as bycatch in the croaker fishery or the portion of the bycatch that occurs in the action area. Mortality of Atlantic sturgeon in commercial otter trawls has been estimated at 5%; we expect a similar mortality rate for Atlantic sturgeon bycatch in the croaker fishery operating in the action area. No information on interactions between shortnose sturgeon and the croaker fishery is available; however, because shortnose sturgeon can be caught in hook and line fisheries as well as in otter trawls, if this gear is used in areas of the river and estuary where shortnose sturgeon are present, there could be some capture of shortnose sturgeon in this fishery.

Coastal sharks

ASMFC manages coastal sharks through an Interstate Fishery Management Plan, which mirrors NMFS regulations regarding opening and closing dates, as well as quotas. New York prohibits commercial and recreational fishing for 20 species of sharks in state waters (the prohibited and research groups, as defined by the ASMFC's ISFMP). The commercial fishery for non-sandbar large coastal sharks closes when federal waters are closed by NMFS. No person is allowed to possess more than 33 sharks, regardless of species, in any 24-hour period. Commercial fishermen may use hook and line, small and large mesh gillnets, trawl nets, shortlines, weirs, and pound nets, while recreational anglers may only catch sharks using handlines or rod and reel. Commercial fishermen must practice bycatch reduction measures when using shortlines and large mesh gillnet fisheries, including release and disentanglement procedures for sea turtles. New York allows recreational fishermen to take only 20 species of sharks, with minimum size limits of 54 inches, except for Atlantic sharpnose, finetooth, blacknose, bonnethead, smooth dogfish, and spiny dogfish, which have no minimum size restrictions. Recreational shore and vessel-based anglers are limited to one shark plus an additional Atlantic sharpnose and bonnethead, and unlimited numbers of smooth and spiny dogfish. Atlantic sturgeon are known to interact with hook and line fisheries using live bait, as well as with large mesh gillnets and otter trawls; thus, some Atlantic sturgeon are likely captured during fishing targeting coastal sharks, although no estimates of the level of interaction are available.

Horseshoe crabs

ASMFC manages horseshoe crabs through an Interstate Fisheries Management Plan that sets state quotas, and allows states to set closed seasons. New York is allowed 366,272 crabs by the ASMFC under Addendum IV, but has issued a lower state quota of 170,000. Commercial horseshoe crab harvester may take 30 crabs per day during the open season by hand harvest or with pound nets, trap nets, gillnets, otter trawls, seines, or dredges. The use of dredges is prohibited in September and October, and dredges are limited to six feet in width at other times. Recreational harvesters are allowed to take five crabs per person per day, all year. Once the

ASMFC quota is reached, the fishery is closed. Trawls are known to incidentally capture Atlantic sturgeon. Stein *et al.* (2004) examined bycatch of Atlantic sturgeon using the NMFS sea-sampling/observer database (1989-2000) and found that the bycatch rate for horseshoe crabs was very low, at 0.05%. Few Atlantic sturgeon are expected to be caught in the horeshoe crab fishery in the action area.

Shad and River herring
Shad and river herring (blueback herring (*Alosa aestivalis*) and alewives (*Alosa pseudoharengus*)) are managed under an ASMFC Interstate Fishery Management Plan. In 2005, the ASMFC approved a coastwide moratorium on commercial and recreational fishing for shad. In May 2009, ASMFC adopted Amendment 2 to the ISFMP for Shad and River Herring, which closes all recreational and commercial fisheries unless each state can show its fisheries are sustainable. New York has submitted a Sustainable Fishing Plan that is currently under review. The plan prohibits the taking of river herring in any state waters, except for Hudson River stocks, for which it proposes partial closure in the tributaries and a five-year commercial gillnet fishery in the lower river. Although now closed, in the past this fishery was known to capture Atlantic and shortnose sturgeon.

Striped bass
Fishing for striped bass occurs within the Hudson River as well as in marine waters. Striped bass are managed by ASMFC through Amendment 6 to the Interstate FMP, which requires minimum sizes for the commercial and recreational fisheries, possession limits for the recreational fishery, and state quotas for the commercial fishery (ASMFC 2003). Under Addendum 2, the coastwide striped bass quota remains the same, at 70% of historical levels. Data from the Atlantic Coast Sturgeon Tagging Database (2000-2004) shows that the striped bass fishery accounted for 43% of Atlantic sturgeon recaptures; however, no information on the total number of Atlantic sturgeon caught by fishermen targeting striped bass is available. No information on interactions between shortnose sturgeon and the striped bass fishery is available; however, because shortnose sturgeon can be caught in hook and line fisheries as well as in otter trawls, if this gear is used in areas of the river and estuary where shortnose sturgeon are present, there could be some capture of shortnose sturgeon in this fishery.

Weakfish
The weakfish fishery occurs in both state and federal waters but the majority of commercially and recreationally caught weakfish are caught in state waters (ASMFC 2002). Fishing for weakfish could occur in the Hudson River estuary as well as in marine waters. The dominant commercial gears include gill nets, pound nets, haul seines, and trawls, with the majority of landings occurring in the fall and winter months (ASMFC 2002).

A quantitative assessment of the number of Atlantic sturgeon captured in the weakfish fishery is not available. A review of the NEFOP database indicates that from 2006-2010, 36 Atlantic sturgeon (out of a total of 726 observed interactions) were captured during observed trips where the trip target was identified as weakfish. This represents a minimum number of Atlantic sturgeon captured in the weakfish fishery during this time period as it only considers observed trips, and most inshore fisheries are not observed. An earlier review of bycatch rates and landings for the weakfish fishery reported that the weakfish-striped bass fishery had an Atlantic sturgeon bycatch rate of 16% from 1989-2000; the weakfish-Atlantic croaker fishery had an

Atlantic sturgeon bycatch rate of .02%, and the weakfish fishery had an Atlantic sturgeon bycatch rate of 1.0% (ASSRT 2007). No information on interactions between shortnose sturgeon and the weakfish fishery is available; however, because shortnose sturgeon can be caught in hook and line fisheries as well as in otter trawls, if this gear is used in areas of the river and estuary where shortnose sturgeon are present, there could be some capture of shortnose sturgeon in this fishery.

American lobster trap fishery
An American lobster trap fishery also occurs in state waters. Atlantic sturgeon are not known to interact with lobster trap gear.

6.3 Other Impacts of Human Activities in the Action Area

6.3.1 Impacts of Contaminants and Water Quality
Historically, shortnose sturgeon were rare in the lower Hudson River, likely as a result of poor water quality precluding migration further downstream. However, in the past several years, the water quality has improved and sturgeon have been found as far downstream as the Manhattan/Staten Island area. It is likely that contaminants remain in the water and in the action area, albeit to reduced levels. Sewage, industrial pollutants and waterfront development has likely decreased the water quality in the action area. Contaminants introduced into the water column or through the food chain, eventually become associated with the benthos where bottom dwelling species like sturgeon are particularly vulnerable. Several characteristics of shortnose sturgeon life history including long life span, extended residence in estuarine habitats, and being a benthic omnivore, predispose this species to long term repeated exposure to environmental contaminants and bioaccumulation of toxicants (Dadswell 1979).

Principal toxic chemicals in the Hudson River include pesticides and herbicides, heavy metals, and other organic contaminants such as PAHs and PCBs. Concentrations of many heavy metals also appear to be in decline and remaining areas of concern are largely limited to those near urban or industrialized areas. With the exception of areas near New York City, there currently does not appear to be a major concern with respect to heavy metals in the Hudson River, however metals could have previously affected sturgeon.

PAHs, which are products of incomplete combustion, most commonly enter the Hudson River as a result of urban runoff. As a result, areas of greatest concern are limited to urbanized areas, principally near New York City. The majority of individual PAHs of concern have declined during the past decade in the lower Hudson River and New York Harbor.

PCBs are the principal toxic chemicals of concern in the Hudson River. Primary inputs of PCBs in freshwater areas of the Hudson River are from the upper Hudson River near Fort Edward and Hudson Falls, New York. In the lower Hudson River, PCB concentrations observed are a result of both transport from upstream as well as direct inputs from adjacent urban areas. PCBs tend to be bound to sediments and also bioaccumulate and biomagnify once they enter the food chain. This tendency to bioaccumulate and biomagnify results in the concentration of PCBs in the tissue concentrations in aquatic-dependent organisms. These tissue levels can be many orders of magnitude higher than those observed in sediments and can approach or even exceed levels that pose concern over risks to the environment and to humans who might consume these organisms.

PCBs can have serious deleterious effects on aquatic life and are associated with the production of acute lesions, growth retardation, and reproductive impairment (Ruelle and Keenlyne 1993). PCB's may also contribute to a decreased immunity to fin rot (Dovel *et al.* 1992). Large areas of the upper Hudson River are known to be contaminated by PCBs, and this is thought to account for the high percentage of shortnose sturgeon in the Hudson River exhibiting fin rot. Under a statewide toxics monitoring program, the NYSDEC analyzed tissues from four shortnose sturgeon to determine PCB concentrations. In gonadal tissues, where lipid percentages are highest, the average PCB concentration was 29.55 parts per million (ppm; Sloan 1981) and in all tissues ranged from 22.1 to 997.0 ppm. Dovel (1992) reported that more than 75% of the shortnose sturgeon captured in his study had severe incidence of fin rot. Given that Atlantic sturgeon have similar sensitivities to toxins as shortnose sturgeon it is reasonable to anticipate that Atlantic sturgeon have been similarly affected. In the Connecticut River, coal tar leachate was suspected of impairing sturgeon reproductive success. Kocan (1993) conducted a laboratory study to investigate the survival of sturgeon eggs and larvae exposed to PAHs, a by-product of coal distillation. Only approximately 5% of sturgeon embryos and larvae survived after 18 days of exposure to Connecticut River coal-tar (i.e., PAH) demonstrating that contaminated sediment is toxic to shortnose sturgeon embryos and larvae under laboratory exposure conditions (NMFS 1998). Manufactured Gas Product (MGP) waste, which is chemically similar to the coal tar deposits found in the Connecticut River, is known to occur at several sites within the Hudson River and this waste may have had similar effects on any sturgeon present in the action area over the years.

Point source discharge (i.e., municipal wastewater, paper mill effluent, industrial or power plant cooling water or waste water) and compounds associated with discharges (i.e., metals, dioxins, dissolved solids, phenols, and hydrocarbons) contribute to poor water quality and may also impact the health of sturgeon populations. The compounds associated with discharges can alter the pH of receiving waters, which may lead to mortality, changes in fish behavior, deformations, and reduced egg production and survival.

Heavy usage of the Hudson River and development along the waterfront could have affected shortnose sturgeon throughout the action area. Coastal development and/or construction sites often result in excessive water turbidity, which could influence sturgeon spawning and/or foraging ability.

The Hudson River is used as a source of potable water, for waste disposal, transportation and cooling by industry and municipalities. Rohman *et al.* (1987) identified 183 separate industrial and municipal discharges to the Hudson and Mohawk Rivers. The greatest number of users were in the chemical industry, followed by the oil industry, paper and textile manufactures, sand, gravel, and rock processors, power plants, and cement companies. Approximately 20 publicly owned treatment works discharge sewage and wastewater into the Hudson River. Most of the municipal wastes receive primary and secondary treatment. A relatively small amount of sewage is attributed to discharges from recreational boats.

Water quality conditions in the Hudson River have dramatically improved since the mid-1970s. It is thought that this improvement may be a contributing factor to the improvement in the status of shortnose sturgeon in the river. However, as evidenced above, there are still concerns regarding the impacts of water quality on sturgeon in the river; particularly related to legacy contaminants for which no new discharges may be occurring, but environmental impacts are long lasting (e.g., PCBs, dioxins, coal tar, etc.)

6.4 Summary of Information on shortnose and Atlantic sturgeon in the action area

As discussed in the life history sections above, spawning sites for Atlantic and shortnose sturgeon are located outside of the action area. The distance from the spawning area and the brackish water in the action area makes it extremely unlikely that eggs or larvae of either species would be present in the action area.

Atlantic sturgeon adults are likely to migrate through the portion of the action area where construction will take place in the spring as they move from oceanic overwintering sites to upstream spawning sites and then migrate back through the area as they move to lower reaches of the estuary or oceanic areas in the late spring and early summer. Atlantic sturgeon adults are most likely to occur in the construction portion of the action area from May – September. Tracking data from tagged juvenile Atlantic sturgeon indicates that during the spring and summer individuals are most likely to occur within rkm 60-170. During the winter months, juvenile Atlantic sturgeon are most likely to occur between rkm 19 and 74. This seasonal change in distribution may be associated with seasonal movements of the saltwedge and differential seasonal use of habitats.

Based on the available data, juvenile, subadult and adult Atlantic sturgeon may be present in the construction portion of the action area year round. In the marine waters where the dredge disposal barge will transit and at the HARS site, only subadult and adult Atlantic sturgeon are likely to be present. While we do not have information on the seasonal distribution of Atlantic sturgeon at the HARS, Atlantic sturgeon have been caught in fisheries operating in Statistical Area 612, in which the HARS is located, in all months of the year. Therefore, we expect that Atlantic sturgeon will be present in the marine waters of the action area during the August 1 – November 1 time period when the HARS is being used. As explained above, Atlantic sturgeon in the action area are likely to have originated from the New York Bight DPS, Chesapeake Bay DPS and Gulf of Maine DPS, with the majority of individuals originating from the New York Bight DPS, and the majority of those individuals originating from the Hudson River.

Shortnose sturgeon juveniles and adults are likely to be present in the Hudson River portion of the action area year round, with the highest numbers present between May and October. At other times of the year, the majority of individuals are expected to be at overwintering sites located outside of the action area. All shortnose sturgeon in the action area are likely to have originated from the Hudson River. Coastal migrations have been documented in the Gulf of Maine, and two individuals tagged in the Hudson River have been caught in the Connecticut River. However, no shortnose sturgeon originating from another river or tagged in another river have been captured or detected in the Hudson River. Based on this, at this time we believe that interbasin movements into the Hudson River are rare. We do not expect shortnose sturgeon to be present in the marine waters of the action area.

7.0 CLIMATE CHANGE

The discussion below presents background information on global climate change and information on past and predicted future effects of global climate change throughout the range of the listed species considered here. Additionally, we present the available information on predicted effects of climate change in the action area and how listed sea turtles and sturgeon may be affected by those predicted environmental changes over the life of the proposed action. Climate change is relevant to the Status of the Species, Environmental Baseline and Cumulative Effects sections of this Opinion; rather than include partial discussion in several sections of this Opinion, we are synthesizing this information into one discussion. Effects of the proposed action that are relevant to climate change are included in the Effects of the Action section below (section 8.0 below).

7.1 Background Information on predicted climate change

The global mean temperature has risen 0.76°C (1.36°F) over the last 150 years, and the linear trend over the last 50 years is nearly twice that for the last 100 years (IPCC 2007a). Precipitation has increased nationally by 5%-10%, mostly due to an increase in heavy downpours (NAST 2000). There is a high confidence, based on substantial new evidence, that observed changes in marine systems are associated with rising water temperatures, as well as related changes in ice cover, salinity, oxygen levels, and circulation. Ocean acidification resulting from massive amounts of carbon dioxide and other pollutants released into the air can have major adverse impacts on the calcium balance in the oceans. Changes to the marine ecosystem due to climate change include shifts in ranges and changes in algal, plankton, and fish abundance (IPCC 2007b); these trends have been most apparent over the past few decades.

Climate model projections exhibit a wide range of plausible scenarios for both temperature and precipitation over the next century. Both of the principal climate models used by the National Assessment Synthesis Team (NAST) project warming in the southeast by the 2090s, but at different rates (NAST 2000): the Canadian model scenario shows the southeast U.S. experiencing a high degree of warming, which translates into lower soil moisture as higher temperatures increase evaporation; the Hadley model scenario projects less warming and a significant increase in precipitation (about 20%). The scenarios examined, which assume no major interventions to reduce continued growth of world greenhouse gases (GHG), indicate that temperatures in the U.S. will rise by about 3°-5°C (5°-9°F) on average in the next 100 years which is more than the projected global increase (NAST 2000). A warming of about 0.2°C (0.4°F) per decade is projected for the next two decades over a range of emission scenarios (IPCC 2007). This temperature increase will very likely be associated with more extreme precipitation and faster evaporation of water, leading to greater frequency of both very wet and very dry conditions. Climate warming has resulted in increased precipitation, river discharge, and glacial and sea-ice melting (Greene *et al.* 2008).

The past three decades have witnessed major changes in ocean circulation patterns in the Arctic, and these were accompanied by climate associated changes as well (Greene *et al.* 2008). Shifts in atmospheric conditions have altered Arctic Ocean circulation patterns and the export of freshwater to the North Atlantic (Greene *et al.* 2008, IPCC 2006). With respect specifically to the North Atlantic Oscillation (NAO), changes in salinity and temperature are thought to be the result of changes in the earth's atmosphere caused by anthropogenic forces (IPCC 2006). The

NAO impacts climate variability throughout the northern hemisphere (IPCC 2006). Data from the 1960s through the present show that the NAO index has increased from minimum values in the 1960s to strongly positive index values in the 1990s and somewhat declined since (IPCC 2006). This warming extends over 1000m (0.62 miles) deep and is deeper than anywhere in the world oceans and is particularly evident under the Gulf Stream/ North Atlantic Current system (IPCC 2006). On a global scale, large discharges of freshwater into the North Atlantic subarctic seas can lead to intense stratification of the upper water column and a disruption of North Atlantic Deepwater (NADW) formation (Greene *et al.* 2008, IPCC 2006). There is evidence that the NADW has already freshened significantly (IPCC 2006). This in turn can lead to a slowing down of the global ocean thermohaline (large-scale circulation in the ocean that transforms low-density upper ocean waters to higher density intermediate and deep waters and returns those waters back to the upper ocean), which can have climatic ramifications for the whole earth system (Greene *et al.* 2008).

While predictions are available regarding potential effects of climate change globally, it is more difficult to assess the potential effects of climate change over the next few decades on coastal and marine resources on smaller geographic scales, such as the Hudson River, especially as climate variability is a dominant factor in shaping coastal and marine systems. The effects of future change will vary greatly in diverse coastal regions for the U.S. Additional information on potential effects of climate change specific to the action area is discussed below. Warming is very likely to continue in the U.S. over the next 25 to 50 years regardless of reduction in GHGs, due to emissions that have already occurred (NAST 2000). It is very likely that the magnitude and frequency of ecosystem changes will continue to increase in the next 25 to 50 years, and it is possible that rate of change will accelerate. Climate change can cause or exacerbate direct stress on ecosystems through high temperatures, a reduction in water availability, and altered frequency of extreme events and severe storms. Water temperatures in streams and rivers are likely to increase as the climate warms and are very likely to have both direct and indirect effects on aquatic ecosystems. Changes in temperature will be most evident during low flow periods when they are of greatest concern (NAST 2000). In some marine and freshwater systems, shifts in geographic ranges and changes in algal, plankton, and fish abundance are associated with high confidence with rising water temperatures, as well as related changes in ice cover, salinity, oxygen levels and circulation (IPCC 2007).

A warmer and drier climate is expected to result in reductions in stream flows and increases in water temperatures. Expected consequences could be a decrease in the amount of dissolved oxygen in surface waters and an increase in the concentration of nutrients and toxic chemicals due to reduced flushing rate (Murdoch *et al.* 2000). Because many rivers are already under a great deal of stress due to excessive water withdrawal or land development, and this stress may be exacerbated by changes in climate, anticipating and planning adaptive strategies may be critical (Hulme 2005). A warmer-wetter climate could ameliorate poor water quality conditions in places where human-caused concentrations of nutrients and pollutants other than heat currently degrade water quality (Murdoch *et al.* 2000). Increases in water temperature and changes in seasonal patterns of runoff will very likely disturb fish habitat and affect recreational uses of lakes, streams, and wetlands. Surface water resources in the southeast are intensively managed with dams and channels and almost all are affected by human activities; in some systems water quality is either below recommended levels or nearly so. A global analysis of the potential effects of climate change on river basins indicates that due to changes in discharge and water stress, the area of large river basins in need of reactive or proactive management interventions in response to climate change will be much higher for basins impacted by dams than for basins with free-flowing rivers (Palmer *et al.* 2008). Human-induced disturbances also influence coastal and marine systems, often reducing the ability of the systems to adapt so that systems that might ordinarily be capable of responding to variability and change are less able to do so. Because stresses on water quality are associated with many activities, the impacts of the existing stresses are likely to be exacerbated by climate change. Within 50 years, river basins that are impacted by dams or by extensive development may experience greater changes in discharge and water stress than unimpacted, free-flowing rivers (Palmer *et al.* 2008).

While debated, researchers anticipate: 1) the frequency and intensity of droughts and floods will change across the nation; 2) a warming of about 0.2°C (0.4°F) per decade; and 3) a rise in sea level (NAST 2000). A warmer and drier climate will reduce stream flows and increase water temperature resulting in a decrease of DO and an increase in the concentration of nutrients and toxic chemicals due to reduced flushing. Sea level is expected to continue rising: during the 20th century global sea level has increased 15 to 20 cm (6-8 inches).

7.2 Species Specific Information on Climate Change

7.2.1 Shortnose sturgeon

Global climate change may affect shortnose sturgeon in the future. Rising sea level may result in the salt wedge moving upstream in affected rivers. Shortnose sturgeon spawning occurs in fresh water reaches of rivers because early life stages have little to no tolerance for salinity. Similarly, juvenile shortnose sturgeon have limited tolerance to salinity and remain in waters with little to no salinity. If the salt wedge moves further upstream, shortnose sturgeon spawning and rearing habitat could be restricted. In river systems with dams or natural falls that are impassable by sturgeon, the extent that spawning or rearing may be shifted upstream to compensate for the shift in the movement of the saltwedge would be limited. While there is an indication that an increase in sea level rise would result in a shift in the location of the salt wedge, for most spawning rivers there are no predictions on the timing or extent of any shifts that may occur; thus, it is not possible to predict any future loss in spawning or rearing habitat. However, in all river systems, spawning occurs miles upstream of the saltwedge. It is unlikely that shifts in the location of the saltwedge would eliminate freshwater spawning or rearing habitat. If habitat was severely restricted, productivity or survivability may decrease.

The increased rainfall predicted by some models in some areas may increase runoff and scour spawning areas and flooding events could cause temporary water quality issues. Rising temperatures predicted for all of the U.S. could exacerbate existing water quality problems with DO and temperature. While this occurs primarily in rivers in the southeast U.S. and the Chesapeake Bay, it may start to occur more commonly in the northern rivers. Shortnose sturgeon are tolerant to water temperatures up to approximately 28°C (82.4°F); these temperatures are experienced naturally in some areas of rivers during the summer months. If river temperatures rise and temperatures above 28°C are experienced in larger areas, sturgeon may be excluded from some habitats.

Increased droughts (and water withdrawal for human use) predicted by some models in some areas may cause loss of habitat including loss of access to spawning habitat. Drought conditions in the spring may also expose eggs and larvae in rearing habitats. If a river becomes too shallow or flows become intermittent, all shortnose sturgeon life stages, including adults, may become susceptible to strandings. Low flow and drought conditions are also expected to cause additional water quality issues. Any of the conditions associated with climate change are likely to disrupt river ecology causing shifts in community structure and the type and abundance of prey. Additionally, cues for spawning migration and spawning could occur earlier in the season causing a mismatch in prey that are currently available to developing shortnose sturgeon in rearing habitat; however, this would be mitigated if prey species also had a shift in distribution or if developing sturgeon were able to shift their diets to other species.

7.2.2 Atlantic sturgeon

Global climate change may affect all DPSs of Atlantic sturgeon in the future; however, effects of increased water temperature and decreased water availability are most likely to effect the South Atlantic and Carolina DPSs. Rising sea level may result in the salt wedge moving upstream in affected rivers. Atlantic sturgeon spawning occurs in fresh water reaches of rivers because early life stages have little to no tolerance for salinity. Similarly, juvenile Atlantic sturgeon have limited tolerance to salinity and remain in waters with little to no salinity. If the salt wedge moves further upstream, Atlantic sturgeon spawning and rearing habitat could be restricted. In river systems with dams or natural falls that are impassable by sturgeon, the extent that spawning or rearing may be shifted upstream to compensate for the shift in the movement of the saltwedge would be limited. While there is an indication that an increase in sea level rise would result in a shift in the location of the salt wedge, at this time there are no predictions on the timing or extent of any shifts that may occur; thus, it is not possible to predict any future loss in spawning or rearing habitat. However, in all river systems, spawning occurs miles upstream of the saltwedge. It is unlikely that shifts in the location of the saltwedge would eliminate freshwater spawning or rearing habitat. If habitat was severely restricted, productivity or survivability may decrease.

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Increased droughts (and water withdrawal for human use) predicted by some models in some areas may cause loss of habitat including loss of access to spawning habitat. Drought conditions in the spring may also expose eggs and larvae in rearing habitats. If a river becomes too shallow or flows become intermittent, all Atlantic sturgeon life stages, including adults, may become susceptible to strandings or habitat restriction. Low flow and drought conditions are also expected to cause additional water quality issues. Any of the conditions associated with climate change are likely to disrupt river ecology causing shifts in community structure and the type and abundance of prey. Additionally, cues for spawning migration and spawning could occur earlier in the season causing a mismatch in prey that are currently available to developing sturgeon in rearing habitat.

7.3 Effects of Climate Change in the Action Area

Information on how climate change will impact the action area is extremely limited. Available information on climate change related effects for the Hudson River largely focuses on effects that rising water levels may have on the human environment. The New York State Sea Level Rise Task Force (Spector in Bhutta 2010) predicts a state-wide sea level rise of 7-52 inches by the end of this century, with the conservative range being about 2 feet. This compares to an average sea level rise of about 1 foot in the Hudson Valley in the past 100 years. Sea level rise is expected to result in the northward movement of the salt wedge. The location of the salt wedge in the Hudson River is highly variable depending on season, river flow, and precipitation so it is unclear what effect this northward shift could have. Potential negative effects of a shift in the salt wedge include restricting the habitat available for early life stages and juvenile sturgeon which are intolerant to salinity and are present exclusively upstream of the salt wedge. While there is an indication that an increase in sea level rise would result in a shift in the location of the salt wedge, at this time there are no predictions on the timing or extent of any shift that may occur.

Air temperatures in the Hudson Valley have risen approximately 0.5°C (0.9°F) since 1970. In the 2000s, the mean Hudson river water temperature, as measured at the Poughkeepsie Water Treatment Facility, was approximately 2°C (3.6°F) higher than averages recorded in the 1960s (Pisces 2008). However, while it is possible to examine past water temperature data and observe a warming trend, there are not currently any predictions on potential future increases in water temperature in the action area specifically or the Hudson River generally. The Pisces report (2008) also states that temperatures within the Hudson River may be becoming more extreme. For example, in 2005, water temperature on certain dates was close to the maximum ever recorded and also on other dates reached the lowest temperatures recorded over a 53-year period. Other conditions that may be related to climate change that have been reported in the Hudson Valley are warmer winter temperatures, earlier melt-out and more severe flooding. An average increase in precipitation of about 5% is expected; however, information on the effects of an increase in precipitation on conditions in the action area is not available.

The Office of the New Jersey State Climatologist has summarized available information on a state-wide basis; this information is relevant to understanding potential effects of climate change at the HARS site and at the coastal transit routes. Although there is much variation from year to year, these data show a statistically significant rise in average statewide temperature (approximately 2 degrees Fahrenheit) over the last 113 years. It is predicted that in the Northeastern US, precipitation, particularly in the form of rainfall, and runoff are expected to increase in future years (NECIA 2007). NOAA tide gauge data reported by the State of New Jeresey indicates that the sea level at the New Jersey coast sites of Atlantic City, Cape May, and Sandy Hook has risen at a rate of approximately 4 mm/y since recording began in the early- to mid-1900s; anthropogenic contribution to the recent higher rate of rise is approximately 2 mm/y, approximately one-half of the total observed rate of rise, which is in line with recent estimates of the global rate.

Sea surface temperatures have fluctuated around a mean for much of the past century, as measured by continuous 100+ year records at Woods Hole (Mass.), and Boothbay Harbor (Maine) and shorter records from Boston Harbor and other bays. Periods of higher than average temperatures (in the 1950s) and cooler periods (1960s) have been associated with changes in the North Atlantic Oscillation (NAO), which affects current patterns. Over the past 30 years however, records indicate that ocean temperatures in the Northeast have been increasing; for example, Boothbay Harbor's temperature has increased by about 1°C since 1970. While we are not able to find predictive models for New York and New Jersey, given the geographic proximity of these waters to the Northeast, we assume that predictions would be similar. The model projections are for an increase of somewhere between 3-4°C by 2100 and a pH drop of 0.3-0.4 units by 2100 (Frumhoff *et al.* 2007). Assuming that these predictions also apply to the action area, one could anticipate similar conditions in the action area over that same time period.

7.3 Effects of Climate Change in the Action Area to Atlantic and shortnose sturgeon
As there is significant uncertainty in the rate and timing of change as well as the effect of any changes that may be experienced in the action area due to climate change, it is difficult to predict the impact of these changes on shortnose and Atlantic sturgeon. The new Tappan Zee Bridge is predicted to have a lifespan of 100 years before substantial structural replacements would be required; thus, we consider here, likely effects of climate change in the next 100 years.

Over time, the most likely effect to shortnose and Atlantic sturgeon would be if sea level rise was great enough to consistently shift the salt wedge far enough north which would restrict the range of juvenile sturgeon and may affect the development of these life stages. Upstream shifts in spawning or rearing habitat in the Hudson River are limited by the existence of the Troy Dam (RKM 250, RM 155), which is impassable by sturgeon. Currently, the saltwedge normally shifts seasonally from Yonkers to as far north as Poughkeepsie (RKM 120, RM 75). Given that sturgeon currently have over 75 miles of habitat upstream of the salt wedge before the Troy Dam, it is unlikely that the saltwedge would shift far enough upstream to result in a significant restriction of spawning or nursery habitat. The available habitat for juvenile sturgeon could decrease over time; however, even if the saltwedge shifted several miles upstream, it seems unlikely that the decrease in available habitat would have a significant effect on juvenile sturgeon because there would still be many miles of available low salinity habitat between the salt wedge and the Troy Dam.

In the action area, it is possible that changing seasonal temperature regimes could result in changes in the timing of seasonal migrations through the area as sturgeon move to spawning and overwintering grounds. There could be shifts in the timing of spawning; presumably, if water temperatures warm earlier in the spring, and water temperature is a primary spawning cue, spawning migrations and spawning events could occur earlier in the year. However, because spawning is not triggered solely by water temperature, but also by day length (which would not be affected by climate change) and river flow (which could be affected by climate change), it is not possible to predict how any change in water temperature or river flow alone will affect the seasonal movements of sturgeon through the action area.

Any forage species that are temperature dependent may also shift in distribution as water temperatures warm. However, because we do not know the adaptive capacity of these individuals or how much of a change in temperature would be necessary to cause a shift in distribution, it is not possible to predict how these changes may affect foraging sturgeon. If sturgeon distribution shifted along with prey distribution, it is likely that there would be minimal, if any, impact on the availability of food. Similarly, if sturgeon shifted to areas where different forage was available and sturgeon were able to obtain sufficient nutrition from that new source of forage, any effect would be minimal. The greatest potential for effect to forage resources would be if sturgeon shifted to an area or time where insufficient forage was available; however, the likelihood of this happening seems low because sturgeon feed on a wide variety of species and in a wide variety of habitats.

Limited information on the thermal tolerances of Atlantic and shortnose sturgeon is available. Atlantic sturgeon have been observed in water temperatures above 30°C in the south (see Damon-Randall *et al.* 2010); in the wild, shortnose sturgeon are typically found in waters less than 28°C. In the laboratory, juvenile Atlantic sturgeon showed negative behavioral and bioenergetics responses (related to food consumption and metabolism) after prolonged exposure to temperatures greater than 28°C (82.4°F) (Niklitschek 2001). Tolerance to temperatures is thought to increase with age and body size (Ziegweid *et al.* 2008 and Jenkins *et al.* 1993), however, no information on the lethal thermal maximum or stressful temperatures for subadult or adult Atlantic sturgeon is available. Shortnose sturgeon, have been documented in the lab to experience mortality at temperatures of 33.7°C (92.66°F) or greater and are thought to experience stress at temperatures above 28°C. For purposes of considering thermal tolerances, we consider Atlantic sturgeon to be a reasonable surrogate for shortnose sturgeon given similar geographic distribution and known biological similarities.

Normal surface water temperatures in the Hudson River can be as high as 24-27°C at some times and in some areas during the summer months; temperatures in deeper waters and near the bottom are cooler. A predicted increase in water temperature of 3-4°C within 100 years is expected to result in temperatures approaching the preferred temperature of shortnose and Atlantic sturgeon (28°C) on more days and/or in larger areas. This could result in shifts in the distribution of sturgeon out of certain areas during the warmer months. Information from southern river systems suggests that during peak summer heat, sturgeon are most likely to be found in deep water areas where temperatures are coolest. Thus, we could expect that over time, sturgeon would shift out of shallow habitats on the warmest days. This could result in reduced foraging opportunities if sturgeon were foraging in shallow waters.

As described above, over the long term, global climate change may affect shortnose and Atlantic sturgeon by affecting the location of the salt wedge, distribution of prey, water temperature and water quality. However, there is significant uncertainty, due to a lack of scientific data, on the degree to which these effects may be experienced and the degree to which shortnose or Atlantic sturgeon will be able to successfully adapt to any such changes. Any activities occurring within and outside the action area that contribute to global climate change are also expected to affect shortnose and Atlantic sturgeon in the action area. While we can make some predictions on the likely effects of climate change on these species, without modeling and additional scientific data these predictions remain speculative. Additionally, these predictions do not take into account the adaptive capacity of these species which may allow them to deal with change better than predicted.

8.0 EFFECTS OF THE ACTION

This section of an Opinion assesses the direct and indirect effects of the proposed action on threatened and endangered species or critical habitat, together with the effects of other activities that are interrelated or interdependent. Indirect effects are those that are caused later in time, but are still reasonably certain to occur. Interrelated actions are those that are part of a larger action and depend upon the larger action for their justification. Interdependent actions are those that have no independent utility apart from the action under consideration (50 CFR 402.02; see also 1998 FWS-NMFS Joint Consultation Handbook, pp. 4-26 to 4-28). We have not identified any interrelated or interdependent actions. This Opinion examines the likely effects of the proposed action on shortnose sturgeon and three DPSs of Atlantic sturgeon and their habitat in the action area within the context of the species current status, the environmental baseline and cumulative effects. Because there is no critical habitat in the action area, none will be affected.

The proposed action has the potential to affect shortnose and Atlantic sturgeon in several ways: dredging; changes to habitat from armoring the river bottom; exposure to increased underwater noise resulting from pile installation; vessel interactions; changes in water quality, including TSS; and, altering the abundance or availability of potential prey items. The effects analysis below is organized around these topics.

8.1 Dredging the Access Channel

8.1.1 Overview of Dredging Activity

As described in Section 3.4.2, dredging will occur in three years, between August 1 and November 1. A total of 1.68 - 1.74 million cubic yards (MCY) would be removed from a channel with a width of 145 to 161 m extending approximately 2,133 m (7,000 feet) from the Rockland County side into deeper waters and 610 m (2,000) feet from the Tarrytown access trestle into deeper waters. Approximately 64% of the material (1.08-1.12 MCY) will be removed in Stage 1, 25% (0.42-0.43 MCY) in Stage 2 and 11% (0.18-0.19 MCY) in Stage 3. All dredging will be completed with a closed environmental bucket.

Bucket dredges are relatively stationary. While operating, the dredge swings slowly in an arc across the channel cut as material is excavated. This is accomplished by pivoting the dredge on vertical pilings called spuds that are alternately raised and lowered from the stern corners of the dredge. Cables to anchors set roughly perpendicular to the forward section of the dredge are used to shift the lateral position of the digging area. Periodically, as the cut advances, the anchors are reset. Bucket dredging entails lowering the open bucket through the water column, closing the bucket after impact on the bottom, lifting the bucket up through the water column, and emptying the bucket into a barge. An environmental clamshell dredge differs from traditional dredging buckets by having an outer covering that seals when the bucket is closed. Water passes through its top moveable vents as it submerges, thereby reducing turbidity. Once it lifts off the bottom and closes, the covering seals over the bucket and minimizes overspill as the dredge bucket moves back up through the water column.

8.1.2 Capture of sturgeon in the dredge bucket

Aquatic species can be captured in dredge buckets and may be injured or killed from entrapment in the bucket or burial in sediment during dredging and/or when sediment is deposited into the dredge scow. Fish captured and emptied out of the bucket could suffer stress or injury, which could also lead to mortality.

In rare occurrences sturgeon have been captured in dredge buckets and placed in the scow. Very few mechanical dredge operations have employed observers to document interactions between sturgeon and the dredge; because of that we do not know if the lack of observations is a result of fish not being captured at other projects or that captures occur but are not observed. Captures of two shortnose and one Atlantic sturgeon have been documented at the Bath Iron Works (BIW) facility in the Kennebec River, Maine. It is unknown if these observations are the result of a unique situation in this river or whether interactions have occurred elsewhere but have just been undocumented. Observer coverage at dredging operations at BIW has been 100% for approximately 15 years and three observations of captured sturgeon have been documented. Dredging occurs every one to two years at this location. An Atlantic sturgeon was killed in the Cape Fear River in a bucket and barge operation (NMFS 1998).

Due to the nature of interactions between listed species and dredge operations, it is difficult to predict the number of interactions that are likely to occur from a particular dredging operation. Projects that occur in an identical location with the same equipment year after year may result in interactions in some years and none in other years. For example, dredging in the BIW sinking basin prior to 2003 resulted in no interactions with shortnose sturgeon but one shortnose sturgeon was killed by the clamshell dredge in the last hour of the last day of dredging of a dredge event running from April 7 to April 30, 2003. An additional shortnose sturgeon was captured in this area in 2009, but none were captured between 2003 and 2009 or 2009-2011. Regardless, based on all available evidence, the risk of capture in a mechanical dredge is low due to the slow speed at which the bucket moves and the relatively small area of the bottom it interacts with at any one time.

Based on the occurrence of shortnose and Atlantic sturgeon in the area where mechanical dredging will take place and the documented vulnerability of this species to capture with mechanical dredges, it is likely that a small number of sturgeon will be captured by the mechanical dredge working to dredge the access channel. Due to the relatively low level of risk that an individual shortnose sturgeon would be captured in the slow moving dredge bucket, no more than one shortnose sturgeon and no more than one Atlantic sturgeon is likely to be captured during each year that dredging occurs. As dredging will occur in three years, we expect a total of three or fewer shortnose sturgeon and three or fewer Atlantic sturgeon to be captured during dredging.

Sturgeon captured in the dredge bucket could be injured or killed. Sources of mortality include injuries suffered during contact with the dredge bucket or burial in the dredge scow. Of the three captures of sturgeon with mechanical dredges in the Kennebec River (two shortnose (in 2003 and 2009), one Atlantic (in 2001)), one of the shortnose sturgeon was killed. This fish was killed during the last hour of a 24-hour a day dredging operation that had been ongoing for approximately four weeks. This fish suffered from a large laceration, likely experienced due to contact with the dredge bucket. Of the other two fish, both were observed alive in the dredge scow and were released, with no visible external injuries. Assuming that the risk of mortality once captured is similar across dredging projects, we expect a similar mortality rate at the

Tappan Zee project as has been observed at BIW. Therefore, we expect no more than one of the three captured shortnose sturgeon and no more than one of the three captured Atlantic sturgeon to be injured or killed during dredging operations. Injury or mortality could result from contact with the dredge bucket or through suffocation due to burial in the scow. Because FHWA will require an observer be present to watch for captured fish as sediment is deposited in the scow and to monitor the scow for fish, we expect that any captured sturgeon will be documented. Shortnose sturgeon captured or killed could be juveniles or adults.

During the time of year that dredging will occur (August 1 – November 1), only juvenile and subadult Atlantic sturgeon are likely to be present in the area to be dredged. Therefore, the affected Atlantic sturgeon will be juveniles or subadults. Based on the mixed-stock analysis, it is most likely that all three captured Atlantic sturgeon, including the one that could be killed, would originate from the New York Bight DPS. However, because Atlantic sturgeon from the Chesapeake Bay and Gulf of Maine DPSs are also present in the area where dredging will occur, it is possible that one of the captured or killed fish could originate from either the Chesapeake Bay or Gulf of Maine DPS; these fish would be subadults because juveniles remain in their natal rivers and therefore, juveniles from these DPSs do not occur in the action area.

8.2 Disposal of Dredged Material at HARS

As discussed in Section 4.3 above, dredged material will be transferred to large ocean going scows and towed by tugboat to the HARS disposal area. Shortnose and Atlantic sturgeon are present throughout the Hudson River and could both be present along the transit route as far south as New York Harbor. From New York Harbor to the HARS, only Atlantic sturgeon are expected to be present. During the August 1 – November 1 time period, Atlantic sturgeon in this area are likely to be foraging or migrating between foraging areas. As water temperatures begin to cool in October, Atlantic sturgeon are likely to be moving through the action area to overwintering areas. The HARS is not known to be used for overwintering.

Dredging, and subsequently disposal, would be conducted in three stages, each stage conducted during a separate dredging season occurring within a three-month period from August 1 to November 1. For the Long Span Option, the option with the higher dredging quantities, approximately 1.12 MCY would be disposed of during Stage 1, 0.43 MCY during Stage 2, and 0.19 MCY during Stage 3, for a total of 1.74 MCY. Effects to Atlantic sturgeon from HARS disposal include: turbidity; exposure to contaminants; reduction in available prey; and vessel strikes. The effects of vessel traffic are discussed in Section 7.8 below.

As discussed in Section 4.2, material to be disposed at HARS will be thoroughly screened and tested for its potential to cause toxicity to marine organisms, including species that could serve as forage for Atlantic sturgeon. A summary of sediment sampling programs for contaminants is presented in Section 4.2. In order for the dredged material to be disposed of at the HARS, it must be tested in accordance with the ACOE and EPA procedures for suitability. Material that can be disposed of at the HARS is specifically selected for its low potential to introduce toxins into the marine environment and for purposes of capping contaminated sediments. Material will not be allowed to be disposed of at HARS that would be acutely or chronically toxic to any aquatic species. Further, the material must not present a risk of bioaccumulation; that is, even if it is not acutely or chronically toxic, it must not increase the potential for bioaccumulation of toxins in higher trophic level species (such as Atlantic sturgeon) that may prey upon benthic organisms present at the HARS. Because any material that is disposed of at HARS will not be acutely or chronically toxic to aquatic life and will not increase the risk of bioaccumulation, effects to Atlantic sturgeon of dredged material from the bridge site at HARS will be insignificant and discountable.

For purposes of this consultation, we consider that sediment that is suitable for ocean disposal would not be toxic to marine life and would not be likely to cause adverse effects to Atlantic sturgeon or their prey. Material that can be disposed of at the HARS is specifically selected for its low potential to introduce toxins into the marine environment and for purposes of capping contaminated sediments. Because the material to be disposed will be tested to ensure it is not acutely toxic and will not increase the risk of bioaccumulation of toxins or contaminants in any marine species, effects to Atlantic sturgeon will be insignificant and discountable.

Disposal operations can also affect foraging animals by burying benthic prey. Direct impacts to fish or other mobile species during placement of the dredged material at the HARS would be expected to be minimal due to the small contact footprint of the fluidized sediments as they leave the barge (typically 50 foot by 100 foot). Given the small area impacted by each disposal event, mobile species are expected to be able to avoid the falling sediment and would not be subject to burial. The only species that are likely to be buried are immobile benthic organisms. Some species of benthic invertebrates that Atlantic sturgeon feed on have limited mobility and could be buried during disposal operations; other prey species, such as sand lance, are mobile and would be able to avoid burial.

The loss of potential benthic prey species would be minimized spatially and temporally through use of a grid system for the placement of dredged material. Some buried animals will be able to unbury themselves. Areas where dredged material will be placed are expected to be recolonized by individuals from nearby similar habitats. Because the characteristics of the sediment from the project would be similar to those in and around the HARS, benthic invertebrates would be expected to quickly recolonize the cells used for the placement of this material. Thus, any reduction in benthic prey at the HARS site will be temporary and limited to the small area where dredged material will be placed. The potential loss of prey for Atlantic sturgeon will be extremely small, as only a fraction of the benthic species that Atlantic sturgeon prey on will be affected, and those losses will occur in a very small area. Effects to foraging Atlantic sturgeon will be insignificant.

8.3 Pile Installation

In this section we present: background information on acoustics; a summary of available information on sturgeon hearing; a summary of available information on the physiological and behavioral effects of exposure to underwater noise; and, established thresholds and criteria to consider when assessing impacts of underwater noise. We then present modeling provided by FHWA to establish the noise associated with pile installation and consider the effects of exposure of individual sturgeon to these noise sources.

8.3.1 Information Used to Conduct the Effects Analysis

8.3.1.1 Basic Background on Acoustics and Fish Bioacoustics

Sound in water follows the same physical principles as sound in air. The major difference is that due to the density of water, sound in water travels about 4.5 times faster than in air (approx. 4900 ft./s vs. 1100 ft./s), and attenuates much less rapidly than in air. As a result of the greater speed, the wavelength of a particular sound frequency is about 4.5 times longer in water than in air (Rogers and Cox 1988; Bass and Clarke 2003).

Frequency (i.e., number of cycles per unit of time, with hertz (Hz) as the unit of measurement) and amplitude (loudness, measured in decibels, or dB) are the measures typically used to describe sound. The hearing range for most fish ranges from a low of 20 Hz to 800 to 1,000 Hz. Most fish in the Hudson River fit into this hearing range, although catfish may hear to about 3,000 or 4,000 Hz and some of the herring-like fishes can hear sounds to about 4,000 Hz, while a few, and specifically the American shad, can hear to over 100,000 Hz (Popper *et al.* 2003; Bass and Ladich 2008; Popper and Schilt 2008).

An acoustic field from any source consists of a propagating pressure wave, generated from particle motions in the medium that causes compression and rarefaction. This sound wave consists of both pressure and particle motion components that propagate from the source. All fishes have sensory systems to detect the particle motion component of a sound field, while fishes with a swim bladder (a chamber of air in the abdominal cavity) may also be able to detect the pressure component. Pressure detection is primarily found in fishes where the swim bladder (or other air chamber) lies very close to the ear, whereas fishes in which there is no air chamber near the ear primarily detect particle motion (Popper *et al.* 2003; Popper and Schilt 2009; Popper and Fay 2010). Sturgeon have swim bladders, but they are not located very close to the ear; thus, they are assumed to detect primarily particle motion rather than pressure.

The level of a sound in water can be expressed in several different ways, but always in terms of dB relative to 1 micro-Pascal (μPa). Decibels are a log scale; each 10 dB increase is a ten-fold increase in sound pressure. Accordingly, a 10 dB increase is a 10x increase in sound pressure, and a 20 dB increase is a 100x increase in sound pressure.

The following are commonly used measures of sound:

- Peak sound pressure level (SPL): the maximum sound pressure level (highest level of sound) in a signal measured in dB re 1 μPa.
- Sound exposure level (SEL): the integral of the squared sound pressure over the duration of the pulse (e.g., a full pile driving strike.) SEL is the integration over time of the square of the acoustic pressure in the signal and is thus an indication of the total acoustic energy received by an organism from a particular source (such as pile strikes). Measured in dB re $1\mu Pa^2$-s.
- Single Strike SEL: the amount of energy in one strike of a pile.

- Cumulative SEL (cSEL or SEL_{cum}): the energy accumulated over multiple strikes. cSEL indicates the full energy to which an animal is exposed during any kind of signal. The rapidity with which the cSEL accumulates depends on the level of the single strike SEL. The actual level of accumulated energy (cSEL) is the logarithmic sum of the total number of single strike SELs. Thus, cSEL (dB) = Single-strike SEL + $10\log_{10}(N)$; where N is the number of strikes.

- Root Mean Square (RMS): the average level of a sound signal over a specific period of time.

8.3.1.2 Summary of Available Information on Underwater Noise and Sturgeon

Sturgeon rely primarily on particle motion to detect sounds (Lovell *et al.* 2005). While there are no data both in terms of hearing sensitivity and structure of the auditory system for shortnose or Atlantic sturgeon, there are data for the closely related lake sturgeon (Lovell *et al.* 2005; Meyer *et al.* 2010), which for the purpose of considering acoustic impacts can be considered as a surrogate for shortnose and Atlantic sturgeon.

The available data suggest that lake sturgeon can hear sounds from below 100 Hz to 800 Hz (Lovell *et al.* 2005; Meyer *et al.* 2010). As noted by FHWA, since these two studies examined responses of the ear and did not examine whether fish would behaviorally respond to sounds detected by the ear, it is hard to determine thresholds for hearing (that is, the lowest sound levels that an animal can hear at a particular frequency) using information from these studies.

The swim bladder of sturgeon is relatively small compared to other species (Beregi *et al.* 2001). While there are no data that correlate effects of noise on fishes and swim bladder size, the potential for damage to body tissues from rapid expansion of the swim bladder likely is reduced in a fish where the structure occupies less of the body cavity, and, thus, is in contact with less body tissue. Although there are no experimental data that enable one to predict the potential effects of sound on sturgeon, the physiological effects of pile driving on sturgeon may actually be less than on other species due to the small size of their swim bladder.

Sound is an important source of environmental information for most vertebrates (e.g., Fay and Popper, 2000). Fish are thought to use sound to learn about their general environment, the presence of predators and prey, and, for some species, for acoustic communication. As a consequence, sound is important for fish survival, and anything that impedes the ability of fish to detect a biologically relevant sound could affect individual fish.

Richardson *et al.* (1995) defined different zones around a sound source that could result in different types of effects on fish. There are a variety of different potential effects from any sound, with a decreasing range of effects at greater distances from the source. Thus, very close to the source, effects may range from mortality to behavioral changes. Somewhat further from the source mortality is no longer an issue, and effects range from physiological to behavioral. As one gets even further, the potential for effects declines. The actual nature of effects, and the distance from the source at which they could be experienced will vary and depend on a large number of factors, such as fish hearing sensitivity, source level, how the sounds propagate away from the source and the resultant sound level at the fish, whether the fish stays in the vicinity of the source, the motivation level of the fish, etc.

Underwater sound pressure waves can injure or kill fish (Reyff 2003, Abbott and Bing-Sawyer 2002, Caltrans 2001, Longmuir and Lively 2001, Stotz and Colby 2001). Fish with swim bladders, including shortnose and Atlantic sturgeon are particularly sensitive to underwater impulsive sounds with a sharp sound pressure peak occurring in a short interval of time (Caltrans 2001). As the pressure wave passes through a fish, the swim bladder is rapidly squeezed due to the high pressure, and then rapidly expanded as the under pressure component of the wave passes through the fish. The pneumatic pounding on tissues contacting the swim bladder may rupture capillaries in the internal organs as indicated by observed blood in the abdominal cavity, and maceration of the kidney tissues (Caltrans 2001).

There are limited data from other projects to demonstrate the circumstances under which immediate mortality occurs: mortality appears to occur when fish are close (within a few feet to 30 feet) to driving of relatively large diameter piles. Studies conducted by California Department of Transportation (Caltrans, 2001) showed some mortality for several different species of wild fish exposed to driving of steel pipe piles 8 feet in diameter, whereas Ruggerone *et al.* (2008) found no mortality to caged yearling coho salmon (*Oncorhynchus kisutch*) placed as close as 2 feet from a 1.5 foot diameter pile and exposed to over 1,600 strikes. As noted above, species are thought to have different tolerances to noise and may exhibit different responses to the same noise source.

Physiological effects that could potentially result in mortality may also occur upon sound exposure as could minor physiological effects that would have no effect on fish survival. Potential physiological effects are highly diverse, and range from very small ruptures of capillaries in fins (which are not likely to have any effect on survival) to severe hemorrhaging of major organ systems such as the liver, kidney, or brain (Stephenson *et al.*, 2010). Other potential effects include rupture of the swim bladder (the bubble of air in the abdominal cavity of most fish species that is involved in maintenance of buoyancy). See Halvorsen *et al.* 2011 for a review of potential injuries from pile driving.

Effects on body tissues may result from barotrauma or result from rapid oscillations of air bubbles. Barotrauma occurs when there is a rapid change in pressure that directly affects the body gasses. Gas in the swim bladder, blood, and tissue of fish can experience a change in state, expand and contract during rapid pressure changes, which can lead to tissue damage and organ failure (Stephenson *et al.* 2010).

Related to this are changes that result from very rapid and substantial excursions (oscillations) of the walls of air-filled chambers, such as the swim bladder, striking near-by structures. Under normal circumstances the walls of the swim bladder do not move very far during changes in depth or when impinged upon by normal sounds. However, very intense sounds, and particularly those with very sharp onsets (also called "rise time") will cause the swim bladder walls to move much greater distances and thereby strike near-by tissues such as the kidney or liver. Rapid and frequent striking (as during one or more sound exposures) can result in bruising, and ultimately in damage, to the nearby tissues.

There is some evidence to suggest that very intense signals may not necessarily have substantial physiological effects and that the extent of effect will vary depending on a number of factors including sound level, rise time of the signal, duration of the signal, signal intensity, etc. For example, investigations on the effects of very high intensity sonar showed no damage to ears and other tissues of several different fish species (Kane *et al.* 2010). Some studies involving exposure of fish to sounds from seismic air guns, signal sources that have very sharp onset times, as found in pile driving, also did not result in any tissue damage (Popper *et al.* 2007; Song *et al.* 2008). However, the extent that results from one study are comparable to another is difficult to determine due to difference in species, individuals, and experimental design. Recent studies of the effects of pile driving sounds on fish showed that there is a clear relationship between onset of physiological effects and single strike and cumulative sound exposure level, and that the initial effects are very small and would not harm an animal (and from which there is rapid and complete recovery), whereas the most intense signals (e.g., >210 dB cumulative SEL) may result in tissue damage that could have long-term mortal effects (Halvorsen *et al.* 2011; Casper *et al.* 2011, in prep.)

8.3.1.3 Criteria for Assessing the Potential for Physiological Effects

The Fisheries Hydroacoustic Working Group (FHWG) was formed in 2004 and consists of biologists from NMFS, USFWS, FHWA, and the California, Washington and Oregon DOTs, supported by national experts on sound propagation activities that affect fish and wildlife species of concern. In June 2008, the agencies signed an MOA documenting criteria for assessing physiological effects of pile driving on fish. The criteria were developed for the acoustic levels at which physiological effects to fish could be expected. It should be noted, that these are onset of physiological effects (Stadler and Woodbury, 2009), and not levels at which fish are necessarily mortally damaged. These criteria were developed to apply to all species, including listed green sturgeon, which are biologically similar to shortnose and Atlantic sturgeon and for these purposes can be considered a surrogate. The interim criteria are:

- Peak SPL: 206 decibels relative to 1 micro-Pascal (dB re 1 μPa).
- cSEL: 187 decibels relative to 1 micro-Pascal-squared second (dB re 1μPa^2-s) for fishes above 2 grams (0.07 ounces).
- cSEL: 183 dB re 1μPa^2-s for fishes below 2 grams (0.07 ounces).

NMFS has relied on these criteria in determining the potential for physiological effects in ESA Section 7 consultations conducted on the US West Coast. At this time, they represent the best available information on the thresholds at which physiological effects to sturgeon are likely to occur. It is important to note that physiological effects may range from minor injuries from which individuals are anticipated to completely recover with no impact to fitness to significant injuries that will lead to death. The severity of injury is related to the distance from the pile being installed and the duration of exposure. The closer to the source and the greater the duration of the exposure, the higher likelihood of significant injury.

In the BA, FHWA presents information on several studies related to assessing physiological effects that have been conducted on a variety of species. We have considered the information presented in the BA and do not find that any of it presents a more comprehensive assessment or set of criteria than the FHWG criteria. FHWA has not proposed using a different set of criteria for assessing the potential for physiological effects and presents their effects analysis in terms of the FHWG criteria.

The studies presented in the BA do demonstrate that different species demonstrate different "tolerances" to different noise sources and that for some species and in some situations, fish can be exposed to noise at levels greater than the FHWG criteria and demonstrate little or no negative effects. As described in the BA, a recent peer-reviewed study from the Transportation Research Board (TRB) of the National Research Council of the National Academies of Science describes a carefully controlled experimental study of the effects of pile driving sounds on fish (Halvorsen *et al.* 2011). This investigation documented effects of pile driving sounds (recorded by actual pile driving operations) under simulated free-field acoustic conditions where fish could be exposed to signals that were precisely controlled in terms of number of strikes, strike intensity, and other parameters. The study used Chinook salmon and determined that onset of physiological effects that have the potential of reduced fitness, and thus a potential effect on survival, started at above 210 dB re 1 $\mu Pa^2 \cdot s$ cSEL. Smaller injuries, such as ruptured capillaries near the fins, which the authors noted were not expected to impact fitness, occurred at lower noise levels. The peak noise level that resulted in physiological effects was about the same as the FHWG criteria.

Based on the available information, for the purposes of this Opinion, we consider the potential for physiological effects upon exposure to 206dB re 1 μPa peak and 187 dB re 1 μPa^2-s cSEL. Use of the 183 dB re 1 μPa^2-s cSEL threshold, is not appropriate for this consultation because all shortnose and Atlantic sturgeon in the action area will be larger than 2 grams. As explained here, physiological effects could range from minor injuries that a fish is expected to completely recover from with no impairment to survival to major injuries that increase the potential for mortality, or result in death.

8.3.1.4 Available Information for Assessing Behavioral Effects

Results of empirical studies of hearing of fishes, amphibians, birds, and mammals (including humans), in general, show that behavioral responses vary substantially, even within a single species, depending on a wide range of factors, such as the motivation of an animal at a particular time, the nature of other activities that the animal is engaged in when it detects a new stimulus, the hearing capabilities of an animal or species, and numerous other factors (Brumm and Slabbekoorn 2005). Thus, it may be difficult to assign a single criterion above which behavioral responses to noise would occur.

In order to be detected, a sound must be above the "background" level. Additionally, results from some studies suggest that sound may need to be biologically relevant to an individual to elicit a behavioral response. For example, in an experiment on responses of American shad to sounds produced by their predators (dolphins), it was found that if the predator sound is detectable, but not very loud, the shad will not respond (Plachta and Popper 2003). But, if the sound level is raised an additional 8 or 10 dB, the fish will turn and move away from the sound source. Finally, if the sound is made even louder, as if a predator were nearby, the American shad go into a frenzied series of motions that probably helps them avoid being caught. It was speculated by the researchers that the lowest sound levels were those recognized by the American shad as being from very distant predators, and thus, not worth a response. At somewhat higher levels, the shad recognized that the predator was closer and then started to swim away. Finally, the loudest sound was thought to indicate a very near-by predator, eliciting maximum response to avoid predation. Similarly, results from Doksaeter *et al.* (2009) suggest that fish will only respond to sounds that are of biological relevance to them. This study showed no responses by free-swimming herring (*Clupea* spp.) when exposed to sonars produced by naval vessels; but, sounds at the same received level produced by major predators of the herring (killer whales) elicited strong flight responses. Sound levels at the fishes from the sonar in this experiment were from 197 dB to 209 dB (rms) re 1 μPa at 1,000 to 2,000Hz.

For purposes of assessing behavioral effects of pile driving at several West Coast projects, NMFS has employed a 150dB re 1 μPa RMS SPL criterion at several sites including the San Francisco-Oakland Bay Bridge and the Columbia River Crossings. For the purposes of this consultation we will use 150 dB re 1 μPa RMS as a conservative indicator of the noise level at which there is the potential for behavioral effects. That is not to say that exposure to noise levels of 150 dB re 1 μPa RMS will always result in behavioral modifications or that any behavioral modifications will rise to the level of "take" (i.e., harm or harassment) but that there is the potential, upon exposure to noise at this level, to experience some behavioral response. Behavioral responses could range from a temporary startle to avoidance of an ensonified area.

As hearing generalists, sturgeon rely primarily on particle motion to detect sounds (Lovell *et al.* 2005), which does not propagate as far from the sound source as does pressure. However, a clear threshold for particle motion was not provided in the Lovell study. In addition, flanking of the sounds through the substrate may result in higher levels of particle motion at greater distances than would be expected from the non-flanking sounds. Unfortunately, data on particle motion from pile driving is not available at this time, and we are forced to rely on sound pressure level criteria. Although we agree that more research is needed, the studies noted above support the 150 dB re 1 μPa RMS criterion as an indication for when behavioral effects could be expected. We are not aware of any studies that have considered the behavior of shortnose or Atlantic sturgeon in response to pile driving noise. However, given the available information from studies on other fish species, we consider 150 dB re 1 μPa RMS to be a reasonable estimate of the noise level at which exposure may result in behavioral modifications.

As noted by FHWA in the BA, there is not an extensive body of literature on effects of anthropogenic sounds on fish behavior, and even fewer studies on effects of pile driving, and many of these were conducted under conditions that make the interpretation of the results uncertain. FHWA suggests that of the studies available, the most useful in assessing the potential effects on behavior of pile driving on fish are those that use seismic airguns, since the air gun sound spectrum is reasonably similar to that of pile driving. The results of the studies, summarized below, suggest that there is a potential for underwater sound of certain levels and frequencies to affect behavior of fish, but that it varies with fish species and the existing hydroacoustic environment. In addition, behavioral response may change over time as fish individuals habituate to the presence of the sound. Behavioral responses to other noise sources, such as noise associated with vessel traffic, and the results of noise deterrent studies, are also summarized below.

Mueller-Blenke *et al.* (2010), attempted to evaluate response of Atlantic cod (*Gadus morhua*) and Dover sole (*Solea solea*) held in large pens to playbacks of pile driving sounds recorded during construction of Danish wind farms. The investigators reported that a few representatives of both species exhibited some movement response, reported as increased swimming speed or freezing to the pile-driving stimulus at peak sound pressure levels ranging from 144 to 156 dB re 1 μPa for sole and 140 to 161 dB re 1 μPa for cod. In the BA, FHWA notes that these results must be interpreted cautiously as fish position was not able to be determined more frequently than once every 80 seconds.

Feist (1991) examined the responses of juvenile pink (*Oncorhyncus gorbuscha*) and chum (*O. keta*) salmon behavior during pile driving operations. Feist had observers watching fish schools in less than 1.5 m water depth and within 2 m of the shore over the course of a pile driving operation. The report gave limited information on the types of piles being installed and did not give pile size. Feist did report that there were changes in distribution of schools at up to 300 m from the pile driving operation, but that of the 973 schools observed, only one showed any overt startle or escape reaction to the onset of a pile strike. There was no statistical difference in the number of schools in the area on days with and without pile driving, although other behaviors changed somewhat.

Any analysis of the Feist data is complicated by a lack of data on pile type, size and source sound level. Without this data, it is very difficult to use the Feist data to help understand how fish would respond to pile driving and whether such sounds could result in avoidance or other behaviors. It is interesting to note that the size of the stocks of salmon never changed, but appeared to be transient, suggesting that normal fish behavior of moving through the study area was taking place no differently during pile driving operations than in quiet periods. This may suggest that the fish observed during the study were not avoiding pile driving operations.

Andersson *et al.* (2007) presents information on the response of sticklebacks (*Gasterosteus aculeatus*), a hearing generalist, to pure tones and broadband sounds from wind farm operations. Sticklebacks responded by freezing in place and exhibiting startle responses at SPLs of 120 dB (re: 1 μPa) and less. Purser and Radford (2011) examined the response of three-spined sticklebacks to short and long duration white noise. This exposure resulted in increased startle responses and reduced foraging efficiency, although they did not reduce the total number of prey ingested. Foraging was less efficient due to attacks on non-food items and missed attacks on food items. The SPL of the white noise was reported to be similar (at frequencies between 100 and 1000 Hz) to the noise environment in a shoreline area with recreational speedboat activity. While this does not allow a comparison to the 150 dB re 1 μPa RMS guideline, it does demonstrate that significant noise-induced effects on behavior are possible, and that behaviors other than avoidance can occur.

In the BA, FHWA presents information on studies examining the effects of other anthropogenic sounds on fish including seismic airguns, vessel movements and acoustic deterrent devices. Results from these studies are difficult to compare as they consider different species in different, sometimes artificial, environments. FHWA points out flaws with nearly all of the presented studies making interpretation and applicability of these studies more difficult; however, FHWA does not suggest any alternative criteria for assessing the potential for behavioral responses. Several of the studies (Andersson *et al.* 2007, Purser and Radford 2011, Wysocki *et al.* 2007) support our use of the 150 dB re 1 μPa RMS as a threshold for examining the potential for behavioral responses. We will use 150 dB re 1 μPa RMS as a guideline for assessing when behavioral responses to pile driving noise may be expected. The effect of any anticipated response on individuals will be considered in the effects analysis below.

8.3.2 Effects of Pile Installation on Sturgeon

The effects analysis below relies on the information presented above and considers effects of the three types of pile installation: vibratory, drilling, and impact hammer.

8.3.2.1 Noise Associated with Installation of Piles with a Vibratory Hammer

Most, if not all, piles are expected to be at least partially installed with a vibratory hammer. For those piles that can be partially installed by vibratory hammer, FHWA predicts that, depending on the substrate type and location in the river, the first 150 to 300 feet of the pile will be installed with a vibratory hammer. FHWA indicates that installation of the piles with a vibratory hammer is expected to produce acoustic footprints similar to driving sheet piles (163 dB re 1 μPa^2-s SEL_{cum} at a distance of 16-ft or the driving of wood piles with an acoustic footprint of 150 dB re 1 μPa^2-s SEL_{cum} within 10 meters of the pile being driven (Jones and Stokes, 2009)). Installation of piles with a vibratory hammer will not result in peak noise levels greater than 206 dB re 1 μPa or cSEL greater than 187 dB re 1 μPa^2-s. Thus, there is no potential for physiological effects due to exposure to this noise. Given the extremely small footprint of the area where noise greater than 150 dB re 1 μPa RMS will be experienced (i.e., within 10 meters of the pile being installed), it is extremely unlikely that the behavior of any individual sturgeon would be affected by noise associated with the installation of piles with a vibratory hammer. Even if a sturgeon was within 10 meters of the pile being installed, we expect that the behavioral response would, at most, be limited to movement outside the area where noise greater than 150 dB re 1 μPa RMS would be experienced (i.e., moving to an area at least 10 meters from the pile). Because this area is very small and it would take very little energy to make these movements, the effect to any individual sturgeon would be insignificant. Based on this analysis, all effects to shortnose and Atlantic sturgeon exposed to noise associated with the installation of piles with a vibratory hammer will be insignificant and discountable.

8.3.2.2 Noise Associated with the Drilling and Pinning of Piles

In some areas, pile installation may involve drilling a socket into rock. This will result in an increase in underwater noise for up to 1.85 hours. FHWA indicates in the BA that noise generated during drilling will be well below the noise levels likely to result in physiological or behavioral effects (i.e., 206 dB re 1 μPa peak and 187 dB re 1 μPa^2-s cSEL for physiological effects and 150 dB re 1 μPa RMS for behavioral effects). This conclusion is supported by analysis completed by NMFS Northwest Region on bridge projects carried out in Washington State where NMFS concluded that oscillating and rotating steel casements for drilled shafts are not likely to elevate underwater sound to a level that is likely to cause injury or noise that would cause adverse changes to fish behavior. Based on this analysis, all effects to shortnose and Atlantic sturgeon exposed to noise associated with drilling into rock to facilitate the installation of piles will be insignificant and discountable.

8.3.2.3 Noise Associated with Installation of Piles by Impact Hammer

All piles will be at least partially installed with impact hammers. These piles will be installed in two sections. The "bottom" section, which is installed first, is likely to be vibrated in (see 7.6.2 above). The "top" section will then be installed with an impact hammer. Noise attenuation systems, which are expected to reduce underwater noise by at least 10 dB (based on PIDP results), will be in place for all piles installed with impact hammers. The driving of individual piles will take 0.33-1.55 hours, assuming that the entire pile is installed with an impact hammer. Because piles are expected to be partially installed with vibratory hammers, this is expected to be an overestimate of the duration of impact hammering. Between April and August, pile driving of the 8 and 10 foot piles with an impact hammer in Zone C (water depths of 18 to 45 feet) will occur for no more than five hours per day. Outside of this time of year, pile driving will occur for up to twelve hours a day. No night-time pile driving will occur.

In order to assess the potential effects of pile installation on shortnose and Atlantic sturgeon, the spatial extent of the hydroacoustic pattern generated by pile driving operations was evaluated by using computer analyses. This information was presented by FHWA in the BA and the conservatism of the findings was confirmed by the PIDP results.

In-river acoustic footprints for pile diving were obtained by application of three sound transmission models (MONM, VSTACK, and FWRAM) developed by JASCO. Each of these models accounts for the frequency composition of the pile driving source signal and the physics of acoustic propagation in the water and underlying geological substrates. According to FHWA, this type of modeling takes into full account source characteristics, contributions of propagation in the substrate, the depth of water and attenuation characteristics of shallow water, and the many other site-specific factors that influence the rate of noise attenuation.

Model runs were specifically made to determine at what distance from the pile underwater acoustic pressures and energies resulting from pile driving operations will equal or exceed a peak level of 206 dB re 1 μPa and when multiple hammer strikes cause in-water cumulative energy levels will exceed 187 dB re: 1μPa^2-s.

Table 7 provides computed peak sound pressure levels for various downrange distances (in feet) from the pile driving noise source at which noise is attenuated to 206 dB re 1μPa (peak) through 182 dB re 1μPa (peak).

Table 7. Peak Sound Pressure Levels vs. Distance from Pile Driving Source (feet)

Pile Diameter (ft)	206 dB re 1 μPA	200 dB re 1 μPA	194 dB re 1 μPA	188 dB re 1 μPA	182 dB re 1 μPA
Pile Installation scenarios with 10 dB broadband noise attenuation					
4	<10	34	59	100	174
8	101	172	277	724	1100
10	166	248	773	1191	1693

As can be seen in Table 7, the 206 dB re 1 μPa (peak) sound pressure levels extend farthest from the pile driving source when a 10-foot diameter pile is driven; the distance from the pile to the point at which peak pressure levels reach 206 dB re 1 μPa is 166 feet. For other pile diameters (4-feet and 8-feet), the distances from the pile to the point in the river at which peak pressure levels fall beneath 206 dB re 1 μPa is considerably less than for the 10-foot diameter pile. Table 7 reflects noise attenuation profiles for modeled scenarios developed for the PIDP. Because the PIDP field tests yielded results that indicated the peak sound pressure levels extend for shorter distances than the modeling predicted, the distances in the table are considered conservative.

Table 8 presents an estimate of the spatial extent of the cumulative sound exposure level acoustic footprint for each of the four different size piles (4-foot, 8-foot, and 10-foot diameter) that would be driven during bridge construction.

Table 8. Approximate Spatial Extent of the 187 dB SEl_{cum} Acoustic footprint vs. Distance (ft) from Pile Driving Source

Pile Diameter	Approx. North-South Extent of 187 dB SEL_{CUM} Footprint*	Approx. East-West Extent of 187 dB SEL_{CUM} Footprint*
With attenuation system providing 10 dB noise reduction		
4 feet	1,375	1,650
8 feet	3,875	3,900
10 feet	6,550	4,550
Note: * distance is total length in north-south or east-west direction.		

Similar to the analysis for peak sound pressure levels, the modeling of cumulative sound exposure levels shows that the 10-foot diameter pile, when driven, would generate the largest cSEL acoustic footprint. With the operation of an effective noise attenuation system (assumed at least 10 dB broadband noise reduction), the acoustic footprint of the 10-foot diameter pile would be 6,550 feet (North-South) and 4,550 feet (East-West). For smaller diameter piles, the cSEL acoustic footprint would be notably smaller than for the 10-foot diameter piles. It is important to note that the cSEL value is not a measure of the instantaneous or maximum noise level, but is a measure of the accumulated energy over a period of time. FHWA has indicated that the cSEL values include the number of pile strikes necessary to install the entire pile. The number of strikes is 1,000 – 3,800 depending on the size of the pile. Thus, for the cSEL to be a relevant criterion when considering effects to fish, we would have to expect the fish to remain in the exposure area for the entire duration of time that the pile factored into the equation used to calculate cSEL.

Table 9 provides estimates of the spatial extent of the 150 dB re 1 μPa RMS SPL isopleth that would be generated by driving 4-foot, 8-foot, and 10-foot piles with noise attenuation measures in place. This is also illustrated in Figure 10, below.

Table 9. Approximate Spatial Extent of 150 dB re 1 μPa RMS SPL Acoustic Footprint

Non-ensonified river width beyond the 150 db rms SPL isopleth generated during pile-driving with an impact hammer and 10-dB BMP reduction.

Pile size (feet)	Maximum distance from pile to 150-dB rms SPL isopleth (feet)*	North-South extent (feet)**	East-West extent (feet)**	Non-ensonified river width (feet)**
4	1,800	3,500	3,600	11,000
6	3,000	6,500	5,500	8,625
8	4,200	10,000	7,875	6,625
10	7,000	18,750	9,625	4,375

*Based on Figure 29 of JASCO (2011).
**Based on modeled noise isopleths depicted in section C.2 of Appendix to JASCO (2011).

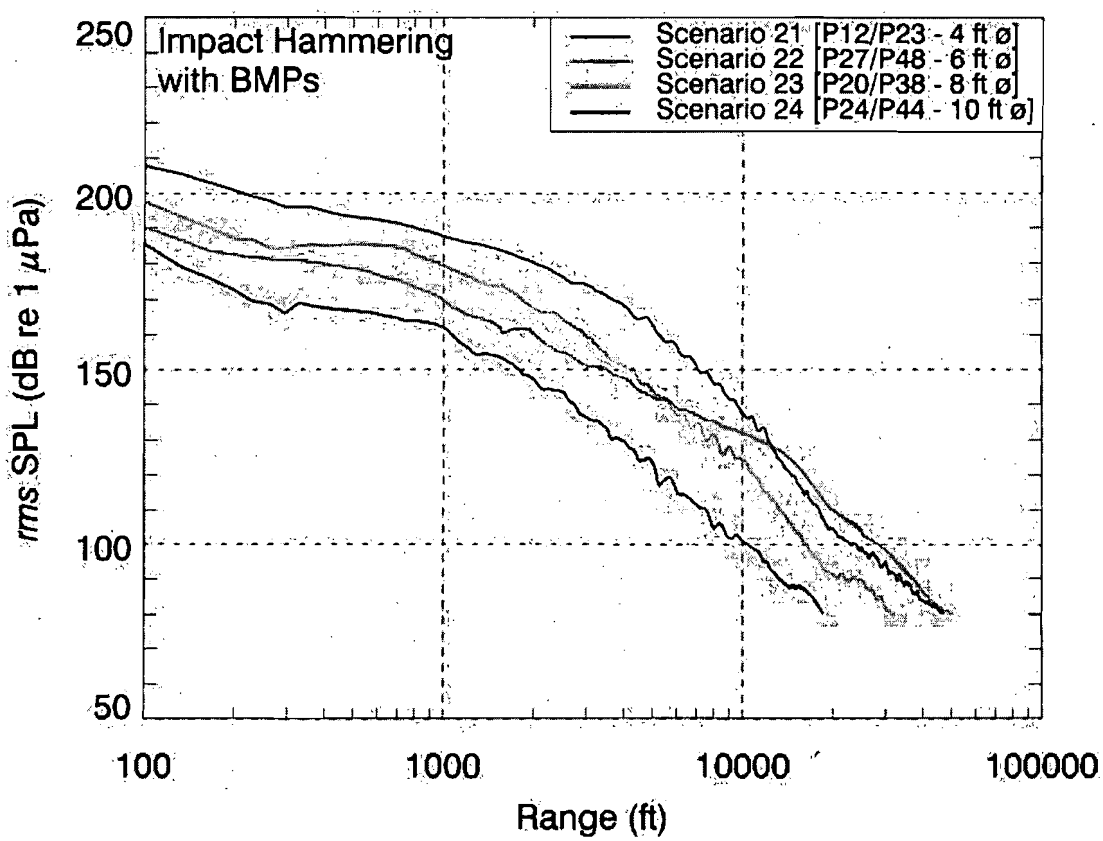

Figure 10. Extent of rms SPL for various sizes of piles.

Various pile driving scenarios were used to generate the cumulative sound exposure level (SEL_{cum}) and peak SEL levels for each day over the construction period. These tables take into account days when multiple piles are being driven and times when more than one pile is being driven at a time. This information is presented in Tables 10, 11, 12 and 13 below. In addition, the application of Best Management Practices (BMPs) that provided a 10 dB reduction in sound was incorporated into the acoustic modeling effort. These practices represent various methods to reduce the extent to which a waterbody would be ensonified by pile driving operations. Various BMPs have been employed on pile driving operations around the country, including air bubble curtains of various forms, isolation casings, Gunderbooms, and dewatered cofferdams. These BMPs were tested during the PIDP; a method that provides at least a 10 dB reduction in underwater noise will be implemented during all pile driving for bridge construction. Preliminary findings from the PIDP confirm that the technologies tested in the field exceed the 10dB noise attenuation target. Furthermore, the PIDP results indicated that the ensonified zones within the 206 dB re 1uPa peak SPL, and the 187 dB re 1uPa s cSEL, and the 150 dB re 1uPa RMS SPL, were all much smaller than had been predicted by the JASCO models.

Figure 11 presents the peak SPL, with BMPs, for 4-, 6-, 8-, and 10-ft piles being driven at representative locations along the alignment of the replacement bridge. The figure illustrates the transmission loss that would occur as distance from the pile driving site increases. Transmission loss is not uniform across the different size piles since the piles would be driven at locations where water depth and other environmental factors vary. For the 4-ft piles, sound above the interim 206 dB peak threshold encompasses a distance of about 35 ft; for the 10-ft piles the 206 dB peak SPL the distance increases to approximately 300 ft.

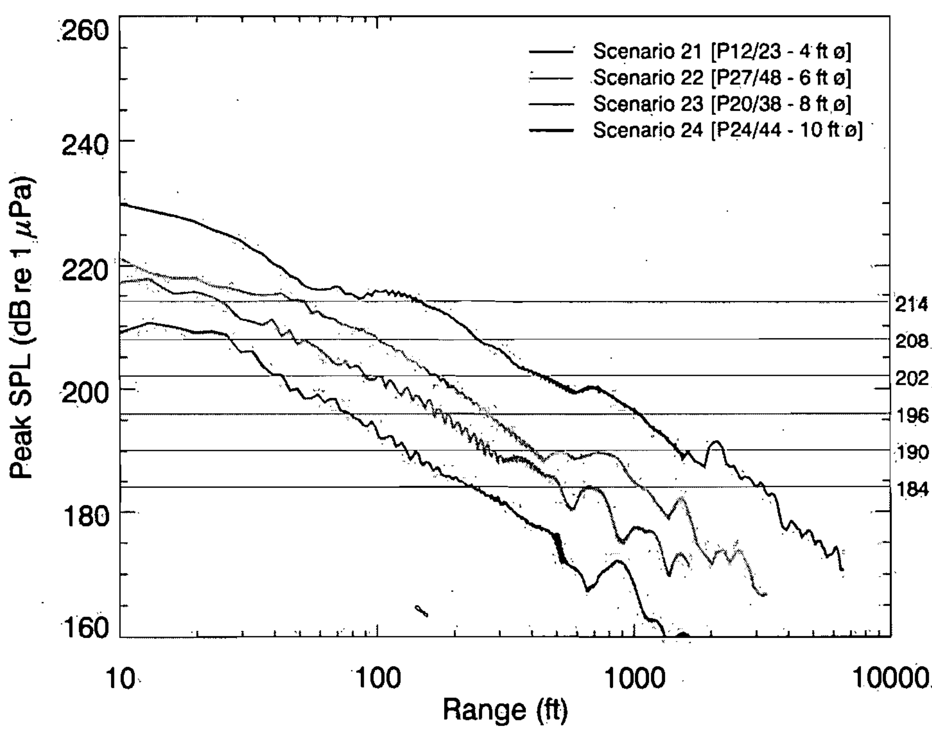

Figure 11. Peak SPL, with 10 dB BMPs, for 4-, 6-, 8-, and 10-ft piles being driven at representative locations along the alignment of the replacement bridge.

Figure 12 presents the SEL_{cum} that results for simultaneously installing two 10-ft piles at the replacement bridge main span over the number of strikes that are predicted to be needed to fully seat the piles; this represents the worst case scenario during project construction. The concentric "circles" (or isopleths) of different colors represent distances from the pile driving activity at which various accumulated sound energy levels (SEL_{cum}) would be reached over the duration of driving of the two piles. For example, the 187 dB isopleths extends over a mile in each direction north and south of the point of pile driving and 49% of the cross sectional width of the river. This can be contrasted with the 187 dB re 1 $\mu Pa^2 \cdot s$ isopleth profile for installing four 4-ft piles at the replacement bridge main span in one day, which does not extend substantial distances in any direction (see Figure 13).

Both of these figures present accumulated energy (SEL_{cum}) for driving a pile over the time for driving the pile. Thus, the information in these figures does *not* represent the energy from a single strike or the instantaneous level of sound at any one moment in time (as represented for peak levels in Figure 9). Instead, it represents the final energy, accumulated over time, of a large number of strikes with a particular SEL_{ss}. Moreover, the accumulated energy in the following figures represents the received energy for an animal *only* if the animal stays in the same location for the duration of the pile driving activity. It should also be understood that the expression SEL_{cum} represents the total energy at a particular location in the river for a discrete duration associated with a particular pile driving operation. For these calculations, the cSEL incorporates the number of strikes necessary to install the entire pile; this will occur over a period of 0.33 – 1.5 hours depending on the pile.

A.2.4. Typical Case 1 (also dual level bridge)

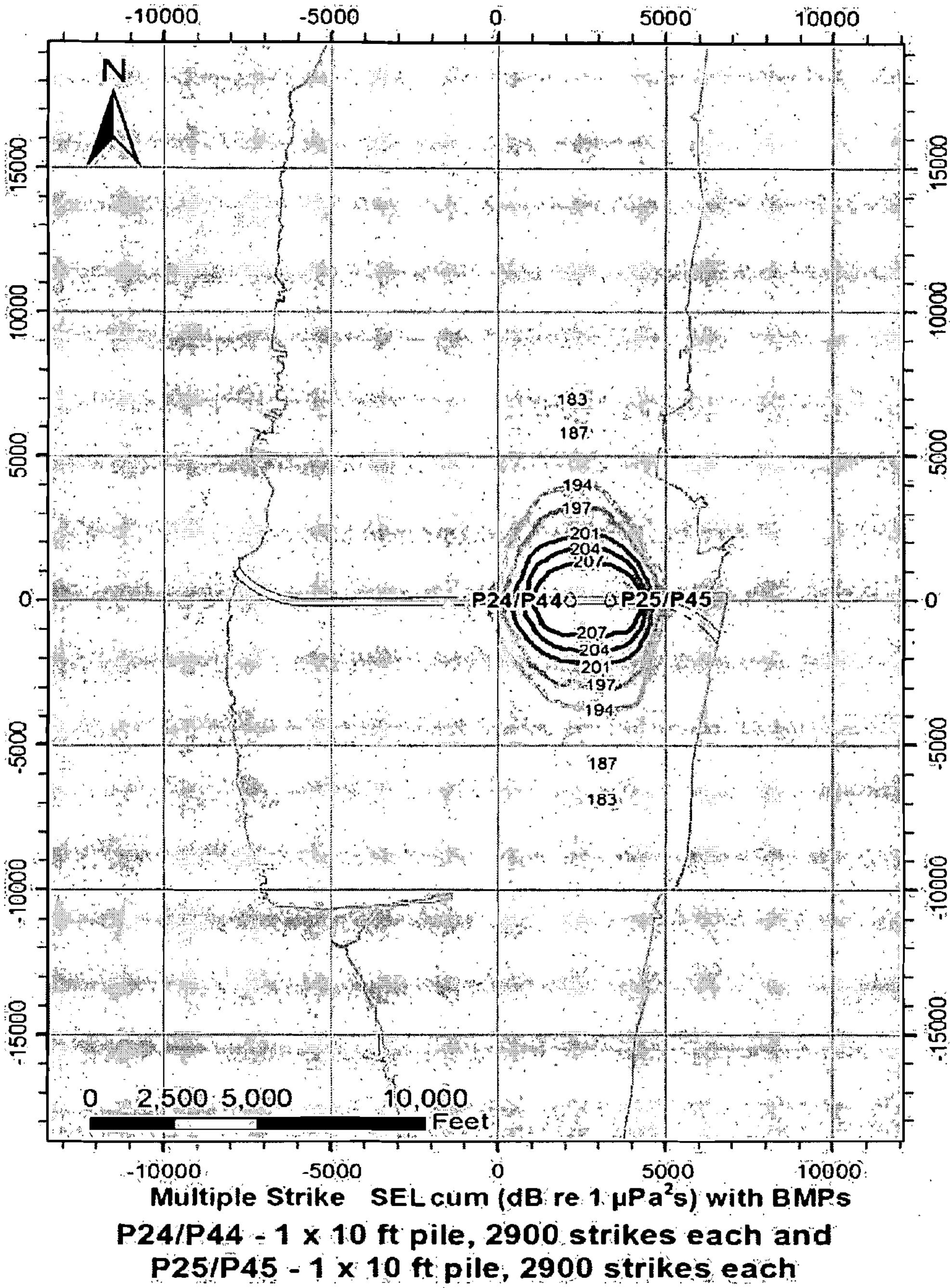

Figure 12. cSEL for installation of two 10-foot diameter piles simultaneously.

A.2.6. Typical Case 3 (also dual level bridge)

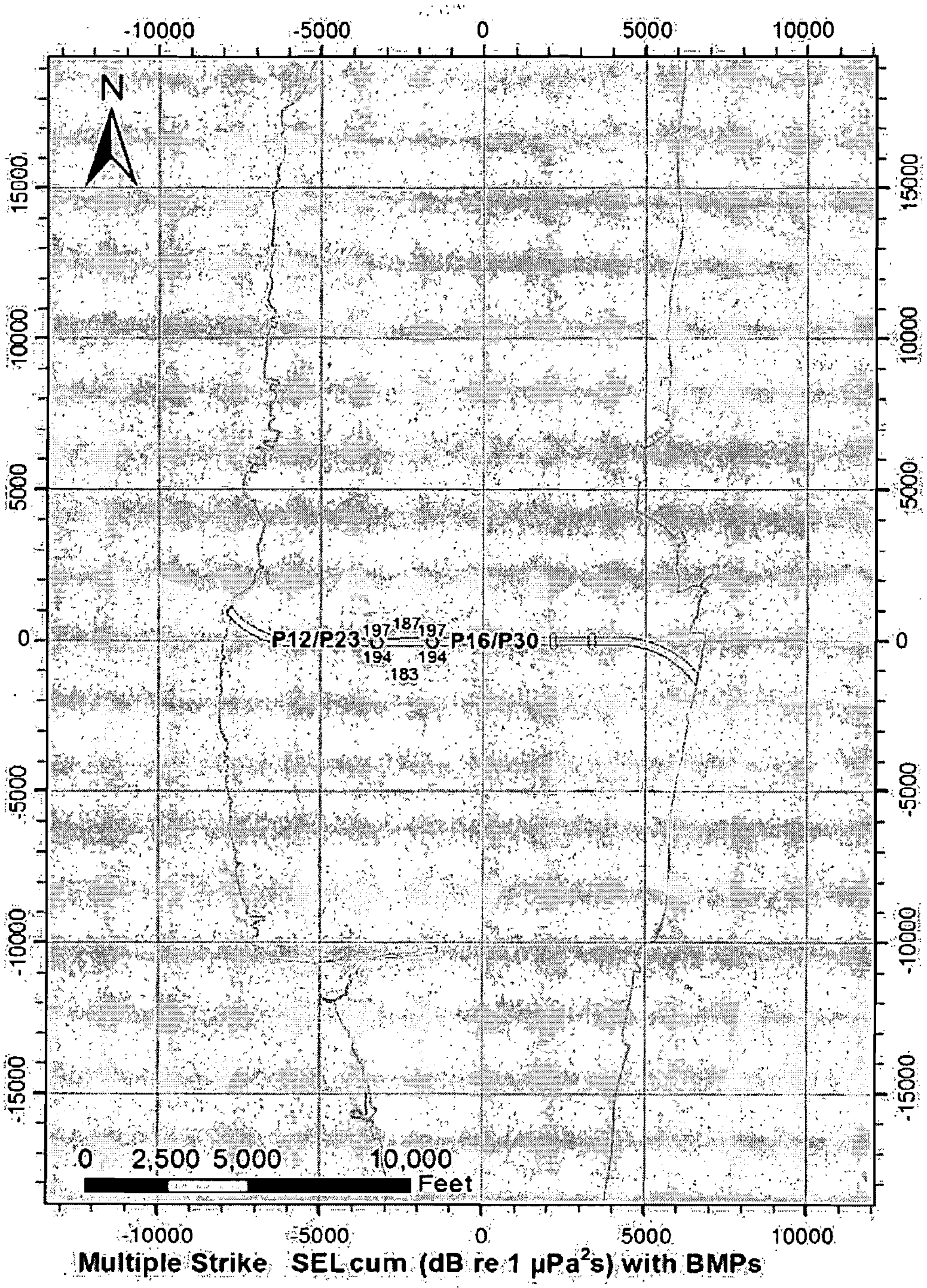

Figure 13. cSEL for installation of two 4-foot diameter piles simultaneously

8.3.2.4 Potential for Exposure to Underwater Noise

Shortnose and Atlantic sturgeon are likely to be present in the Tappan Zee Reach throughout the construction period. If an individual fish occurs within an area(s) ensonified over Peak 206 dB re 1 μPa for a single strike or 187 dB re 1 $\mu Pa^2 \cdot s$ for accumulated energy (SEL_{cum},) there is the potential for the onset of physiological effects. As noted above, in order for the cSEL criteria to be relevant, the fish must stay in the ensonified area throughout the duration of the number of pile strikes factored into the noise estimate; for this action, the number of pile strikes is at least 1,000 and is the number of pile strikes needed to install the entire pile with an impact hammer.

Fish that are close to the piles during a pile driving operation could be exposed to single strike sound levels that are above the interim criteria defined above (e.g., 206 dB re 1 μPa peak), and there is a possibility of injury to these individual animals. However, methods have been tested that suggest, albeit with limited data, that fish move from the vicinity of pile driving prior to the onset of maximum strikes. For example, during the construction of the Woodrow Wilson Bridge over the Potomac River, there is evidence that tapping the pile with lower energy for the first few strikes may cause fish to move away from the piles before full operations begin (FHWA 2003). Reports from the Woodrow Wilson Bridge construction indicated that in some cases this kind of ramp-up procedure substantially decreased mortality; however, these findings were anecdotal and were not part of scientifically controlled studies. This "ramp up" or "soft start" method is also used to minimize potential exposure of marine animals to seismic and other noisy survey methods. The bridge replacement project will use a soft start method for all impact pile driving.

8.3.2.5 Estimating the Number of Sturgeon Likely to be Exposed to Increased Underwater Noise

Using fish abundance estimates from a 1-year comprehensive gillnet sampling study, FHWA estimated the encounter rate of shortnose sturgeon in the project area as the number of shortnose sturgeon collected per gillnet per hour. From June 2007 – May 2008, 476 gillnets were deployed just upstream of the existing Tappan Zee Bridge (and within the area where the bridge replacement will occur) for a total sampling time of 647 hours. During this time, 12 shortnose sturgeon were collected: 7 in September and October, 4 in May and June and 1 in August. Based on the observed number of sturgeon collected over 647 gillnet hours, FHWA calculated an encounter rate for shortnose sturgeon in the project area is 0.02 sturgeon encountered per hour of sampling. The gillnets used for this study consisted of 5 panels, one of each of 1, 2, 3, 4, and 5" stretched mesh. The size of the mesh has a direct relationship to the size of fish caught in the net, with small fish rarely caught in large mesh and large fish rarely caught in small mesh. Shortnose sturgeon of the size that occurs in the action area, would be unlikely to be caught in 1 and 2 inch stretch mesh. Thus, we cannot assume that the entire length of the net fished efficiently for shortnose sturgeon. Since 3/5 of the net likely fished efficiently for sturgeon, it is appropriate to adjust the encounter rate by 0.6 to account for the actual efficiency of the net. This results in an adjusted encounter rate of 0.03 shortnose sturgeon per hour of sampling.

8.3.2.5.1 Exposure Potentially Resulting in Physiological Effects – Shortnose sturgeon

To estimate the potential number of shortnose sturgeon exposed to noise levels that could result in physiological effects (i.e., greater than 187 dB re 1 μPa^2-s cSEL, and greater than 206 dB re 1μPa peak), it is necessary to scale the revised gillnet encounter rates from a single gillnet sample to the area encompassed by the isopleth bounding the noise level under consideration. In the BA, FHWA presented tables that estimated the number of shortnose sturgeon that would be exposed to a cSEL of 187dB dB re 1 μPa^2-s (JASCO 2011). These tables are presented as Table 10 and 11 below.

Table 10. Number of Shortnose Sturgeon Potentially Affected by Pile Driving using cSEL Criteria – Short Span Bridge Option

Year	Week	Pile Diameter (feet)	Number of piles	Number of piles driven/day	Pile driving time (hours/pile)	Number of concurrently driven piles	Estimated pile driving time (hours)	With 10 dB BMPs			
								Width of isopleth for 187-db SEL_{cum} (ft)	Number of gill nets (125-ft) to span width of isopleth	Sturgeon encounter rate per gill net (fish/hr)	Number of shortnose sturgeon potentially exposed to pile driving
1	40-44	10	50	4	1.55	2	38.75	7186	57	0.033	72.89
	45-48	6,8	20	7	1.11	2	11.1	5807	46	0.033	16.85
	49	6,8	8	7	1.11	2	4.44	6336	51	0.033	7.47
	50-51	4,8	20	6	1.14	2	11.4	7170	57	0.033	21.44
	52	4,8	10	6	1.14	2	5.7	6952	56	0.033	10.53
2	1	4,8	10	6	1.14	2	5.7	6952	56	0.033	10.53
	2	4,8	10	6	1.14	2	5.7	6735	54	0.033	10.16
	3-4	4,6,8	30	10	1.14	3	11.4	8418	67	0.033	25.21
	5	4,6,8	15	10	1.14	3	5.7	9324	75	0.033	14.11
	6	4,6,8	15	10	1.14	3	5.7	9253	74	0.033	13.92
	7	4,6,8	15	10	1.14	3	5.7	8312	66	0.033	12.41
	8-12	4,6,8	75	10	1.14	3	28.5	7732	62	0.033	58.31
	13	6,8	12	7	1.14	2	6.84	7732	62	0.033	13.99
	14-28	4,4	160	6	1.14	2	91.2	3490	28	0.033	84.27
	29-49	4	95	3	1.14	1	108.3	2024	16	0.033	57.18
	50-51	4,4,6	30	10	1.14	3	11.4	5581	45	0.033	16.93
	52	4,4,6	15	10	1.14	3	5.7	5036	40	0.033	7.52
3	1	4,4,6	15	10	1.14	3	5.7	5036	40	0.033	7.52
	2	4,4	10	6	1.14	2	5.7	3490	28	0.033	5.27
	3	4,4,6	15	10	1.14	3	5.7	4836	39	0.033	7.34
	4	4,4,6	16	10	1.14	3	6.08	4217	34	0.033	6.82
	5-10	4,4	65	6	1.14	2	37.05	3461	28	0.033	34.23

	11-12	4,4	22	6	1.14	2	12.54	3197	26	0.033	10.76
	13-17	4,4	53	6	1.14	2	30.21	3461	28	0.033	27.91
	18-20	4,4	30	6	1.14	2	17.1	3197	26	0.033	14.67
	21-25	4,4	55	6	1.14	2	31.35	3461	28	0.033	28.97
	26-27	4,4	20	6	1.14	2	11.4	3197	26	0.033	9.78
	28-33	4,4	60	6	1.14	2	34.2	3461	28	0.033	31.6
	34-35	4,4	20	6	1.14	2	11.4	3197	26	0.033	9.78
	36-41	4,4	60	6	1.14	2	34.2	3461	28	0.033	31.6
	42-52	4	60	3	1.14	1	68.4	2024	16	0.033	36.12
4	1-14	4	70	3	1.14	1	79.8	2024	16	0.033	42.13
	15-16	6	12	4	0.33	1	3.96	2120	17	0.033	2.22
	17-18	6	6	4	0.33	1	1.98	2019	16	0.033	1.05
	19	6	6	4	0.33	1	1.98	1821	15	0.033	0.98
	20	6	6	4	0.33	1	1.98	1624	13	0.033	0.85
	21	6	4	4	0.33	1	1.32	1440	12	0.033	0.52
	22-23	6	8	4	0.33	1	1.64	1060	8	0.033	0.43
5	50-52	4	15	3	1.14	1	17.1	2024	16	0.033	9.03
6	1-5	4	25	3	1.14	1	28.5	2024	16	0.033	15.05
	6-7	6	12	4	0.33	1	3.96	2120	17	0.033	2.22
	9	6	6	4	0.33	1	1.98	2019	16	0.033	1.05
	10	6	6	4	0.33	1	1.98	1821	15	0.033	0.98
	11	6	6	4	0.33	1	1.98	1624	13	0.033	0.85
	12	6	4	4	0.33	1	1.32	1440	12	0.033	0.52
	13	6	4	4	0.33	1	1.32	1280	10	0.033	0.44
	14	6	4	4	0.33	1	1.32	1060	8	0.033	0.35
	21	6	6	4	0.33	1	1.98	1346	11	0.033	0.72
	22	6	6	4	0.33	1	1.98	1020	8	0.033	0.52
Total Potential number of sturgeon within the 187-dB cSEL											**796**

Table 11. Number of Shortnose Sturgeon Potentially Affected by Pile Driving using cSEL Criteria - Long Span Bridge Option

Year	Week	Diameter (feet)	Number of piles	Number of piles driven/day	Pile driving time (hours/pile)	Number of concurrently driven piles	Estimated pile driving time (hours)	With 10 dB BMPs			
								Width of isopleth for 187-db SEL_{cum} (ft)	Number of gill nets to span width of isopleth	Sturgeon encounter rate (fish/hr)	Number of shortnose sturgeon potentially affected by pile driving
1	40-44	10	50	4	1.55	2	38.75	7186	57	0.033	72.89
	45-48	6,8	20	7	1.11	2	11.1	5866	47	0.033	17.22
	49-50	6,8	16	7	1.11	2	8.88	6862	55	0.033	16.12
	51	6,8	12	7	1.11	2	6.66	7387	59	0.033	12.97
	52	6,8	14	7	1.11	2	7.77	7965	64	0.033	16.41
2	1	6,8	10	7	1.11	2	5.55	7767	62	0.033	11.36
	2-3	8	12	3	1.11	1	13.32	5648	45	0.033	19.78
	4-11	4,4	88	6	1.14	2	50.16	3458	28	0.033	46.35
	12-13	4,4	20	6	1.14	2	11.4	3910	31	0.033	11.66
	14-21	4,4	80	6	1.14	2	45.6	3458	28	0.033	42.13
	22-23	4,4	22	6	1.14	2	12.54	3910	31	0.033	12.83
	24-30	4,4	73	6	1.14	2	41.61	3458	28	0.033	38.45
	31-33	4	45	3	1.14	1	51.3	2064	17	0.033	28.78
	47-52	4,4	60	6	1.14	2	34.2	3712	30	0.033	33.86
3	1-4	4,4	40	6	1.14	2	22.8	3712	30	0.033	22.57
	5-18	4,4	160	6	1.14	2	91.2	3910	31	0.033	93.3
	19	4,4,6	21	10	1.14	3	7.98	3910	31	0.033	8.16
	20-21	4,6	34	7	1.14	2	19.38	4653	37	0.033	23.66
	22	4,6	22	7	1.14	2	12.54	4200	34	0.033	14.07
	23	4,6	16	7	1.14	2	9.12	3784	30	0.033	9.03
	24	4,6	11	7	1.14	2	6.27	3512	28	0.033	5.79
	25	4,6	11	7	1.14	2	6.27	3240	26	0.033	5.38

	26-33	4	40	3	1.14	1	45.6	2064	17	0.033	25.58
5	17-20	4	20	3	1.14	1	22.8	2064	17	0.033	12.79
	23	6	6	4	0.33	1	1.98	2282	18	0.033	1.18
	25	6	4	4	0.33	1	1.32	1395	11	0.033	0.48
	28	6	6	4	0.33	1	1.98	1759	14	0.033	0.91
	32	6	6	4	0.33	1	1.98	1469	12	0.033	0.78
	36	6	6	4	0.33	1	1.98	1178	9	0.033	0.59
Potential number of sturgeon within the 187-dB cSEL											**603**

While the estimated presented in Tables 10 and 11 is a reasonable estimate of the number of shortnose sturgeon that would be present in areas of this size for this amount of time, in order for this criteria to be relevant, we would need to expect that shortnose sturgeon would remain in that area for the entire duration of the pile driving activity. This is not a reasonable expectation because it does not take into account any behavioral response to noise stimulus. We expect sturgeon to respond behaviorally to noise stimulus and avoid areas above their noise tolerance. This behavioral response is expected to occur at noise levels of 150 dB re 1µPa RMS. We expect that any sturgeon close to piles when pile driving begins to react by leaving the area and expect that any sturgeon approaching the piles while pile driving is ongoing would move around the area. Because of this, it is extremely unlikely that a sturgeon would remain in the ensonified area over the duration of the installation of an entire pile. As evidenced in the figure above (Figure 12), the cSEL 187 dB re 1µPa area never occupies the entire width of the river; therefore, there is no danger that a fish would not be able to "escape" from the area while pile driving is ongoing. Because we do not expect sturgeon to remain within the ensonified area for more than the time it would take them to swim out of the area (no more than a few minutes), we have determined that when assessing the potential for physiological impacts, the 206 dB re 1µPa peak criteria is more appropriate. This represents the instantaneous noise level. Thus, considering the area where this noise level will be experienced would account for fish that were in the area when pile driving started or were temporarily present in the area.

8.3.2.5.2 Estimate of the Number of Shortnose sturgeon that will experience Physiological Effects

Data collected during the gillnet sampling study suggests that movement by shortnose sturgeon is strongly oriented into or with river currents. During the 2007-2008 gillnet study, shortnose sturgeon were collected with greater frequency in gillnets deployed across the river current vs. with the current. Based on these results, FHWA assumed that sturgeon moved in an upstream or downstream direction through the project area and at a constant rate and would thus be intercepted by gillnets spanning the width of the noise isopleth. FHWA also assumed that catch rates are proportional to shortnose sturgeon abundance, which is a central assumption of most fish-sampling gears, and that sturgeon were uniformly distributed throughout the Tappan Zee region. Under these assumptions, each gillnet would encounter shortnose sturgeon at the same rate allowing the estimates of sturgeon numbers to be scaled to the width of the isopleth. As an example, if the isopleth under consideration extended 2,500 feet that would be equivalent to 20 gill nets. At an encounter rate of 0.02 sturgeon per hour, the number of shortnose sturgeon that would pass through the ensonified area during the 4.6 hours required to conduct the test for one 4-ft pile would be: 0.03 shortnose sturgeon per hour * 20 nets*4.6 hrs = 1.84 shortnose sturgeon.

Tables 12 and 13 provide estimates of the number of shortnose sturgeon FHWA estimates to be exposed to the peak 206 dB re 1uPa level for the short and long span bridge replacement options. The analysis assumed a 10dB reduction in noise was achieved by the implementation of noise attenuation measures. This analysis incorporates the best estimate of pile driving scenarios throughout the construction period, including multiple piles being driven at one time. However, it is likely an overestimate because it assumes that every pile will be fully installed with impact hammers when in fact, most, if not all, piles will be installed at least partially with a vibratory hammer which would reduce the duration of impact pile driving and reduce the number of sturgeon exposed to the peak 206 dB re 1µPa noise level. Using the method explained above, FHWA estimates the number of shortnose sturgeon potentially exposed to underwater noise which may cause physiological effects (i.e., peak 206 dB re 1µPa) at 22 for the short span bridge option and 17 for the long span bridge option. However, this methodology adds up fractions of fish in its calculation. To be conservative, we have modified this estimate by rounding up any calculation resulting in a fraction of a fish exposed to a whole fish. Based on this modification to FHWA's estimate, we estimate that the total number of shortnose sturgeon that may be exposed to underwater noise which may cause physiological effects (i.e., peak 206 dB re 1μPa) would be 70 or 43 fish for the short and long span bridge replacement options, respectively.

Table 12. Number of Shortnose Sturgeon Potentially Affected by Pile Driving using peak Criteria - Short Span Bridge Option

Year	Week	Pile Diameter (feet)	Number of piles	Number of piles driven/day	Pile driving time (hours/pile)	Number of concurrently driven piles	Estimated pile driving time (hours)	With 10 dB BMPs				
								Width of isopleth for 206-db peak SPL (ft)	Number of gill nets (125-ft) to span width of isopleth	Sturgeon encounter rate per gill net (fish/hr)	Number of shortnose sturgeon potentially exposed to pile driving	Number of shortnose sturgeon rounded up to whole fish
1	40-44	10	50	4	1.55	2	38.75	1200	10	0.033	12.28	13
	45-48	6,8	20	7	1.11	2	11.1	370	3	0.033	1.08	2
	49	6,8	8	7	1.11	2	4.44	370	3	0.033	0.43	1
	50-51	4,8	20	6	1.14	2	11.4	320	3	0.033	0.96	1
	52	4,8	10	6	1.14	2	5.7	320	3	0.033	0.48	1
2	1	4,8	10	6	1.14	2	5.7	320	3	0.033	0.48	1
	2	4,8	10	6	1.14	2	5.7	320	3	0.033	0.48	1
	3-4	4,6,8	30	10	1.14	3	11.4	440	4	0.033	1.32	2
	5	4,6,8	15	10	1.14	3	5.7	440	4	0.033	0.66	1
	6	4,6,8	15	10	1.14	3	5.7	440	4	0.033	0.66	1
	7	4,6,8	15	10	1.14	3	5.7	440	4	0.033	0.66	1
	8-12	4,6,8	75	10	1.14	3	28.5	440	4	0.033	3.31	4
	13	6,8	12	7	1.14	2	6.84	370	3	0.033	0.67	1
	14-28	4,4	160	6	1.14	2	91.2	70	1	0.033	1.69	2
	29-49	4	95	3	1.14	1	108.3	70	1	0.033	2.00	2
	50-51	4,4,6	30	10	1.14	3	11.4	190	2	0.033	0.57	1
	52	4,4,6	15	10	1.14	3	5.7	190	2	0.033	0.29	1
3	1	4,4,6	15	10	1.14	3	5.7	190	2	0.033	0.29	1
	2	4,4	10	6	1.14	2	5.7	70	1	0.033	0.11	1
	3	4,4,6	15	10	1.14	3	5.7	190	2	0.033	0.29	1
	4	4,4,6	16	10	1.14	3	6.08	190	2	0.033	0.30	1
	5-10	4,4	65	6	1.14	2	37.05	70	1	0.033	0.68	1
	11-12	4,4	22	6	1.14	2	12.54	70	1	0.033	0.23	1

	13-17	4,4	53	6	1.14	2	30.21	70	1	0.033	0.56	1
	18-20	4,4	30	6	1.14	2	17.1	70	1	0.033	0.32	1
	21-25	4,4	55	6	1.14	2	31.35	70	1	0.033	0.58	1
	26-27	4,4	20	6	1.14	2	11.4	70	1	0.033	0.21	1
	28-33	4,4	60	6	1.14	2	34.2	70	1	0.033	0.63	1
	34-35	4,4	20	6	1.14	2	11.4	70	1	0.033	0.21	1
	36-41	4,4	60	6	1.14	2	34.2	70	1	0.033	0.63	1
	42-52	4	60	3	1.14	1	68.4	70	1	0.033	1.26	2
4	1-14	4	70	3	1.14	1	79.8	70	1	0.033	1.47	2
	15-16	6	12	4	0.33	1	3.96	120	1	0.033	0.13	1
	17-18	6	6	4	0.33	1	1.98	120	1	0.033	0.06	1
	19	6	6	4	0.33	1	1.98	120	1	0.033	0.06	1
	20	6	6	4	0.33	1	1.98	120	1	0.033	0.06	1
	21	6	4	4	0.33	1	1.32	120	1	0.033	0.04	1
	22-23	6	8	4	0.33	1	1.64	120	1	0.033	0.05	1
5	50-52	4	15	3	1.14	1	17.1	70	1	0.033	0.32	1
6	1-5	4	25	3	1.14	1	28.5	70	1	0.033	0.53	1
	6-7	6	12	4	0.33	1	3.96	120	1	0.033	0.13	1
	9	6	6	4	0.33	1	1.98	120	1	0.033	0.06	1
	10	6	6	4	0.33	1	1.98	120	1	0.033	0.06	1
	11	6	6	4	0.33	1	1.98	120	1	0.033	0.06	1
	12	6	4	4	0.33	1	1.32	120	1	0.033	0.04	1
	13	6	4	4	0.33	1	1.32	120	1	0.033	0.04	1
	14	6	4	4	0.33	1	1.32	120	1	0.033	0.04	1
	21	6	6	4	0.33	1	1.98	120	1	0.033	0.06	1
	22	6	6	4	0.33	1	1.98	120	1	0.033	0.06	1

Total Potential number of sturgeon within the 206-dB peak SPL **70**

Table 13. Number of Shortnose Sturgeon Potentially Affected by Pile Driving using peak Criteria - Long Span Bridge Option

Year	Week	Diameter (feet)	Number of piles	Number of piles driven/day	Pile driving time (hours/pile)	Number of concurrently driven piles	Estimated pile driving time (hours)	With 10 dB BMPs				
								Width of isopleth for 206-db peak SPL (ft)	Number of gill nets to span width of isopleth	Sturgeon encounter rate (fish/hr)	Number of shortnose sturgeon potentially affected by pile driving	Number of shortnose sturgeon rounded up to whole fish
1	40-44	10	50	4	1.55	2	38.75	1200	10	0.033	12.28	13
	45-48	6,8	20	7	1.11	2	11.1	370	3	0.033	1.08	2
	49-50	6,8	16	7	1.11	2	8.88	370	3	0.033	0.87	1
	51	6,8	12	7	1.11	2	6.66	370	3	0.033	0.65	1
	52	6,8	14	7	1.11	2	7.77	370	3	0.033	0.76	1
2	1	6,8	10	7	1.11	2	5.55	370	3	0.033	0.54	1
	2-3	8	12	3	1.11	1	13.32	250	2	0.033	0.88	1
	4-11	4,4	88	6	1.14	2	50.16	70	1	0.033	0.93	1
	12-13	4,4	20	6	1.14	2	11.4	70	1	0.033	0.21	1
	14-21	4,4	80	6	1.14	2	45.6	70	1	0.033	0.84	1
	22-23	4,4	22	6	1.14	2	12.54	70	1	0.033	0.23	1
	24-30	4,4	73	6	1.14	2	41.61	70	1	0.033	0.77	1
	31-33	4	45	3	1.14	1	51.3	70	1	0.033	0.95	1
	47-52	4,4	60	6	1.14	2	34.2	70	1	0.033	0.63	1
3	1-4	4,4	40	6	1.14	2	22.8	70	1	0.033	0.42	1
	5-18	4,4	160	6	1.14	2	91.2	70	1	0.033	1.69	2
	19	4,4,6	21	10	1.14	3	7.98	190	2	0.033	0.40	1
	20-21	4,6	34	7	1.14	2	19.38	190	2	0.033	0.97	1
	22	4,6	22	7	1.14	2	12.54	190	2	0.033	0.63	1

	23	4,6	16	7	1.14	2	9.12	190	2	0.033	0.46	1
	24	4,6	11	7	1.14	2	6.27	190	2	0.033	0.31	1
	25	4,6	11	7	1.14	2	6.27	190	2	0.033	0.31	1
	26-33	4	40	3	1.14	1	45.6	70	1	0.033	0.84	1
5	17-20	4	20	3	1.14	1	22.8	70	1	0.033	0.42	1
	23	6	6	4	0.33	1	1.98	120	1	0.033	0.06	1
	25	6	4	4	0.33	1	1.32	70	1	0.033	0.02	1
	28	6	6	4	0.33	1	1.98	120	1	0.033	0.06	1
	32	6	6	4	0.33	1	1.98	120	1	0.033	0.06	1
	36	6	6	4	0.33	1	1.98	120	1	0.033	0.06	1
Potential number of sturgeon within the 206-dB peak SPL												**43**

FHWA indicates in the BA that physiological effects are likely to be limited to minor injuries. We agree with this assessment as it is likely that sturgeon will begin to avoid the ensonified area prior to getting close enough to experience noise levels that could result in major injuries or mortality. Minor injuries, such as burst capillaries near fins, could be experienced. However, we expect that fish would fully recover from these types of injuries without any effect on their potential survival or future fitness. Any shortnose sturgeon that are present in the area when pile driving begins are expected to leave the area and not be close enough to any pile driving activity for a long enough period of time to experience major injuries or mortality. This will be facilitated by the use of a "soft start" or system of "warning strikes" where the pile driving will begin at only 25-40% of its total energy. This is expected to cause any sturgeon nearby the pile at the time that pile driving begins to move further away and reduce the potential for exposure to noise levels that would be potentially mortal. While sturgeon in the area would be temporarily exposed to noise levels that are likely to result in physiological effects, the short term exposure is likely to result in these injuries being minor. Shortnose sturgeon are known to avoid areas with conditions that would cause physiological effects (e.g., low dissolved oxygen, high temperature, unsuitable salinity); thus, it is reasonable to anticipate that sturgeon would also readily avoid any areas with noise levels that could result in physiological stress or injury. The only way that a shortnose sturgeon would be exposed to noise levels that could cause major injury or death is if a fish was immediately adjacent to the pile while full strength pile driving was ongoing. Because of the use of the soft start technique and the expected behavioral response of moving away from the piles being installed, this situation is likely to be very rare; however, given the number of piles to be installed and the duration over which pile driving will occur, it is possible that this unexpected event could occur. However, because we expect it to be very rare, we expect that no more than one shortnose sturgeon is likely to suffer major injury or die as a result of exposure to pile driving noise. Effects on behavior are discussed below. It is important to note that during the PIDP, where seven test piles were installed with impact hammers, FHWA conducted monitoring designed to detect any stunned, injured or dead sturgeon during and following pile driving. No sturgeon were observed during this monitoring. This supports the conclusions reached here, that injury and mortality will be rare.

8.3.2.5.3 Exposure Potentially Resulting in Physiological Effects – Atlantic sturgeon

No Atlantic sturgeon were captured during the one year gillnet study which consisted of 476 collections over 679 hours; this is likely due to the relatively small mesh size fished which would likely preclude capture of large subadults and adults as well as the relatively low abundance of Atlantic sturgeon in the area. Other available information, including the Long River surveys and tagging and tracking studies conducted by NYDEC and other researchers indicates that juvenile, subadult and adult Atlantic sturgeon are likely to occur in the Tappan Zee region. Population estimates of Hudson River Atlantic sturgeon from the literature and interaction rates in Fall Shoals Program from 2000-2009 of shortnose vs. Atlantic sturgeon suggest that the number of Atlantic sturgeon in the action area would be considerably lower than numbers of shortnose sturgeon.

In the BA, FHWA presented a methodology to estimate the number of Atlantic sturgeon likely to be exposed to noise that would result in physiological effects. This method aimed to determine the differential gear selectivity for shortnose versus Atlantic sturgeon to use the ratio of shortnose to Atlantic captured in sampling studies to determine how many fewer Atlantic sturgeon than shortnose sturgeon we anticipate in the action area. The first step of the analysis to was to compare the size distribution of shortnose and Atlantic sturgeon collected by the Fall Shoals sampling gear (3-m beam trawl) in an extended data set. Based on the similar size distribution of Atlantic (51 – 952-mm total length (TL)) and shortnose sturgeon (75 – 928-mm TL) collected in the Fall Shoals Program between 1998-2007, it was assumed that gear efficiency is similar for both species within the size range collected (i.e., <1,000 mm TL). In the BA, FHWA considers Atlantic sturgeon <1,000 mm to be resident riverine juveniles; however, Atlantic sturgeon are considered subadults once they reach a size of 500mm and may begin making coastal migrations out of their natal river at that time; therefore, Atlantic sturgeon in the Hudson River that are larger than 500mm, but less than 1,000 mm may originate from rivers other than the Hudson. FHWA explains that because of the lack of population-size estimates for Atlantic sturgeon and the similarities in body size and overlapping habitat use between both sturgeon species during the riverine occupancy (Bain 1997), the population estimate developed by Bain et al. (1998, 2007) for shortnose sturgeon was used to develop a gear-efficiency correction factor for the 3-m beam trawl used to sample sturgeon abundance as part of the Utilities fish sampling program. The population estimate of 61,057 from Bain et al. (1998, 2007) is considered an accurate estimate for shortnose sturgeon as it is based on mark-recapture studies in which the size of the sample population (i.e., tagged fish) is known. The standing crop estimate for shortnose sturgeon using Fall Shoals data (unadjusted for gear efficiency) from the same time period (1994-1997) as the Bain studies were performed was 27,534 fish. The percentage of adult shortnose sturgeon (≥550-mm TL) represented by Bain *et al.*'s (1998, 2007) estimate was 93%, with the remaining 7% represented by juveniles (<550-mm TL). Similarly, 90% of the shortnose sturgeon collected during the Fall Shoals survey between 1994-1997 were adults, with the remaining 10% in the size range of juveniles (<550 mm TL).

Gear efficiency was then estimated for both size classes of shortnose sturgeon (<550-mm TL and ≥550-mm TL) by dividing the juvenile and adult proportions of the Fall Shoals standing crop estimate (2,753 and 24,781, respectively) by the same proportions of the Bain et al. (1997) population estimate (4,274 and 56,783, respectively). The resulting gear-efficiency correction factors were 64% for sturgeon <550-mm TL and 44% for sturgeon between 550-1,000-mm TL.

FHWA's standing crop estimate (unadjusted for gear efficiency) for "riverine juvenile Atlantic sturgeon (<1,000-mm TL)" (see note above regarding FHWA's definition of juveniles) was calculated using volume-corrected Atlantic sturgeon abundances from 1998-2007 Fall Shoals data stratified by sampling week, habitat (shoal, channel, bottom) and Utilities-survey river segment (e.g., Tappan Zee, Battery, Hyde Park, etc.). Abundances were interpolated for weeks that were not sampled. Weekly average standing crop was then calculated for each of the 52 calendar weeks and the maximum weekly average of 12,142 juvenile Atlantic sturgeon was calculated as the standing crop estimate for this time period and size range.

An examination of the Fall Shoals dataset revealed that 30% of the 233 Atlantic sturgeon collected in the Hudson River between 1998 and 2007 were ≥550-mm TL and the remaining 70% were <550-mm TL. These percentages were used to parse the standing crop estimate of 12,142 sturgeon into size classes which were then corrected for gear efficiency to yield an estimate of 13,708 juvenile Atlantic sturgeon (<550-mm TL) and 8,280 juvenile Atlantic sturgeon (≥550-mm TL) in the river (as noted above, we consider fish of this size to not be juveniles, but to be subadults). Based on the size of Atlantic sturgeon in this dataset (51 – 952-mm TL), this population of 21,988 Atlantic sturgeon was considered to consist of a number of age classes, including young of year, 1 and 2 year old fish, and fish 3 years old and possibly older (Bain 1997; Peterson et al. 2000).

To estimate the number of Atlantic sturgeon that would be exposed to noise levels that could result in physiological effects, mean weekly Atlantic sturgeon densities were then applied to the water volumes ensonified by the 206 dB re 1uPa peak isopleths during each week of the proposed construction schedule to estimate the total number of fish expected to be potentially affected by pile-driving activities on a weekly basis over the course of bridge construction. The approach followed the proposed construction schedule and accounted for the various combinations of pile sizes that will be driven simultaneously, their location along the span, and their depth within the River. Fish numbers were expressed by FHWA in terms of the "Hudson River juvenile population of Atlantic sturgeon".

Upper and lower bounds for the number of fish exposed to the ensonified area were estimated by first assuming that the Hudson River population exists in a closed system (i.e., there is no immigration or emigration). Under this assumption, the same individual fish can be observed multiple times and the number of fish vulnerable to noise impacts can not exceed the maximum weekly average number of fish observed.

Therefore, the lower bounds were calculated as:

$$\text{Sturgeon}_{max} / \text{SC}_{max} \text{ X } 100$$

where,
Sturgeon_{max} = the maximum weekly number of sturgeon within the isopleths, and
SC_{max} = the maximum weekly average standing crop of the Hudson River.

Because FHWA considered that fish <1,000 mm would be Hudson River origin fish and in fact, fish >500mm could be migrants from other river systems, the assumption built into this model to generate the lower bounds (i.e., that the Hudson River is a closed system), is not a reasonable assumption.

To estimate the upper bounds, it was assumed that the Hudson River population exists in an open system with juvenile Atlantic sturgeon moving throughout the River. In this case, sturgeon are never observed more than once and every sturgeon observed within the project area is counted as a different individual. Under these assumptions, the number of juvenile sturgeon within the ensonified area each week was summed across all weeks and divided by the number of weeks of pile driving. This average weekly number of sturgeon was then multiplied by 52 weeks in a year to determine the number of affected fish during an average construction year.

Therefore, the upper bounds were calculated as:

$$(\sum \text{Sturgeon}_{weekly} / \text{n}_{weeks}) * 52 / \text{SC}_{max} \text{ X } 100$$

where,
Sturgeon_{weekly} = the weekly number of sturgeon within the isopleths, and
n_{weeks} = the number of weeks of pile driving during construction.

Using this methodology, FHWA determined that no more than one juvenile Atlantic sturgeon would be exposed to noise of a peak 206 dB re 1uPa. The same methodology was also used to determine the number of Atlantic sturgeon that could be exposed to the cSEL of 187 dB re 1uPa; however, as explained above for shortnose sturgeon, use of this criteria is not appropriate in this case for determining the potential for physiological effects. Using the same method, FHWA estimates that no more than 1 "juvenile" Atlantic sturgeon would be exposed to the 206 dB re $1\mu Pa^2 \cdot s$ peak SEL ensonified area during the course of the construction period. However, even when considering the upper bounds of this model, while the model assumes an "open system" with sturgeon moving throughout the River, it does not appear that the model accounts for the potential for Atlantic sturgeon of this size class to leave the river or to enter the river from other systems. Additionally, we cannot validate the assumptions made regarding gear selectivity for shortnose vs. Atlantic sturgeon. For example, we do not know if there are behavioral differences that make it or more or less likely to capture a shortnose sturgeon versus an Atlantic sturgeon of the same size in the same gear. Because of these factors, and because we cannot validate other model parameters, it is difficult to determine the validity of these estimates.

FHWA also estimated the number of adult Atlantic sturgeon that would be exposed to noise that could result in physiological effects. Because of their large size, adult sturgeon are able to avoid collection by the beam trawl during Fall Shoals sampling. Therefore, the number of adults potentially affected by pile-driving noise was estimated as a function of the probability of their exposure to noise. FHWA considered that approximately 288 adult Atlantic sturgeon would enter the Hudson River to spawn that year and that these would be the only adults in the river. This is likely to be an underestimate of the number of adults in the river because: (1) non-spawning adults that originate from the Hudson River as well as from other rivers are known to occur within rivers (as evidenced by genetic sampling (Fox, unpublished data 2011)); and, (2) the number of spawning adults in the Hudson River in a given year could be as high as 730 individuals. This is based on the estimated adult population of 596 males, that spawn every 1-5 years and 267 females that spawn every 2-5 years. FHWA considered only that approximately 1/3 of the total number of adults (863) would return to the river to spawn each year. FHWA also only considered that each sturgeon would pass through the project area twice, once while moving upstream to spawn and once while moving downstream to spawn. While these types of singular directed movements are possible, tracking data suggests that sturgeon may make many up and down movements during the spring. Thus, this methodology likely results in an underestimate of the number of adult Atlantic sturgeon that would be exposed to pile driving noise.

8.3.2.5.4 Estimate of the Number of Atlantic sturgeon that will experience Physiological Effects

While we cannot rely on the estimates provided by FHWA for the number of juvenile or adult Atlantic sturgeon likely to be exposed to noise levels of 206 dB re 1 μPa peak, because we know that there are fewer Atlantic sturgeon in the project area than shortnose sturgeon and we have an estimate of the number of shortnose sturgeon likely to be exposed to noise levels of 206 dB re 1 μPa peak, we can produce an estimate of the maximum number of Atlantic sturgeon we expected to be exposed to noise levels of 206 dB re 1 μPa peak. We do not expect that Atlantic sturgeon use this area of the river more frequently than shortnose sturgeon (i.e., we do not expect more Atlantic sturgeon in the area than shortnose sturgeon) and we expect that because of similar morphology, we expect their hearing and behavioral responses to sound to be similar. Based on the calculations for shortnose sturgeon, we anticipate that the number of Atlantic sturgeon that may be exposed to noise levels of 206 dB re 1 μPa peak and therefore, the number that may experience physiological effects, would be less than 70 or 43 for the short and long span bridge replacement options, respectively.

Pile driving will occur year round; therefore the Atlantic sturgeon exposed to pile driving noise are expected to be juveniles, subadults and adults. However, because the potential for mortal injury due to noise exposure decreases with fish size, and because adult Atlantic sturgeon are very large (at least 1,500 mm (approximately 5 feet in length), it is unlikely that the one fish that we expect to experience serious injury or mortality would be an adult. Based on the mixed-stock analysis, we expect that, for the short span bridge option, of the 70 Atlantic sturgeon that could experience physiological effects, 64 would be from the New York Bight DPS (juveniles, subadults or adults), four from the Gulf of Maine DPS (subadults or adults), and two from the Chesapeake Bay DPS (subadults or adults). For the long span bridge option, based on the mixed-stock analysis, we expect that of the 43 Atlantic sturgeon that could experience physiological effects, 39 would be from the New York Bight DPS, three from the Gulf of Maine DPS, and one from the Chesapeake Bay DPS. It is most likely that the one fish that may be mortally injured or killed would originate from the New York Bight DPS. However, because Atlantic sturgeon from the Chesapeake Bay and Gulf of Maine DPSs are also present in the area, it is possible that the fish that dies could originate from any of the three DPSs.

Like shortnose sturgeon, we anticipate that physiological effects to individual Atlantic sturgeon are likely to be limited to minor injuries as sturgeon are expected to begin to avoid the ensonified area prior to getting close enough to experience noise levels that could result in major injuries or mortality. Minor injuries, such as burst capillaries near fins, could be experienced. However, we expect that fish would fully recover from these types of injuries without any effect on their potential survival or future fitness. Any Atlantic sturgeon that are present in the area when pile driving begins are expected to leave the area and not be close enough to any pile driving activity for a long enough period of time to experience major injuries or mortality. This will be facilitated by the use of a "soft start" or system of "warning strikes" where the pile driving will begin at only 25-40% of its total energy. This is expected to cause any sturgeon nearby the pile at the time that pile driving begins to move further away and reduce the potential for exposure to noise levels that would be potentially mortal. While sturgeon in the area would be temporarily exposed to noise levels that are likely to result in physiological effects, the short term exposure is likely to result in these injuries being minor. Atlantic sturgeon are known to avoid areas with conditions that would cause physiological effects (e.g., low dissolved oxygen, high temperature, unsuitable salinity); thus, it is reasonable to anticipate that sturgeon would also readily avoid any areas with noise levels that could result in physiological stress or injury. The only way that an Atlantic sturgeon would be exposed to noise levels that could cause major injury or death is if a fish was immediately adjacent to the pile while full strength pile driving was ongoing. Because of the use of the soft start technique and the expected behavioral response of moving away from the piles being installed, this situation is likely to be very rare; however, given the number of piles to be installed and the duration over which pile driving will occur, it is possible that this unexpected event could occur. However, because we expect it to be very rare, we expect that no more than one Atlantic sturgeon is likely to suffer major injury or die as a result of exposure to pile driving noise. Effects on behavior are discussed below.

8.3.5.2.4 Exposure Potentially Resulting in Behavioral Effects

It is reasonable to assume that sturgeon, on hearing the pile driving sound, would either not approach the source or move around it. Sturgeon in the area when pile driving begins are expected to leave the area. This will be facilitated by the use of a "soft start" or system of "warning strikes" where the pile driving will begin at only 40% of its total energy. These "warning strikes" are designed to cause fish to leave the area before the pile driving begins at full energy. As noted above, since the pile driving sounds are very loud, it is very likely that any sturgeon in the action area will hear the sound, and respond behaviorally, well before they reach a point at which the sound levels exceed the potential for physiological effects, including injury or mortality. Available information suggests that the potential for behavioral effects may begin upon exposure to noise at levels of 150 dB re 1 μPa rms.

When considering the potential for behavioral effects, we need to consider the geographic and temporal scope of any impacted area. For this analysis, we consider the area within the river where noise levels greater than 150 dB re 1 μPa will be experienced and the duration of time that those underwater noise levels could be experienced (for example, see Figure 14).

Depending on the pile being driven, the 150 dB re 1 μPa RMS isopleth would extend from 2,500 to 19,000 feet in a north-south direction and 2,500 to 9,000 feet in an east-west direction. The Hudson

River at the project site is approximately 3 miles wide (15,840 feet). Even in the worst case, during the installation of multiple 10 foot piles, a continuous east-west stretch of at least 1,500 feet would have noise levels less than 150 dB re 1 μPa. Assuming the worst case behaviorally, that sturgeon would avoid an area with underwater noise greater than 150 dB re 1 μPa, there would still be a significant area where fish could pass through unimpeded. Additionally, the maximum amount of time when pile driving of 8 and 10 feet piles within Zone C (water depths 18-45 feet; nearest to the channel where sturgeon are expected to be migrating) will occur is for 5 hours a day from April – August and no more than 12 hours a day for all other piles. Pile driving will not occur on the weekends. Over the course of the five year project, pile driving will be ongoing for approximately 7% of the time; thus, the time period when sturgeon would expect to react behaviorally to pile driving noise is relatively small. In the worst case, fish would avoid the ensonfied area for the entirety of the pile driving period; however, pile driving will never occur for more than 12 hours a day and the 150 dB re 1uPa RMS isopleth never extends across the entirety of the river.

C.2.4. 10' pile size

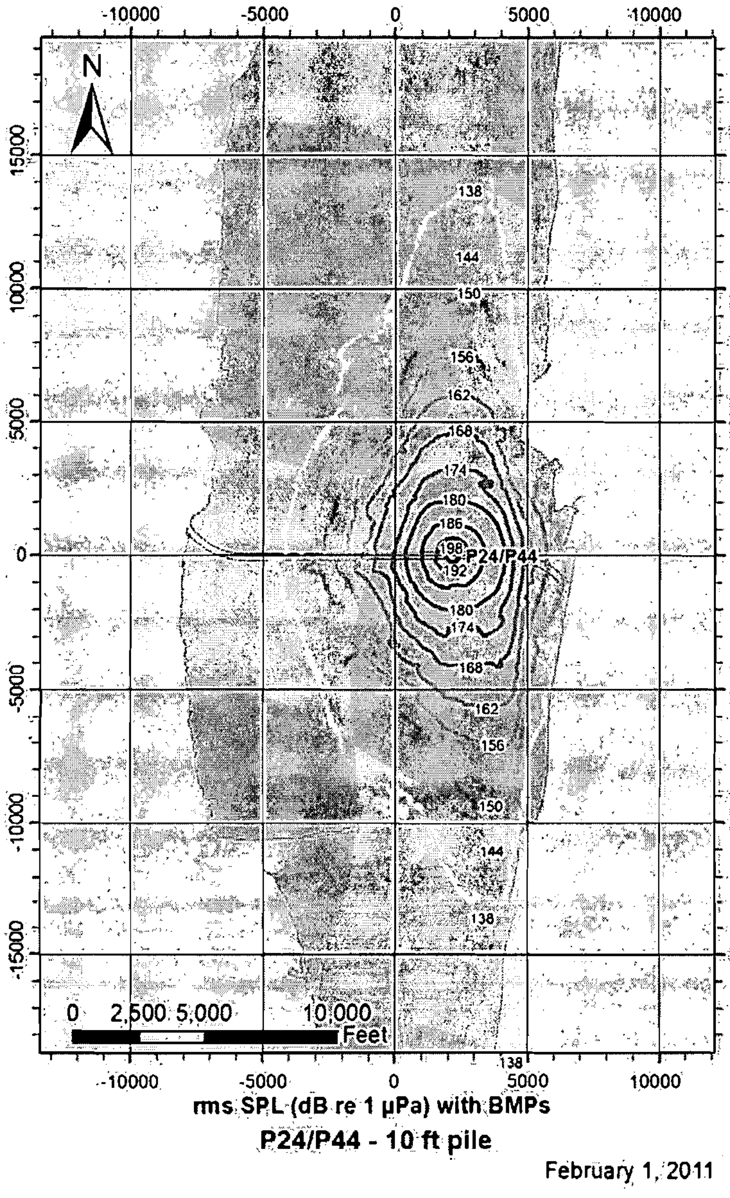

Figure 14. Illustration of rms SPL with 10 dB noise reduction BMPs.

After establishing the potential for exposure, we consider what impact this would have on individual shortnose and Atlantic sturgeon. Shortnose and Atlantic sturgeon in the action area are likely to be migrating through the area and may forage opportunistically while migrating. The action area is not known to be an overwintering area or a spawning or nursery site. An individual migrating up or downstream through the action area may change course to avoid the ensonified area; however, given that there will always be a portion of the river width where noise levels would be less than 150 dB re 1 μPa RMS and that any changes in movements would be limited to a 5-12 hour period when pile driving would be occurring, any disturbance is likely to have an insignificant effect on the individual.

Potentially, the most sensitive individuals that could be present in the action area would be adult Atlantic sturgeon moving through the action area from the ocean to upstream spawning grounds. However, the availability of river width where noise will be low enough that no behavioral response is anticipated (and therefore sturgeon could freely migrate through without any behavioral change) and the limit on the duration of pile driving during the time of year when prespawning adult Atlantic sturgeon would be moving through the action area (April – August) to only five hours per day, make it extremely unlikely that an adult Atlantic sturgeon would not successfully migrate through the action area. The largest ensonified area occurs when the 10-foot piles are being driven. The time required to drive all 50 of the 10-ft piles would be approximately 39 hours or 1.1% of the time in which spawning adults occupy the river (i.e., April – August); thus, the period of time when pile driving will be ongoing that overlaps with the period when adult Atlantic sturgeon would be moving through the project area is extremely small. As such, it is extremely unlikely that there would be any delay to the spawning migration or abandonment of spawning migrations.

Based on this analysis, we have determined that it is extremely unlikely that any minor changes in behavior resulting from exposure to increased underwater noise associated with pile installation will preclude any shortnose or Atlantic sturgeon from completing any normal behaviors such as resting, foraging or migrating or that the fitness of any individuals will be affected. Additionally, there is not expected to be any increase in energy expenditure that has any detectable effect on the physiology of any individuals or any future effect on growth, reproduction, or general health.

8.3.2.5.6 Summary of effects of noise exposure

In summary, we anticipate that individual sturgeon present in the action area during the time that impact pile driving occurs may make minor adjustments to their behaviors to avoid the ensonified areas. For the reasons outlined above, we expect the effects of any changes in behavior to be insignificant and discountable. We do, however, expect that any sturgeon that do not avoid the ensonified area will be exposed to underwater noise levels that could result in physiological impacts. However, with rare exception, we anticipate that the effects of this exposure will be limited to minor injuries from which all affected individuals will fully recover without any future reduction in survival or fitness. We anticipate that the number of sturgeon that may experience physiological impacts would be limited to 70 or fewer shortnose sturgeon and 70 or fewer than Atlantic sturgeon for the short span bridge option and 43 or fewer shortnose sturgeon and 43 or fewer Atlantic sturgeon for the long span bridge option. We anticipate the serious injury or mortality of no more than one shortnose sturgeon and no more than one Atlantic sturgeon for either bridge option.

8.4 Impacts of Vessel Traffic

8.4.1 Potential for Vessel Strike

There is limited information on the effects of vessel operations on shortnose sturgeon. It is generally assumed that as shortnose sturgeon are benthic species, that their movements are limited to the bottom of the water column and that vessels operating with sufficient navigational clearance would not pose a risk of ship strike. Shortnose sturgeon may not be as susceptible due to their smaller size in comparison to Atlantic sturgeon that are larger and for which ship strikes have been documented more frequently. However, anecdotal evidence suggests that shortnose sturgeon at least occasionally interact with vessels, as evidence by wounds that appear to be caused by propellers. There has been only one confirmed incidence of a ship strike on a shortnose sturgeon and two suspected ship strike mortalities. On November 5, 2008, in the Kennebec River, Maine, Maine Department of Marine Resources (MEDMR) staff observed a small (<20 foot) boat transiting a known shortnose sturgeon overwintering area at high speeds. When MEDMR approached the area after the vessel had passed, a fresh dead shortnose sturgeon was discovered. The fish was collected for necropsy, which later confirmed that the mortality was the result of a propeller wound to the right side of the mouth and gills. The other two suspected ship strike mortalities occurred in the Delaware River. On June 8, 2008, a shortnose was collected near Philadelphia. The fish was necropsied and found to have suffered from blunt force trauma; though there was no ability to confirm whether the source of the trauma resulted from a vessel interaction. Lastly, on November 28, 2007, a shortnose sturgeon was collected on the trash racks of the Salem Nuclear Generating Facility. The fish was not necropsied, however, a pattern of lacerations on the carcass suggested a possible vessel interaction; however, it could not be determined if these wounds were inflicted prior to or after the fish's death.

Aside from these incidents, no information on the characteristics of vessels that are most likely to interact with shortnose sturgeon is available and there is no information on the rate of interactions. However, assuming that the likelihood of interactions increases with the number of vessels present in an area, NMFS has considered the likelihood that an increase in ship traffic associated with the bridge construction project would increase the risk of interactions between shortnose sturgeon and ships in the Hudson River generally.

As noted in the 2007 Status Review and the final listing rule, in certain geographic areas vessel strikes have been identified as a threat to Atlantic sturgeon. While the exact number of Atlantic sturgeon killed as a result of being struck by boat hulls or propellers is unknown, it is an area of concern in the Delaware and James rivers. Brown and Murphy (2010) examined twenty-eight dead Atlantic sturgeon observed in the Delaware River from 2005-2008. Fifty-percent of the mortalities resulted from apparent vessel strikes and 71% of these (10 of 14) had injuries consistent with being struck by a large vessel (Brown and Murphy 2010). Eight of the fourteen vessel struck sturgeon were adult-sized fish (Brown and Murphy 2010). Given the time of year in which the fish were observed (predominantly May through July; Brown and Murphy 2010), it is likely that many of the adults were migrating through the river to the spawning grounds.

The factors relevant to determining the risk to Atlantic sturgeon from vessel strikes are currently unknown, but they may be related to size and speed of the vessels, navigational clearance (i.e., depth of water and draft of the vessel) in the area where the vessel is operating, and the behavior of Atlantic sturgeon in the area (e.g., foraging, migrating, etc.). Large vessels have been implicated because of their deep draft [up to 12.2-13.7 m (40-45 feet)] relative to smaller vessels [<4.5 m (15 feet)], which increases the probability of vessel collision with demersal fishes like sturgeon, even in deep water (Brown and Murphy 2010). Smaller vessels and those with relatively shallow drafts provide more clearance with the river bottom and reduce the probability of vessel-strikes. Because the construction vessels (tug boats, barge crane, hopper scow) have relatively shallow drafts, the chances of vessel-related mortalities are expected to be low. The maximum allowable draft of any of the construction vessels will be 3.2 to 3.6 m

(10.5 to 12ft), however, under typical operating conditions, vessels will draft 2.1 to 2.4 m (7 to 8 ft), providing 1.8-2.4 m (6-7 ft) of clearance with the bottom at all times. Maximum allowable drafts will only occur under full load and while turning. Under working conditions, stationary tug boats will maintain 1.8 m (6 ft) clearance between the prop and the bottom and will only infrequently approach 1.1 m (3.5 ft) clearance.

The increased vessel traffic associated with the Tappan Zee Bridge replacement is not expected to result in direct interactions with sturgeon, because the life stages present in this reach of the river tend to occupy the bottom meter of the water column over fine-grained substrates in the deepest water areas and would be below the draft of the vessels involved.

It is important to note that vessel strikes have only been identified as a significant concern in the Delaware and James rivers and current thinking suggests that there may be unique geographic features in these areas (e.g., potentially narrow migration corridors combined with shallow/narrow river channels) that increase the risk of interactions between vessels and Atlantic sturgeon. These geographic features are not present in the Hudson River generally or in the action area specifically. Vessel strike is not considered to be a significant threat in the Hudson River and in contrast to the Delaware and James rivers where several vessel struck individuals are identified each year, very few Atlantic sturgeon with injuries consistent with vessel strike have been observed in the Hudson River.

We have considered the likelihood that an increase in vessel traffic associated with the bridge replacement project would generally increase the risk of interactions between Atlantic sturgeon and vessels in the Hudson River. As explained above, there will be a small, localized increase in vessel traffic. There is likely to be considerable variation in the amount of vessel traffic in the river on a seasonal and daily basis. Annual vessel traffic under the Tappan Zee Bridge between 2000 and 2008, ranged from 8,000 to 16,000 vessels per year (excluding small recreational boats, as no data are available). Given the large volume of traffic on the river and the wide variability in traffic in any given day, the increase in traffic associated with the bridge replacement project is extremely small.

Given the small increase in vessel traffic, the slow speeds that these vessels are expected to operate at, and the navigational clearance in the area, it is unlikely that there would be any detectable increase in the risk of vessel strike. As such, effects to shortnose and Atlantic sturgeon from the increase in vessel traffic are likely to be discountable.

8.4.2 Noise Associated with Vessel Movements

Another potential impact associated with increased vessel traffic is radiated noise. Fish in the action area experience an acoustic environment that is generally highly energetic under "normal" conditions. The sound levels lower in the estuary result from the high volume of commercial shipping traffic within the tidal Hudson and New York Harbor, and these do not appear to affect the behavior or migration of sturgeon that bypass this very noisy region each year. While noise levels resulting from shipping in the estuary are not known, it is possible to get a first approximation based upon results of other studies which indicate that sound levels due to radiated vessel noise would be below thresholds for the onset of injury to fish (Wursig *et al.* 2002). Furthermore, because of the comparatively poor hearing ability of sturgeon (Lovell *et al.* 2005; Meyer *et al.* 2010, 2012), it is likely that many of the sounds which are audible to most species, are not audible to sturgeon.

Because these representative values of radiated vessel noise are well below the peak SEL of 206 dB re 1 μPa criterion established for pile driving, and because the Hudson River is subject to substantial commercial and recreational vessel noise under "normal" conditions, any incremental increase sound associated with vessel traffic related to bridge construction is not expected to affect sturgeon.

8.5 Loss of Benthic Resources

Dredging will remove benthic organisms that are immobile or have limited mobility from the access channel. Dredging will remove benthic macroinvertebrates, including oyster beds. Approximately 0.67 to 0.71 km^2 (165 to 175 acres) of bottom habitat, including about 0.0004 km^2 (0.11 acres) of NYSDEC littoral zone tidal wetland and 0.65-0.69 km^2 (160-170 acres) of open water benthic habitat, would be dredged over the four year period. In addition, the trench would be armored following dredging and the benthic habitat within the dredge zone which was primarily soft sediment would be changed to a substrate of sand and gravel. Since armoring would occur up to 6.1 m (20 feet) of the side slope, total acreage of hard bottom would be approximately 0.63 to 0.67 km^2 (155 to 165 acres). The materials would not be removed after the project completion, since they would become fully buried by the gradual deposition of river sediments over time once construction was completed. Modeling indicated that the rate of this transformation would begin at approximately one foot per year, likely decreasing as the bed nears it natural pre-dredged elevation. Other studies indicate that deposition rates in this portion of the river can vary widely depending on seasonal events such as storm events and freshets, and may be somewhat slower than predicted by the modeling. It is expected that the sand and gravel will, over time, naturally return to soft sediment as new material is deposited in the access channel area. Since much of the benthic community exists in the upper 10 cm of sediment as demonstrated from benthic samples taken throughout the Hudson River (Versar 2003), benthic recovery should begin quickly, particularly in the soft bottom sediments.

Recovery rates of benthic macroinvertebrate communities following dredging range from only a few weeks or months to a few years, depending upon the type of project, the type of bottom material, the physical characteristics of the environment and the timing of disturbance (Hirsch *et al.* 1978, LaSalle *et al.* 1991). In a two year study in the lower Hudson River, Bain *et al.* (2006) reported that within a few months following dredging, the fish and benthic communities at a dredged location were no different from seven nearby sites that had not been dredged. The results of monitoring did not indicate a lasting effect at the dredged site. This suggests, that as material is redeposited in the access channel area, it will be settled by macroinvertebrates.

The temporary loss of the access channel area for foraging would represent a minor fraction of similar available habitat throughout the Tappan Zee region (1.2%) as defined by the Hudson River Utilities (RM 24-33), and an even smaller percentage of the riverwide benthic area (0.2%). The majority of the bottom habitat (and associated benthic macroinvertebrates within the area impacted) is the soft sediment community which dominates the Upper New York Harbor and Hudson River. Deposition within the dredged channel is predicted to occur at a rate of about one foot per year (see Appendix E of DEIS for deposition rate calculations) or less. Recolonization by benthic organisms adapted to softer sediments could be expected to begin within a few months after completion of in-water activities in any given area. Prior to the deposition of sufficient sediment to support a soft substrate benthic invertebrate community, some recolonization of the gravel armor material would be expected occur. Organisms within the nearby gravel substrate located within the main channel (NYSDEC benthic mapper http://www.dec.ny.gov/lands/33596.html, and Nitsche *et al.* 2007) would serve as a source of organisms to colonize the gravel capping material until the soft sediment is of a sufficient depth to be colonized by soft substrate organisms. Once in-water activities are completed, the dredged channels would be restored over time to their original elevations by action of natural sedimentation, and the river's benthic community would recolonize those areas as well.

In summary, with the exception of up to 13 acres of oyster beds that may be permanently lost where access channels are dredged, there would be a temporary loss of habitat that could affect sturgeon that use the dredged area for foraging. These effects would occur as a result of a localized reduction in benthic fauna. However, the dredging footprint represents a very small percentage of the soft bottom habitat of the Tappan Zee region (1.2%) and the Hudson River Estuary (0.2%). Thus, the temporary reduction of benthic fauna within the dredged area would not substantially reduce foraging opportunities for the river's sturgeon populations. As noted above, once in-water activities are completed, the dredged channels would be restored over time to their original elevations and the river's benthic community would recolonize those areas. As the area returns to soft sediment and is recolonized by benthic invertebrates, sturgeon will regain any lost foraging habitat.

Dredging would remove about 0.05 km^2 (13 acres) of oyster beds, some or all of which may be permanently lost due to dredging and armoring of the bottom. Oyster beds were mapped using side scan sonar imagery approximately two miles north and south of the existing bridge from depths of 2.4 to 9.1 m (8 to 30 feet). Seven potential oyster beds were identified south of the bridge and six potential beds to the north (see Appendix E-3 of the DEIS for a description of each of the beds). During the subsequent grab sample program all identified oyster beds except one were confirmed to contain at least some live organisms with beds exhibiting differences in terms of oyster density, amount of shell hash, gravel, or sandstone fragments, etc. It is likely that mitigation for loss of the oyster beds will be implemented; however, no details on the extent or likely success of oyster mitigation requirements (e.g. creation of new oyster beds, augmentation of existing beds) are available at this time. Neither Atlantic or shortnose sturgeon are known to feed on oysters (see Haley *et al.* 1996 and Haley 1999 for discussion of diets in the Hudson River). Studies on foraging Atlantic sturgeon indicate that their benthic invertebrate prey are typically found in fine-grained silt-clay sediments (Hatin *et al.* 2002, 2007). Studies carried out on foraging Atlantic and shortnose sturgeon in the Hudson River indicate that significantly more shortnose and Atlantic sturgeon were collected over silt substrate as compared to sand or gravel. Ninety-two percent of collected shortnose were on silt substrate with none on gravel substrate. Similarly, 96% of Atlantic sturgeon were collected over silt substrate, with none collected over gravel substrate. Based on this, the loss of hard bottom substrate provided by the oyster beds is not likely to affect foraging shortnose sturgeon.

In summary, with the exception of oyster beds that may be permanently lost, where access channels are dredged, there would be a temporary loss of habitat that could affect sturgeon that use the dredged area for foraging. These effects would occur as a result of a localized reduction in benthic fauna. However, the dredging footprint represents a very small percentage of the Hudson River Estuary and its soft bottom habitat. Thus, the temporary reduction of benthic fauna within the dredged area would not substantially reduce foraging opportunities for the river's sturgeon populations. Because similar habitat is available nearby and because sturgeon are highly mobile and move throughout the estuary and river during the summer months while foraging, any effects on sturgeon movements are likely to be within their normal foraging behaviors. The very small amount of habitat lost, and the temporary nature of this loss, makes it extremely unlikely that the ability of sturgeon to find appropriate forage in sufficient quantities would be reduced.

8.6 Effects of Increased Turbidity and Suspended Sediment

Several activities will result in increases in turbidity and/or suspended sediment including dredging, depositing sand and gravel to armor the access channel and the installation of cofferdams and piles. The background concentration of TSS in the vicinity of the TZB generally varies between 15 and 50 mg/L throughout the year, but reaches much higher levels as a consequence of storm events, such as Hurricane Irene in 2011 when the extremely high turbidity episode lasted several weeks.

Dredging operations cause sediment to be suspended in the water column. This results in a sediment plume in the river, typically present from the dredge site and decreasing in concentration as sediment falls out of the water column as distance increases from the dredge site. Dredging will occur for approximately 90 days, with dredging occurring up to 24 hours a day depending on the particular contractor, weather and other activities ongoing in the river.

Several studies have been conducted on water quality changes associated with bucket dredge operations. In 2001, Normandeau Associates monitored water quality during dredging operations at BIW. Pre-dredge total suspended solids (TSS) levels ranged from 20-49mg/L. The maximum observed TSS levels during and after dredging with a mechanical dredge was 55mg/L. This level was recorded during an ebb tide, 50 feet from the dredge. Additional monitoring was conducted during dredging in 2002. Pre-dredge turbidity ranged from 5.0-7.9 NTU with TSS values ranging from 12 -18 mg/L. During dredging, TSS ranged from 24 to 43 mg/L. While increased turbidity was experienced at a distance of 150 feet from the dredge, the highest concentrations were limited to the area within 50 feet of the dredge.

Monitoring of twelve mechanical dredge operations in the Delaware River (Burton 1993) in 1992 indicated that sediment plumes fully dissipated by 3,300-feet from the dredge area. The Delaware River study also indicated that mechanical dredging does not alter turbidity or dissolved oxygen to a biologically significant degree and analysis did not reveal a consistent trend of higher turbidity and lower dissolved oxygen within the sediment plume.

Neither the BIW study or the Delaware River study employed a closed environmental bucket dredge; this type of dredge is designed to release even less material into the water column. A study carried out in Boston Harbor monitored TSS levels during dredging with a closed environmental dredge in an area where depths ranged tidally from 38 to 48 feet. The highest TSS level observed with the environmental dredge was 112 mg/L (ACOE 2001).

Hydrodynamic modeling conducted for the Tappan Zee project and discussed in the DEIS (FHWA 2012) indicated that on flood and ebb tides, concentrations of suspended sediment 10 mg/L above ambient conditions may extend in a relatively thin band approximately 1,000 to 2,000 feet from the dredges, while concentrations of 5 mg/L may extend a greater distance. These changes are considered well within the natural variation that has been observed within the Hudson River. For example, during the sampling conducted for the project, TSS concentrations ranged from 13 to 111 mg/L. Data recorded at Poughkeepsie indicated that during higher freshwater flow periods the difference between suspended sediment concentrations can vary by 20 to 40 mg/L.

A layer of sand and gravel (referred to as "armor") will be placed at the bottom of the access channel following dredging. This is being done to minimize the scouring of the bottom from propellers on working tugboats. Sand and gravel will be deposited on the bottom with barge-mounted cranes. The thickness of the deposit will be two feet; resulting depths in the access channel will be 16 feet below MLLW. Deposition of this material will result in increases in suspended sediment and turbidity and could bury benthic resources.

Placement of the sand/gravel armoring material within the dredged area has the potential to result in sediment resuspension when the capping material is deposited upon the sediment. Results of monitoring conducted during placement of granular capping material on soft sediment indicated that resuspended sediment plumes were due to fines washed of the sand cap material and not due to resuspension of bottom sediment as the capping material was put in place (USACE 2005a). Measures would be implemented during placement of the sand layer of the armoring to minimize resuspension of the newly exposed sediment. These measures are the same type of measures that have been demonstrated to successfully cap contaminated sediment with minimal mixing of the cap with contaminated sediment (Palermo *et al.* 2011), and for the capping of subaqueous dredged material (Palermo *et al.* 1998). They include both mechanical (dry sand capping material with bottom-dump barge, side-casting, bucket/clamshell, tremie (gravity-fed downpipe)) and hydraulical (wet/slurry of sand placed from a pipe or tremie, or from a spreader barge) placement of the capping material (USACE 2005a and 2006, USEPA 1994, Palermo *et al.* 2011). Mechanical methods rely on the gravity settling of the granular capping materials in the water column (Palermo *et al.* 2011) which can result in less water column dispersion than discharge of hydraulically-handled cap material because it settles faster in the water column (USACE 1991). Hydraulic methods can allow for a more precise placement of the material at the surface or depth but may require use of a dissipation device to reduce sediment resuspension (Palermo *et al.* 2011, USACE 1991).

Placing sand capping material in layers has been found to allow gentle spreading, resulting in a more stable sand cap (Ling and Leshchinsky undated), and avoiding displacement of or mixing with the underlying sediment (USEPA 2005). This results in a decrease in the turbidity plume with each successive cap layer. The reduction in sediment resuspension observed by placing granular capping material in lifts or layers may afford the ability to place subsequent layers using an alternative methodology that would allow faster placement (USEPA 2008). Therefore, once the sand layer of the proposed armoring is in place, the placement of the gravel would have limited potential to result in sediment resuspension. With the implementation of these methods of placement of granular capping material that have been proven to reduce sediment resuspension during placement, additional sediment resuspension that would occur during the placement of the armoring material would be minimized and would not be expected to result in adverse water quality impacts.

There will also be increases in suspended sediment during cofferdam construction and during pile driving. Available information indicates that turbidity levels during these activities will be about 30% and 40% of average resuspension levels experienced during dredging, respectively (FHWA 2012); therefore, increases in suspended sediment are expected to be less than 50 mg/l. Concentrations of total suspended sediment resulting from pile driving would be elevated approximately 5 to 10 mg/L above background within a few hundred feet of the pile being driven (FHWA 2011b -pDEIS). Increases in concentrations of total suspended sediment resulting from construction vessel movement are projected to be less than 5 mg/L.

Studies of the effects of turbid waters on fish suggest that concentrations of suspended solids can reach thousands of milligrams per liter before an acute toxic reaction is expected (Burton 1993). The studies reviewed by Burton demonstrated lethal effects to fish at concentrations of 580mg/L to 700,000mg/L depending on species. Sublethal effects have been observed at substantially lower turbidity levels. For example, prey consumption was significantly lower for striped bass larvae tested at concentrations of 200 and 500 mg/L compared to larvae exposed to 0 and 75 mg/L (Breitburg 1988 in Burton 1993). Studies with striped bass adults showed that pre-spawners did not avoid concentrations of 954 to 1,920 mg/L to reach spawning sites (Summerfelt and Moiser 1976 and Combs 1979 in Burton 1993). The Normandeau 2001 report identified five species in the Kennebec River for which TSS toxicity information was available. The most sensitive species reported was the four spine stickleback which demonstrated less than 1% mortality after exposure to TSS levels of 100mg/L for 24 hours. Striped bass showed some adverse blood chemistry effects after 8 hours of exposure to TSS levels of 336mg/L. While there have been no directed studies on the effects of TSS on shortnose or Atlantic sturgeon, shortnose and Atlantic sturgeon juveniles and adults are often documented in turbid water and Dadswell (1984) reports that shortnose sturgeon are more active under lowered light conditions, such as those in turbid waters. As such, shortnose and Atlantic sturgeon are assumed to be as least as tolerant to suspended sediment as other estuarine fish such as striped bass.

The life stages of sturgeon most vulnerable to increased sediment are eggs and larvae which are subject to burial and suffocation. As noted above, no eggs and/or larvae will be present in the action area. Juvenile and adult sturgeon are frequently found in turbid water and would be capable of avoiding any sediment plume by swimming higher in the water column. Laboratory studies (Niklitschek 2001 and Secor and Niklitschek 2001) have demonstrated shortnose sturgeon are able to actively avoid areas with unfavorable water quality conditions and that they will seek out more favorable conditions when available. TSS is most likely to affect subadult or adult Atlantic sturgeon if a plume causes a barrier to normal behaviors or if sediment settles on the bottom affecting their benthic prey. Because any increase in suspended sediment is likely to be within the range of normal suspended sediment levels in the Hudson River, it is unlikely to affect the movement of individual sturgeon. Even if the movements of sturgeon were affected, these changes would be small. As sturgeon are highly mobile any effect on their movements or behavior is likely to be insignificant. Additionally, the TSS levels expected (<112mg/l) are below those shown to have an adverse effect on fish (580.0 mg/L for the most sensitive species, with 1,000.0 mg/L more typical; see summary of scientific literature in Burton 1993) and benthic communities (590.0 mg/L (EPA 1986)); therefore, effects to benthic resources that sturgeon may eat are extremely unlikely. Based on this information, it is likely that the effects of increased suspended sediment and turbidity will be insignificant.

8.7 Contaminant Exposure

Resuspension of sediments by dredging or pile installation may release contaminants into the water column from either sediment pore water or from contaminants that partition from the sediment's solid phase. However, due to the nature of sediments in the bridge vicinity (i.e., low levels of contamination), and the limited areal extent of any sediment plume expected to be generated, any mobilization of contaminated sediments is expected to be minor (FHWA 2012). Contaminants may be released from the pore water of the sediments, on the resuspended sediments or may dissolve into the water. Although limited SVOCs, pesticide, PCBs and TCDD were detected in the sediments in the area of the bridge, FHWA has concluded that because of the low detection rates and low concentrations of these contaminants, there would be no measurable increase in the level of these contaminants in the area.

In order to evaluate the potential for any resuspension of sediment during the project releasing contaminants into the water column and affecting shortnose or Atlantic sturgeon, FHWA considered the potential release of contaminants compared to the NYSDEC water quality criteria.

Water quality criteria are developed by EPA for protection of aquatic life. Both acute (short term exposure) and chronic (long term exposure) water quality criteria are developed by EPA based on toxicity data for plants and animals. Often, both saltwater and freshwater criteria are developed, based on the suite of species likely to occur in the freshwater or saltwater environment. For aquatic life, the national recommended toxics criteria are derived using a methodology published in *Guidelines for Deriving Numeric National Water Quality Criteria for the Protection of Aquatic Organisms and Their*

Uses. Under these guidelines, criteria are developed from data quantifying the sensitivity of species to toxic compounds in controlled chronic and acute toxicity studies. The final recommended criteria are based on multiple species and toxicity tests. The groups of organisms are selected so that the diversity and sensitivities of a broad range of aquatic life are represented in the criteria values. To develop a valid criterion, toxicity data must be available for at least one species in each of eight families of aquatic organisms. The eight taxa required are as follows: (1) salmonid (e.g., trout, salmon); (2) a fish other than a salmonid (e.g., bass, fathead minnow); (3) chordata (e.g., salamander, frog); (4) planktonic crustacean (e.g., daphnia); (5) benthic crustacean (e.g., crayfish); (6) insect (e.g., stonefly, mayfly); (7) rotifer, annelid (worm), or mollusk (e.g., mussel, snail); and, (8) a second insect or mollusk not already represented. Where toxicity data are available for multiple life stages of the same species (e.g., eggs, juveniles, and adults), the procedure requires that the data from the most sensitive life stage be used for that species.

The result is the calculation of acute (criteria maximum concentration (CMC)) and chronic (criterion continuous concentration (CCC)) criteria. CMC is an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed briefly (i.e., for no more than one hour) without resulting in an unacceptable effect. The CCC is an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed indefinitely without resulting in an unacceptable effect. EPA defines "unacceptable acute effects" as effects that are lethal or immobilize an organism during short term exposure to a pollutant and defines "unacceptable chronic effects" as effects that will impair growth, survival, and reproduction of an organism following long term exposure to a pollutant. The CCC and CMC levels are designed to ensure that aquatic species exposed to pollutants in compliance with these levels will not experience any impairment of growth, survival or reproduction.

Data on toxicity as it relates to shortnose and Atlantic sturgeon is extremely limited. In the absence of species specific chronic and acute toxicity data, the EPA aquatic life criteria represent the best available scientific information. Absent species specific data, NMFS believes it is reasonable to consider that the CMC and CCC criteria are applicable to NMFS listed species as these criteria are derived from data using the most sensitive species and life stages for which information is available. As explained above, a suite of species is utilized to develop criteria and these species are intended to be representative of the entire ecosystem, including marine mammals and sea turtles and their prey. These criteria are designed to not only prevent mortality but to prevent all "unacceptable effects", which, as noted above, is defined by EPA to include not only lethal effects but also effects that impair growth, survival and reproduction.

Table 14. FHWA's Comparison of Calculated Water Concentrations to NYSDEC TOGS 1.1.1 and EPA Water Quality Criteria.

Contaminant	**Expected Water Concentration (mg/L) 500 feet down river of dredged based on 164 mg/L sediment Plume**	**Expected Water Concentration (ug/L)**	**NYSDEC Water Quality Criteria (ug/L) (Hudson River classified as Class SB (A(C))**	**EPA Water Quality Criteria (CMC and CCC) ug/L**	
Arsenic	1.33E-04	0.133	63	69	36
Cadmium	1.79E-05	0.0189	7.7	40	8.8
Copper	3.18E-04	0.318	3.4	4.8	3.1
Lead	8.02E-05	0.0802	8	210	8.1
Mercury	3.56E-06	0.00356	0.05	1.8	0.94
Total PCBs	4.99E-07	0.000499	0.000001	-	0.014

With the exception of Total PCBs, expected water concentrations of the contaminants that may be mobilized during the bridge replacement project are well below the NYSDEC and EPA water quality criteria. Levels of Total PCBs may be above the NYSDEC water quality criteria at 500 feet from the dredge, but the concentrations are still well below the EPA's criteria for PCB exposure. Based on this reasoning outlined above, for the purposes of this consultation, we consider that the exposure to contaminants at levels below the acute and chronic water quality criteria will not cause effects that impair growth, survival and reproduction of listed species. Therefore, the effect of any exposure to these contaminants at levels that are far less that the relevant water quality standards, which by design are consistent with, or more stringent than, EPA's aquatic life criteria, will be insignificant on shortnose and Atlantic sturgeon.

8.8 Bridge Demolition

Bridge demolition would occur in two stages. The first stage includes partial demolition to allow for construction of the replacement bridge in the vicinity of the Westchester shoreline. The second stage includes the remaining demolition after completion of the replacement bridge. Use of turbidity curtains during removal of the columns and footings and cutting of the timber piles would minimize the potential for sediment resuspended during the bridge removal activities to affect water quality. Following removal of the existing bridge, sediment that has been deposited within mounds in the vicinity of the existing bridge piers may erode over time until reaching a new equilibrium elevation. Because the Tappan Zee portion of the Hudson River is considered to be neither a depositional or erosional environment (i.e., in equilibrium) (Nitsche *et al.* 2007), the erosion of these sediments in the vicinity of the existing bridge would be limited under normal river conditions and would most likely occur during high flow events. While some of these sediment deposits have elevated concentrations of certain contaminants (Class B or Class C categories), these elevated concentrations do not extend more than a few feet below the mudline. Therefore, the gradual erosion of some areas of contaminated sediment following the removal of the bridge would not be expected to result in adverse impacts to water quality or result in water quality conditions that fail to meet the Class SB standards.

Turbidity curtains would be used during removal of the columns and footings as well as cutting of the timber piles would minimize the potential for sediment that may be resuspended during bridge removal activities to affect benthic macroinvertebrates and other aquatic biota. Since the benthic sampling program for the project indicated similar benthic community structure in bottom sediments at both existing and proposed bridge location, and because the demolition is not expected to substantially alter sediment chäracteristics, the benthic community recolonizing the restored bottom habitat following bridge demolition is expected to be similar to surrounding areas. Demolition of the existing bridge would also remove the benthic invertebrates and algae that are attached to the bridge, which provide forage and structural habitat for fish. However, the new bridge would offset much of these losses by providing similar structural habitat for these species. Any effects to sturgeon due to increased water column suspended sediments from bridge demolition activities are expected to be minimal and temporary, and effects to feeding or behavior would be insignificant.

8.9 Operation of new bridge

Potential effects of the new bridge include habitat alteration/loss of benthic habitat, shading and storm water runoff. These effects are considered below. It is important to note that because the existing bridge will be removed, there is not likely to be a net change in the conditions in the river as compared to now. The new bridge is expected to have an operational life of approximately 100 years before substantial structural replacements would be required. The total anticipated lifespan before a new crossing is needed would be 150 years.

8.9.1 Shading

Shading of estuarine habitats can result in decreased light levels and reduced benthic and water-column primary production, both of which may adversely affect invertebrates and fishes that use these areas, particularly with respect to use as refuge and foraging habitat (Able *et al.* 1998, and Struck *et al.* 2004). The amount of area shaded by overwater structures will be affected by the height and width of the structure, construction materials and orientation of the structure relative to the arc of the sun (Burdick and Short 1995, Fresh *et al.* 1995 and 2000, Olson *et al.* 1996, 1997 in Nightingale and Simenstad 2001) as well as piling density. Shading due to bridges has been found to affect plant communities such as tidal marshes and SAV, as well as benthic invertebrate communities within tidal marshes (Struck *et al.* 2004, and Broome *et al.*, 2005 in CZR 2009). However, adverse effects on marsh vegetation and benthic macroinvertebrates have been found to be minimal when the bridge height-to-width ratio is greater than 0.7 (Struck et al, 2004, Broome *et al.* 2005 in CZR 2009). Significantly fewer oligochaete worms, which are common in the Hudson River, were found under bridges with a height-to-width ratio less than 0.7 when compared to marshes not affected by shading (Struck *et al.* 2004). Struck *et al.* (2004) found that bridges with height-to-width ratios greater than 1.5 had the lowest light attenuation beneath the bridge.

Because the elevations of the existing Tappan Zee Bridge and the new bridge are not consistent over the length of the structure, the height-to-width ratio of the bridge varies along its length. The two spans of the new bridge would be separated by a gap up to 70 feet. While there are no vegetated wetlands or SAV that could be affected by the construction of the new bridge, the height-to-width ratios presented below provide an indication of the potential for the existing and new bridges to result in shading impacts. The height-to-width ratio for the portion of the existing bridge within the causeway is low, ranging from 0.25 to 0.34). The ratio for these same stations for the new bridge, Short and Long Span Options, are generally much higher, ranging from 0.21 near the shoreline to 1.07, with the ratios for the Long Span Option being slightly less because the height for this approach option is lower. The portion of the western approach just prior to the main span (has a ratio that ranges from 0.60 to 1.11 for the existing bridge. Again, the ratios of these stations for the new bridge are much greater, ranging from

1.07 to 1.47. The ratio for the main span of the existing bridge is 1.57 and for the replacement bridge 1.39 to 1.67, while the ratios for the eastern approach are fairly similar for the existing and new bridge, ranging from 0.89 to 1.43 with the Long Span Option for the new bridge having the lower ratios.

The separation between the decks of the two spans (i.e., 70 feet at the main span and then decreasing toward the shorelines) allows light to penetrate between the two structures. This represents the best case analysis. Under this case, the new bridge would result in a lower potential for shading of aquatic habitat compared to the existing bridge, particularly along the causeway (western approach to the main span). Even under the worst case, which assumes no separation between the spans of the new bridge and which would conservatively result in a halving of the height-to-width ratios presented above, the new bridge would still result in greater ratios (i.e., less shading) than the existing bridge for the western approach, but may result in more shading than the existing bridge for the eastern approach. Overall, the height-to-width ratios indicate that even if the new bridge was treated as a single structure, with no separation between the spans, there would be a decrease in the potential for shading impacts to aquatic resources along much of the bridge route. The approximately 99,153-square foot permanent platform at the Rockland Bridge Landing would result in additional aquatic habitat affected by shading. Considering the extensive area of aquatic habitat not affected by shading within the area, any effects to sturgeon from the additional shading caused by the permanent platform and by the bridge are extremely unlikely.

8.9.2 Habitat Alteration

Because the existing bridge will be removed and the new bridge piers will have a smaller footprint, the only net change in available benthic habitat will be from the permanent platform to be located along the Rockland County shoreline. The DEIS indicated that construction of the permanent platform along the Rockland County shoreline would result in the loss of 2.16 acres of benthic habitat. Revisions to the construction plans since the DEIS was drafted have reduced the acreage of habitat loss due to the permanent platform to 0.12 acres. The area of permanent habitat loss is equivalent to <0.01% of the available soft-sediment benthic habitat in the Tappan Zee region (RMs 24-33). The permanent platform will be constructed in water depths of 6-10 feet and will extend out from the Rockland County shoreline along the upstream edge of the proposed bridge. The platform will be located approximately 1.5 miles from the 20-foot depth contour and the edge of the navigation channel. Sturgeon are only likely to be present in the shallow waters along the shoreline if suitable forage is present. The effects of the loss of forage are considered above and were determined to be insignificant. Given the small size of the platform and the extremely small loss of soft-bottom benthic habitat, effects to sturgeon are likely to be limited to the loss insignificant and discountable.

8.9.3 Stormwater Runoff

Stormwater runoff will flow directly from the decks of the replacement bridge to the Hudson River. Because the existing bridge will be removed, there is little net change in stormwater runoff anticipated. NYSDEC General Permit GP-0-10-001 regulates the discharge of stormwater runoff from construction activities associated with soil disturbance, including both water quality and quantity controls. NYSDEC requires treatment of stormwater runoff from areas of soil disturbance to improve water quality, as well as a reduction of peak flows of stormwater runoff providing channel protection, overbank flood protection and flood control. The stormwater quality management goals are to achieve an 80 percent reduction in TSS and a 40 percent reduction in total phosphorous (TP).

The Hudson River is not on the State's Section 303(d) list of waterbodies impaired by stormwater runoff or within a watershed improvement strategy area. Stormwater runoff from the existing bridge is therefore not impairing water quality in the action area. As noted in the DEIS, with the implementation of post-construction or long-term quality treatment controls at the bridge landings, the net concentration of pollutants to the Hudson River from the new bridge is expected to decrease for TSS and increase by only 4.6 pounds per year for TP. FHWA has determined that this increase in TP loadings from the new bridge would not result in adverse impacts to water quality of the Hudson River, or result in a failure to meet the Class SB water quality standards. As such, effects to shortnose and Atlantic sturgeon from the discharge of stormwater to the Hudson River from the new bridge will be insignificant and discountable.

8.9.4 Climate Change Related Effects

In the DEIS, FHWA considers effects of the construction and operation of the new bridge on greenhouse gas (GHG) emissions and energy use. According to FHWA, the new bridge would not increase traffic volumes or reduce vehicle speeds; therefore, fuel consumption and greenhouse gas emissions would be largely unaffected by the shift in traffic from the existing bridge to the new bridge.

As noted in the DEIS, while the contribution of any single project to climate change is infinitesimal, the combined GHG emissions from all human activity impact the global climate. Total GHG emissions associated with construction of the project are projected to be approximately 0.5 million metric tons, with emissions from the Short Span Option approximately 12 percent higher than the Long Span Option. Annual global emissions of GHG are currently approximately 9 billion metric tons; the contribution from the bridge replacement project are approximately 0.006% of total global emissions. As there is an extremely small contribution to total global emissions, we expect any effect of these emissions on listed species to be insignificant and discountable.

In sections 5.0 and 7.0 above we considered effects of global climate change, generally, on shortnose and Atlantic sturgeon. Given the likely rate of climate change, it is unlikely that there will be any noticeable effects to shortnose or Atlantic sturgeon in the action area during the time period when the Tappan Zee Bridge is being replaced (i.e., through 2016). It is possible that there will be effects to sturgeon over the time period that the new bridge is in place (expected to be a 100 year period); as explained above, based on currently available information and predicted habitat changes, these effects are most likely to be changes in distribution of sturgeon throughout the Hudson River and changes in seasonal migrations through the Tappan Zee reach of the river. The presence and continued use of the bridge over the next 100 years will not affect the ability of these species to adapt to climate change or affect their movement or distribution within the river.

9.0 CUMULATIVE EFFECTS

Cumulative effects, as defined in 50 CFR 402.02, are those effects of future State or private activities, not involving Federal activities, which are reasonably certain to occur within the action area. Future Federal actions are not considered in the definition of "cumulative effects."

Activities reasonably certain to occur in the action area and that are s carried out or regulated by the States of New York and New Jersey and that may affect shortnose and Atlantic sturgeon include the authorization of state fisheries and the regulation of point and non-point source pollution through the National Pollutant Discharge Elimination System. We are not aware of any local or private actions that are reasonably certain to occur in the action area that may affect listed species. It is important to note that the definition of "cumulative effects" in the section 7 regulations is not the same as the NEPA definition of cumulative effects. The activities discussed in the Cumulative Effects section of the DEIS - Champlain-Hudson Power Express and dredging at the US Gypsum and American Sugar facilities – will require authorization by the US Army Corps of Engineers, therefore they are considered future

Federal actions and do not meet the definition of "cumulative effects" under the ESA and are not considered here.

While there may be other in-water construction or coastal development within the action area, all of these activities are likely to need a permit or authorization from the US Army Corps of Engineers and would therefore, be subject to section 7 consultation.

State Water Fisheries - Future recreational and commercial fishing activities in state waters may take shortnose and Atlantic sturgeon. In the past, it was estimated that up to 100 shortnose sturgeon were captured in shad fisheries in the Hudson River each year, with an unknown mortality rate. Atlantic sturgeon were also incidentally captured in NY state shad fisheries. In 2009, NY State closed the shad fishery indefinitely. That state action is considered to benefit both sturgeon species. Should the shad fishery reopen, shortnose and Atlantic sturgeon would be exposed to the risk of interactions with this fishery. However, NMFS has no indication that reopening the fishery is reasonably certain to occur.

Information on interactions with shortnose and Atlantic sturgeon for other fisheries operating in the action area is not available, and it is not clear to what extent these future activities would affect listed species differently than the current state fishery activities described in the Status of the Species/Environmental Baseline section. However, this Opinion assumes effects in the future would be similar to those in the past and are, therefore, reflected in the anticipated trends described in the status of the species/environmental baseline section.

State PDES Permits – The states of New York and New Jersey have been delegated authority to issue NPDES permits by the EPA. These permits authorize the discharge of pollutants in the action area. Some of the facilities that operate pursuant to these permits are included in the Environmental Baseline (e.g., Indian Point). Other permitees include municipalities for sewage treatment plants and other industrial users. The states will continue to authorize the discharge of pollutants through the SPDES permits. However, this Opinion assumes effects in the future would be similar to those in the past and are therefore reflected in the anticipated trends described in the status of the species/environmental baseline section.

10.0 INTEGRATION AND SYNTHESIS OF EFFECTS

Dredging to be carried out during the bridge replacement project is expected to result in the capture of three shortnose sturgeon and three Atlantic sturgeon, with the injury or mortality of one of these shortnose sturgeon and one of these Atlantic sturgeon. The number of sturgeon exposed to underwater noise that could result in physiological effects depends on whether the short span or long span bridge replacement is chosen. Because the short span option involves the installation of more piles, more sturgeon are likely to be exposed to noise that could result in effects. Pile driving carried out for the short span bridge option is expected to result in the injury of 70 or fewer shortnose sturgeon and 70 or fewer Atlantic sturgeon (64 New York Bight DPS, four Chesapeake Bay DPS, and two Gulf of Maine DPS). Pile driving carried out for the long span bridge option is expected to result in the injury of 43 or fewer shortnose sturgeon and 43 or fewer Atlantic sturgeon (40 New York Bight DPS, two Chesapeake Bay DPS, and one Gulf of Maine DPS). Normal sturgeon behavior is expected to result in avoidance of areas loud enough to cause significant injury or mortality. However, due to the length of the project and the duration of pile driving, we expect that no more than one shortnose sturgeon and no more than one Atlantic sturgeon will suffer serious injury or mortality due to exposure to pile driving noise. The two Atlantic sturgeon that are likely to be seriously injured or killed during dredging and pile driving are likely to be New York Bight DPS; however it is possible that they could also originate from the Gulf of Maine or Chesapeake Bay DPS. As explained in the "Effects of the Action" section of the Opinion, with the exception of the one shortnose sturgeon and one Atlantic sturgeon, none of these sturgeon are expected to die, immediately or later, as a result of exposure to increased underwater noise levels resulting from pile driving. All injuries are anticipated to be minor and any injured individuals are expected to make a full recovery with no impact to future survival or fitness.

Additionally, any shortnose and Atlantic sturgeon present in the action area when impact pile driving is occurring may be exposed to levels of underwater noise which may alter their normal behaviors. These behaviors are expected to occur in areas where underwater noise is elevated above 150 dB re 1 μPa RMS. Behavioral changes could range from a startle response followed by resumption of normal behaviors to complete avoidance of the ensonified area over the duration that the elevated noise will be experienced. As explained above, effects of this temporary behavioral disturbance will be insignificant and discountable. As explained in the "Effects of the Action" section, effects of the bridge replacement project on shortnose and Atlantic sturgeon also include exposure to noise resulting from the installation of piles by vibration, drilling to facilitate the installation of some piles, potential exposure to contaminants, a localized increase in vessel traffic, effects to prey items, and effects of dredge disposal at HARS. We have determined that all behavioral effects will be insignificant and discountable. We do not anticipate any take of shortnose sturgeon due to any of the other effects including vessel traffic and dredge disposal.

In the discussion below, NMFS considers whether the effects of the proposed action reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of the listed species in the wild by reducing the reproduction, numbers, or distribution of shortnose sturgeon and each of three DPSs of Atlantic sturgeon. The purpose of this analysis is to determine whether the proposed action, in the context established by the status of the species, environmental baseline, and cumulative effects, would jeopardize the continued existence of shortnose sturgeon. In the NMFS/USFWS Section 7 Handbook, for the purposes of determining jeopardy, survival is defined as, "the species' persistence as listed or as a recovery unit, beyond the conditions leading to its endangerment, with sufficient resilience to allow for the potential recovery from endangerment. Said in another way, survival is the condition in which a species continues to exist into the future while retaining the potential for recovery. This condition is characterized by a species with a sufficient population, represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring, which exists in an environment providing all requirements for completion of the species' entire life cycle, including reproduction, sustenance, and shelter." Recovery is defined as, "Improvement in the status of listed species to the point at which listing is no longer appropriate under the criteria set out in Section 4(a)(1) of the Act." Below, for the listed species that may be affected by the proposed action, we summarize the status of the species and consider whether the proposed action will result in reductions in reproduction, numbers or distribution of these species and then considers whether any reductions in reproduction, numbers or distribution resulting from the proposed action would reduce appreciably the likelihood of both the survival and recovery of these species, as those terms are defined for purposes of the federal Endangered Species Act.

10.1 Shortnose sturgeon

Historically, shortnose sturgeon are believed to have inhabited nearly all major rivers and estuaries along nearly the entire east coast of North America. Today, only 19 populations remain. The present range of shortnose sturgeon is disjunct, with northern populations separated from southern populations by a distance of about 400 km. Population sizes range from under 100 adults in the Cape Fear and Merrimack Rivers to tens of thousands in the St. John and Hudson Rivers. As indicated in Kynard 1996, adult abundance is less than the minimum estimated viable population abundance of 1,000 adults for 5 of 11 surveyed northern populations and all natural southern populations. The only river systems likely supporting populations close to expected abundance are the St John, Hudson and possibly the Delaware and the Kennebec (Kynard 1996), making the continued success of shortnose sturgeon in these rivers critical to the species as a whole.

The Hudson River population of shortnose sturgeon is the largest in the United States. Historical estimates of the size of the population are not available as historic records of sturgeon in the river did not discriminate between Atlantic and shortnose sturgeon. Population estimates made by Dovel *et al.* (1992) based on studies from 1975-1980 indicated a population of 13,844 adults. Bain *et al.* (1998) studied shortnose sturgeon in the river from 1993-1997 and calculated an adult population size of 56,708 with a 95% confidence interval ranging from 50,862 to 64,072 adults. Bain determined that based on sampling effort and methodology his estimate is directly comparable to the population estimate made by Dovel *et al.* Bain concludes that the population of shortnose sturgeon in the Hudson River in the 1990s was 4 times larger than in the late 1970s. Bain states that as his estimate is directly comparable to the estimate made by Dovel, this increase is a "confident measure of the change in population size." Bain concludes that the Hudson River population is large, healthy and particular in habitat use and migratory behavior. Woodland and Secor (2007) conducted studies to determine the cause of the increase in population size. Woodland and Secor captured 554 shortnose sturgeon in the Hudson River and made age estimates of these fish. They then hindcast year class strengths and corrected for gear selectivity and cumulative mortality. The results of this study indicated that there was a period of high recruitment (31,000 – 52,000 yearlings) in the period 1986-1992 which was preceded and succeeded by 5 years of lower recruitment (6,000 – 17,500 yearlings/year). Woodland and Secor reports that there was a 10-fold recruitment variability (as measured by the number of yearlings produced) over the 20-year period from the late 1970s to late 1990s and that this pattern is expected in a species, such as shortnose sturgeon, with periodic life history characterized by delayed maturation, high fecundity and iteroparous spawning, as well as when there is variability in interannual hydrological conditions. Woodland and Secor examined environmental conditions throughout this 20-year period and determined that years in which water temperatures drop quickly in the fall and flow increases rapidly in the fall (particularly October), are followed by high levels of recruitment in the spring. This suggests that these environmental factors may index a suite of environmental cues that initiate the final stages of gonadal development in spawning adults.

The Hudson River population of shortnose sturgeon has exhibited tremendous growth in the 20-year period between the late 1970s and late 1990s. Woodland and Secor conclude that this is a robust population with no gaps in age structure. Lower recruitment that followed the 1986-1992 period is coincident with record high abundance suggesting that the population may be reaching carrying capacity. The population in the Hudson River exhibits substantial recruitment and is considered to be stable at high levels.

While no reliable estimate of the size of either the shortnose sturgeon population in the Northeastern US or of the species throughout its range exists, it is clearly below the size that could be supported if the threats to shortnose sturgeon were removed. Based on the number of adults in population for which estimates are available, there are at least 104,662 adult shortnose sturgeon, including 18,000 in the Saint John River in Canada. The lack of information on the status of some populations, such as that in the Chesapeake Bay, add uncertainty to any determination on the status of this species as a whole. Based on the best available information, NMFS believes that the status of shortnose sturgeon throughout their range is stable (Bowers-Altman *et al.* 2012 Draft).

As described in the Status of the Species, Environmental Baseline, and Cumulative Effects sections above, shortnose sturgeon in the Hudson River are affected by impingement at water intakes, habitat alteration, bycatch in commercial and recreational fisheries, water quality and in-water construction activities. It is difficult to quantify the number of shortnose sturgeon that may be killed in the Hudson River each year due to anthropogenic sources. Through reporting requirements implemented under Section 7 and Section 10 of the ESA, for specific actions NMFS obtains some information on the number of incidental and directed takes of shortnose sturgeon each year. Typically, scientific research results in the capture and collection of less than 100 shortnose sturgeon in the Hudson River each year, with little if any mortality. NMFS has no reports of interactions or mortalities of shortnose sturgeon in the Hudson River resulting from dredging or other in-water construction activities. NMFS also has no quantifiable information on the effects of habitat alteration or water quality; in general, water quality has improved in the Hudson River since the 1970s when the CWA was implemented. NMFS also has anecdotal evidence that shortnose sturgeon are expanding their range in the Hudson River and fully utilizing the river from the Manhattan area upstream to the Troy Dam, which suggests that the movement and distribution of shortnose sturgeon in the river is not limited by habitat or water quality impairments. Impingement at the Roseton and Danskammer plants is regularly reported to NMFS. Since reporting requirements were implemented in 2000, less than the exempted number of takes (6 total for the two facilities) have occurred each year. Impingement also occurs at Indian Point; we have estimated an annual impingement rate of approximately eight sturgeon per year. Despite these ongoing threats, there is evidence that the Hudson River population of shortnose sturgeon experienced tremendous growth between the 1970s and 1990s and that the population is now stable at high numbers. Over the life of the action, shortnose sturgeon in the Hudson River will continue to experience anthropogenic and natural sources of mortality. However, we are not aware of any future actions that are reasonably certain to occur that are likely to change this trend or reduce the stability of the Hudson River population. Also, as discussed above, we do not expect shortnose sturgeon to experience any new effects associated with climate change during the 3-4 year duration of the bridge construction. While climate change related effects to distribution in the river may occur during the period that the new Tappan Zee Bridge is in existence, the presence of the new bridge will not exacerbate or contribute to these effects or impact the ability of shortnose sturgeon to adapt to changing conditions in the river. As such, NMFS expects that numbers of shortnose sturgeon in the action area will continue to be stable at high levels over the life of the proposed action.

NMFS has estimated that the proposed bridge replacement project will result in minor injury to no more than 70 shortnose sturgeon and that two shortnose sturgeon are likely to be killed. Other than for the fish that are killed, physiological effects are expected to be limited to minor injuries that will not impair the fitness of any individuals or affect survival. Behavioral responses are expected to be temporally and spatially limited to the area and time when underwater noise levels are greater than 150dB RMS and as such will be limited to only several hours at a time, and always less than 12 hours per day for no more than 5 hours per day. The potential for behavioral responses is limited to the time when impact pile driving will take place and is therefore limited to a period of less than 12 hours per day; over the duration of the Tappan Zee construction project, pile driving will be ongoing for approximately 7% of the time. Therefore, for the vast majority of time there will be no potential for behavioral disturbance. Behavioral responses could range from a temporary startle to avoidance of the ensonified area. We have determined that any behavioral responses, including in the worst case, complete avoidance of the ensonified area, would have insignificant and discountable effects to individuals. This is because while individuals may be displaced from, or avoid, the ensonified area: (1) there will always be some river width with noise levels less than 150 dB re 1uPa RMS which would allow unimpeded passage through this reach of the river; (2) any changes in movements would be limited to a period of no more than 12 hours per day when pile driving would be occurring (in total no more than 7% of the entire project duration); (3) it is extremely unlikely that there would be any delay to the spawning migration or abandonment of spawning migrations; (4) there is not expected to be any increase in energy expenditure that has any detectable effect on the physiology of any individuals or any future effect on growth, reproduction, or general health, and, (5) any minor changes in behavior resulting from exposure to increased underwater noise associated with the pile driving will not preclude any shortnose sturgeon from completing any normal behaviors such as resting, foraging or migrating or that the fitness of any individuals will be affected.

The number of shortnose sturgeon that are likely to die as a result of the proposed bridge replacement project (two), represents an extremely small percentage of the shortnose sturgeon population in the Hudson River, which is believed to be stable at high numbers, and an even smaller percentage of the total population of shortnose sturgeon rangewide, which is also stable. The best available population estimates indicate that there are approximately 56,708 (95% CI=50,862 to 64,072) adult shortnose sturgeon in the Hudson River and an unknown number of juveniles (Bain 2007). While the death of up to 2 shortnose sturgeon over the five year construction period will reduce the number of shortnose sturgeon in the population compared to the number that would have been present absent the proposed action, it is not likely that this reduction in numbers will change the status of this population or its stable trend as this loss represents a very small percentage of the population (less than 0.004%).

Reproductive potential of the Hudson population is not expected to be affected in any other way other than through a reduction in numbers of individuals. A reduction in the number of shortnose sturgeon in the Hudson River would have the effect of reducing the amount of potential reproduction in this system as the fish killed would have no potential for future reproduction. However, it is estimated that on average, approximately 1/3 of adult females spawn in a particular year and approximately ½ of males spawn in a particular year. Given that the best available estimates indicate that there are more than 56,000 adult shortnose sturgeon in the Hudson River, it is reasonable to expect that there are at least 20,000 adults spawning in a particular year. It is unlikely that the loss of two shortnose sturgeon over a 5-year period would affect the success of spawning in any year. Additionally, this small reduction in potential spawners is expected to result in a small reduction in the number of eggs laid or larvae produced in future years and similarly, a very small effect on the strength of subsequent year classes. Even considering the potential future spawners that would be produced by the individuals that would be killed as a result of the proposed action, any effect to future year classes is anticipated to be very small and would not change the stable trend of this population. Additionally, the proposed action will not affect spawning habitat in any way and will not create any barrier to pre-spawning sturgeon accessing the overwintering sites or the spawning grounds.

The proposed action is not likely to reduce distribution because the action will not impede shortnose sturgeon from accessing any seasonal concentration areas, including foraging, spawning or overwintering grounds in the Hudson River. Further, the action is not expected to reduce the river by river distribution of shortnose sturgeon. Additionally, as the number of shortnose sturgeon likely to be killed as a result of the proposed action is less than 0.004% of the Hudson River population, there is not likely to be a loss of any unique genetic haplotypes and therefore, it is unlikely to result in the loss of genetic diversity.

While generally speaking, the loss of a small number of individuals from a subpopulation or species can have an appreciable effect on the numbers, reproduction and distribution of the species, this is likely to occur only when there are very few individuals in a population, the individuals occur in a very limited geographic range or the species has extremely low levels of genetic diversity. This situation is not likely in the case of shortnose sturgeon because: the species is widely geographically distributed, it is not known to have low levels of genetic diversity (see status of the species/environmental baseline section above), and there are thousands of shortnose sturgeon spawning each year.

Based on the information provided above, the death of up to two shortnose sturgeon over a 5-year period resulting from the proposed construction of a bridge to replace the existing Tappan Zee Bridge, will not appreciably reduce the likelihood of survival of this species (*i.e.*, it will not decrease the likelihood that the species will continue to persist into the future with sufficient resilience to allow for the potential recovery from endangerment). The action will not affect shortnose sturgeon in a way that prevents the species from having a sufficient population, represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring, and it will not result in effects to the environment which would prevent shortnose sturgeon from completing their entire life cycle, including reproduction, sustenance, and shelter. This is the case because: (i.e., it will not increase the risk of extinction faced by this species) given that: (1) the population trend of shortnose sturgeon in the Hudson River is stable; (2) the death of up to two shortnose sturgeon represents an extremely small percentage of the number of shortnose sturgeon in the Hudson River and an even smaller percentage of the species as a whole; (3) the loss of these shortnose sturgeon is likely to have such a small effect on reproductive output of the Hudson River population of shortnose sturgeon or the species as a whole that the loss of these shortnose sturgeon will not change the status or trends of the Hudson River population or the species as a whole; (4) the action will have only a minor and temporary effect on the distribution of shortnose sturgeon in the action area (related to movements to avoid the ensonified area) and no effect on the distribution of the species throughout its range; and, (5) the action will have no effect on the ability of shortnose sturgeon to shelter and only an insignificant effect on individual foraging shortnose sturgeon.

In certain instances, an action that does not appreciably reduce the likelihood of a species' survival might affect its likelihood of recovery or the rate at which recovery is expected to occur. As explained above, NMFS has determined that the proposed action will not appreciably reduce the likelihood that shortnose sturgeon will survive in the wild. Here, NMFS considers the potential for the action to reduce the likelihood of recovery. As noted above, recovery is defined as the improvement in status such that listing is no longer appropriate. Section 4(a)(1) of the ESA requires listing of a species if it is in danger of extinction throughout all or a significant portion of its range (i.e., "endangered"), or likely to become in danger of extinction throughout all or a significant portion of its range in the foreseeable future (i.e., "threatened") because of any of the following five listing factors: (1) the present or threatened destruction, modification, or curtailment of its habitat or range, (2) overutilization for commercial, recreational, scientific, or educational purposes, (3) disease or predation, (4) the inadequacy of existing regulatory mechanisms, (5) other natural or manmade factors affecting its continued existence.

The proposed action is not expected to modify, curtail or destroy the range of the species since it will result in a small reduction in the number of shortnose sturgeon in the Hudson River and since it will not affect the overall distribution of shortnose sturgeon other than to cause minor temporary adjustments in movements in the action area. The proposed action will not utilize shortnose sturgeon for recreational, scientific or commercial purposes or affect the adequacy of existing regulatory mechanisms to protect this species. The proposed action is likely to result in the mortality of up to 2 shortnose sturgeon;

however, over the 5-year construction period, the loss of these individuals and what would have been their progeny is not expected to affect the persistence of the Hudson River population of shortnose sturgeon or the species as a whole. The loss of these individuals will not change the status or trend of the Hudson River population, which is stable at high numbers. As it will not affect the status or trend of this population, it will not affect the status or trend of the species as a whole. As the reduction in numbers and future reproduction is very small, this loss would not result in an appreciable reduction in the likelihood of improvement in the status of shortnose sturgeon throughout their range. The effects of the proposed action will not hasten the extinction timeline or otherwise increase the danger of extinction since the action will cause the mortality of only a small percentage of the shortnose sturgeon in the Hudson River and an even smaller percentage of the species as a whole and these mortalities are not expected to result in the reduction of overall reproductive fitness for the species as a whole. The effects of the proposed action will also not reduce the likelihood that the status of the species can improve to the point where it is recovered and could be delisted. Therefore, the proposed action will not appreciably reduce the likelihood that shortnose sturgeon can be brought to the point at which they are no longer listed as endangered or threatened. Based on the analysis presented herein, the proposed action, resulting in the mortality of no more than 2 shortnose sturgeon over the 5-year construction period is not likely to appreciably reduce the survival and recovery of this species.

10.2 Atlantic sturgeon

10.2.1 Determination of DPS Composition

As explained above, the proposed action is likely to result in the capture of three Atlantic sturgeon in the dredge, the injury of 70 or fewer Atlantic sturgeon due to exposure to underwater noise, and the mortality of two Atlantic sturgeon (one in the dredge and one due to noise exposure). We have considered the best available information to determine from which DPSs these individuals are likely to have originated. Using mixed stock analysis explained above, we have determined that Atlantic sturgeon in the action area likely originate from three DPSs at the following frequencies: NYB 92%; Gulf of Maine 6%; and, Chesapeake Bay 2%. Given these percentages, we expect that for the short span bridge option, of the 70 injured fish, 64 will originate from the NYB DPS, four from the GOM DPS and 2 from the CB DPS. Of the three fish likely to be captured in the dredge, two are likely to be from the NYB DPS and the other will be from the CB or GOM DPS. The two Atlantic sturgeon likely to be killed are most likely to be NYB DPS; however, it is possible that they could be GOM or CB fish.

For the long span bridge option, of the 43 injured fish, 40 will originate from the NYB DPS, 2 from the GOM DPS and 1 from the CB DPS. Of the three fish likely to be captured in the dredge, two are likely to be from the NYB DPS and the other will be from the CB or GOM DPS. The two Atlantic sturgeon likely to be killed are most likely to be NYB DPS; however, it is possible that they could be GOM or CB fish.

10.2.2 Gulf of Maine DPS

Individuals originating from the GOM DPS are likely to occur in the action area. The GOM DPS has been listed as threatened. While Atlantic sturgeon occur in several rivers in the GOM DPS, recent spawning has only been documented in the Kennebec and Androscoggin rivers. No total population estimates are available. We have estimated, based on fishery-dependent data, that there are approximately 166 mature adults in the GOM DPS, at least 498 subadults and additional numbers of juveniles (which remain in their natal river and would not be present in the action area). We expect that 6% of the Atlantic sturgeon in the action area will originate from the GOM DPS. Most of these fish are expected to be subadults, with few adults from the GOM DPS expected to be present in the Hudson

River. GOM origin Atlantic sturgeon are affected by numerous sources of human induced mortality and habitat disturbance throughout the riverine and marine portions of their range. While there are some indications that the status of the GOM DPS may be improving, there is currently not enough information to establish a trend for any life stage or for the DPS as a whole.

We have estimated that the proposed bridge replacement project will result in the capture or injury of 73 or fewer Atlantic sturgeon for the short span option and 46 for the long span option, of which 4 and 3 are likely to be from the GOM DPS, respectively. The following analysis applies to anticipated effects of capture and injury of up to 4 individuals, but given the nature of the effects (i.e., minor injuries that will have no impact on fitness), it applies equally well to the worst case, the unlikely scenario of all 73 captured or injured fish being from the GOM DPS. We anticipate the mortality of two Atlantic sturgeon; these are both likely to originate from the NYB DPS; however, it is possible, although very unlikely, that one of these sturgeon could originate from the GOM DPS; therefore, we consider the effects to the GOM DPS from the loss of one subadult (>500mm TL <1,500 mm TL).

The death of one subadult Atlantic sturgeon from the GOM DPS over a 5-year period represents a very small percentage of the subadult population (*i.e.*, approximately 0.2% of the population, just considering the minimum estimated number of subadults). While the death of one subadult Atlantic sturgeon will reduce the number of GOM DPS Atlantic sturgeon compared to the number that would have been present absent the proposed action, it is not likely that this reduction in numbers will change the status of this species as this loss represents a very small percentage of the subadult population and an even smaller percentage of the overall population of the DPS (juveniles, subadults and adults combined). Even when converting this fish to an adult equivalent[13] (using a conversion rate of 0.48), and assuming no growth in the adult population, this mortality represent a very small percentage of the adult population (less than 0.3%).

The reproductive potential of the GOM DPS will not be affected in any way other than through a reduction in numbers of individuals. The loss of one subadult would have the effect of reducing the amount of potential reproduction as any dead GOM DPS Atlantic sturgeon would have no potential for future reproduction. This small reduction in potential future spawners is expected to result in an extremely small reduction in the number of eggs laid or larvae produced in future years and similarly, an extremely small effect on the strength of subsequent year classes. Even considering the potential future spawners that would be produced by the individual that would be killed as a result of the proposed action, any effect to future year classes is anticipated to be extremely small and would not change the status of this species. Reproductive potential of other captured or injured individuals is not expected to be affected in any way. Additionally, we have determined that any impacts to behavior will be minor and temporary and that there will not be any delay or disruption of any normal behavior including spawning; there will also be no reduction in individual fitness or any future reduction in numbers of individuals.

The proposed action will also not affect the spawning grounds within the rivers where GOM DPS fish spawn. The action will also not create any barrier to pre-spawning sturgeon accessing the overwintering sites or the spawning grounds used by GOM DPS fish.

[13] The "adult equivalent" rate converts a number of subadults to adult equivalents (the number of subadults that would, through natural mortality, live to be adults; for Atlantic sturgeon, this is calculated as 0.48).

The proposed action is not likely to reduce distribution because the action will not impede Atlantic sturgeon from accessing any seasonal concentration areas, including foraging areas within the Hudson River that may be used by GOM DPS subadults or adults. Further, the action is not expected to reduce the river by river distribution of Atlantic sturgeon. Any effects to distribution will be minor and temporary and limited to the temporary avoidance of the ensonified area.

Based on the information provided above, the death of no more than one GOM DPS Atlantic sturgeon over a 5-year period resulting from the proposed construction of a bridge to replace the existing Tappan Zee Bridge, will not appreciably reduce the likelihood of survival of the GOM DPS (*i.e.*, it will not decrease the likelihood that the species will continue to persist into the future with sufficient resilience to allow for the potential recovery from endangerment). The action will not affect GOM DPS Atlantic sturgeon in a way that prevents the species from having a sufficient population, represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring, and it will not result in effects to the environment which would prevent Atlantic sturgeon from completing their entire life cycle, including reproduction, sustenance, and shelter. This is the case because: (1) the death of one subadult GOM DPS Atlantic sturgeon over a 5-year period represents an extremely small percentage of the species as a whole; (2) the death of one subadult GOM DPS Atlantic sturgeon will not change the status or trends of the species as a whole; (3) the loss of this subadult GOM DPS Atlantic sturgeon is not likely to have an effect on the levels of genetic heterogeneity in the population; (4) the loss of this subadult GOM DPS Atlantic sturgeon is likely to have such a small effect on reproductive output that the loss of this individual will not change the status or trends of the species; (5) the action will have only a minor and temporary effect on the distribution of GOM DPS Atlantic sturgeon in the action area and no effect on the distribution of the species throughout its range; and, (6) the action will have no effect on the ability of GOM DPS Atlantic sturgeon to shelter and only an insignificant effect on individual foraging GOM DPS Atlantic sturgeon.

In certain instances an action that does not appreciably reduce the likelihood of a species survival (persistence) may affect its likelihood of recovery or the rate at which recovery is expected to occur. As explained above, we have determined that the proposed action will not appreciably reduce the likelihood that GOM DPS Atlantic sturgeon will survive in the wild. Here, we consider the potential for the action to reduce the likelihood of recovery. As noted above, recovery is defined as the improvement in status such that listing is no longer appropriate. Section 4(a)(1) of the ESA requires listing of a species if it is in danger of extinction throughout all or a significant portion of its range (*i.e.*, "endangered"), or likely to become in danger of extinction throughout all or a significant portion of its range in the foreseeable future (*i.e.*, "threatened") because of any of the following five listing factors: (1) The present or threatened destruction, modification, or curtailment of its habitat or range, (2) overutilization for commercial, recreational, scientific, or educational purposes, (3) disease or predation, (4) the inadequacy of existing regulatory mechanisms, (5) other natural or manmade factors affecting its continued existence.

The proposed action is not expected to modify, curtail or destroy the range of the species since it will result in an extremely small reduction in the number of GOM DPS Atlantic sturgeon in any geographic area and thus, it will not affect the overall distribution of GOM DPS Atlantic sturgeon. The proposed action will not utilize GOM DPS Atlantic sturgeon for recreational, scientific or commercial purposes, affect the adequacy of existing regulatory mechanisms to protect this species or affect its continued existence. The proposed action is likely to result in the capture and injury of Atlantic sturgeon and the mortality of no more than one subadult GOM DPS Atlantic sturgeon; however, as explained above, the loss of this individual and what would have been their progeny is not expected to affect the persistence of the GOM DPS. As the reduction in numbers and future reproduction is very small, the loss of these individuals will not change the status of GOM DPS Atlantic sturgeon. The effects of the proposed action will not delay the recovery timeline or otherwise decrease the likelihood of recovery since the action will cause the mortality of only a very small percentage of the species as a whole and this mortality is not expected to result in the reduction of overall reproductive fitness for the species as a whole. The effects of the proposed action will also not reduce the likelihood that the status of the species can improve to the point where it is recovered and could be delisted. Therefore, the proposed action will not appreciably reduce the likelihood that the GOM DPS can be brought to the point at which they are no longer listed as threatened. Based on the analysis presented herein, the proposed action, resulting in the mortality of one subadult GOM DPS Atlantic sturgeon, is not likely to appreciably reduce the survival and recovery of this species.

10.2.3 New York Bight DPS

Individuals originating from the NYB DPS are likely to occur in the action area. The NYB DPS has been listed as endangered. While Atlantic sturgeon occur in several rivers in the NYB DPS, recent spawning has only been documented in the Delaware and Hudson rivers. Kahnle *et al.* (2007) estimated that there is a mean annual total mature adult population of 863 Hudson River Atlantic sturgeon. Using fishery-dependent data we have estimated that there are 87 Delaware River origin adults; combined, we estimate a total adult population of 950 in the New York Bight DPS. We have also estimated that there are at least 2,850 subadults and additional numbers of juveniles. We expect that 92% of the Atlantic sturgeon in the action area will originate from the NYB DPS. These fish could be juveniles, subadults and, seasonally, adults. NYB DPS origin Atlantic sturgeon are affected by numerous sources of human induced mortality and habitat disturbance throughout the riverine and marine portions of their range. There is currently not enough information to establish a trend for any life stage, for the Hudson or Delaware River spawning populations or for the DPS as a whole.

We have estimated that the proposed bridge replacement project will result in the capture or injury of 73 or fewer Atlantic sturgeon for the short span option and 46 for the long span option, of which 64 and 40 are likely to be from the NYB DPS, respectively. The following analysis applies to anticipated effects of capture and injury of up to 64 individuals, but given the nature of the effects (i.e., minor injuries that will have no impact on fitness), it applies equally well to the worst case, the unlikely scenario of all 73captured or injured fish being from the NYB DPS. The majority of individuals are likely to be Hudson River origin, but some may be Delaware River origin. We anticipate the mortality of two Atlantic sturgeon; these are most likely to originate from the NYB DPS. One mortality is expected during dredging and one due to exposure to underwater noise during pile driving. We expect that these mortalities will be juveniles (<500 mm TL) or subadults (<1,500 mm TL).

The mortality of two juvenile or subadult Atlantic sturgeon from the NYB DPS over a 5-year period represents a very small percentage of the subadult and juvenile population (*i.e.*, approximately 0.07% of the population, just considering the minimum estimated number of subadults). While the death of two juvenile or subadult Atlantic sturgeon will reduce the number of NYB DPS Atlantic sturgeon compared to the number that would have been present absent the proposed action, it is not likely that this reduction in numbers will change the status of this species as this loss represents a very small percentage of the juvenile and subadult population and an even smaller percentage of the overall population of the DPS (juveniles, subadults and adults combined). Even when converting these two fish to adult equivalents[14]

[14] The "adult equivalent" rate converts a number of subadults to adult equivalents (the number of subadults that would, through natural mortality, live to be adults; for Atlantic sturgeon, this is calculated as 0.48).

(assuming they were both subadults; using a conversion rate of 0.48 considering the adult equivalent), and assuming no growth in the adult population, these two mortalities represent an extremely small percentage of the adult population (approximately 0.1%).

The reproductive potential of the NYB DPS will not be affected in any way other than through a reduction in numbers of individuals. The loss of two juveniles or subadults would have the effect of reducing the amount of potential reproduction as any dead NYB DPS Atlantic sturgeon would have no potential for future reproduction. This small reduction in potential future spawners is expected to result in an extremely small reduction in the number of eggs laid or larvae produced in future years and similarly, an extremely small effect on the strength of subsequent year classes. Even considering the potential future spawners that would be produced by the individual that would be killed as a result of the proposed action, any effect to future year classes is anticipated to be extremely small and would not change the status of this species. Reproductive potential of other captured or injured individuals is not expected to be affected in any way. Additionally, we have determined that any impacts to behavior will be minor and temporary and that there will not be any delay or disruption of any normal behavior including spawning; there will also be no reduction in individual fitness or any future reduction in numbers of individuals.

The proposed action will also not affect the spawning grounds within either the Delaware or Hudson rivers where NYB DPS fish spawn. The action will also not create any barrier to pre-spawning sturgeon accessing the overwintering sites or the spawning grounds.

The proposed action is not likely to reduce distribution because the action will not impede Atlantic sturgeon from accessing any seasonal concentration areas, including foraging, spawning or overwintering grounds in the Hudson River. Further, the action is not expected to reduce the river by river distribution of Atlantic sturgeon.

The proposed action is not likely to reduce distribution because the action will not impede NYB DPS Atlantic sturgeon from accessing any seasonal concentration areas, including foraging, spawning or overwintering grounds in the Hudson River or elsewhere. Any effects to distribution will be minor and temporary and limited to the temporary avoidance of the ensonified area.

Based on the information provided above, the death of up to two shortnose sturgeon over a 5-year period resulting from the proposed construction of a bridge to replace the existing Tappan Zee Bridge, will not appreciably reduce the likelihood of survival of the New York Bight DPS (*i.e.*, it will not decrease the likelihood that the species will continue to persist into the future with sufficient resilience to allow for the potential recovery from endangerment). The action will not affect NYB DPS Atlantic sturgeon in a way that prevents the species from having a sufficient population, represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring, and it will not result in effects to the environment which would prevent Atlantic sturgeon from completing their entire life cycle, including reproduction, sustenance, and shelter. This is the case because: (1) the death of two juvenile or subadult NYB DPS Atlantic sturgeon over a 5-year period represents an extremely small percentage of the species as a whole; (2) the death of two juvenile or subadult NYB DPS Atlantic sturgeon will not change the status or trends of the species as a whole; (3) the loss of these juvenile or subadult NYB DPS Atlantic sturgeon is not likely to have an effect on the levels of genetic heterogeneity in the population; (4) the loss of these juvenile or subadult NYB DPS Atlantic sturgeon is likely to have such a small effect on reproductive output that the loss of these individuals will not change the status or trends of the species; (5) the action will have only a minor and temporary effect on the distribution of NYB DPS Atlantic sturgeon in the action area and no effect on the distribution of the species throughout its range; and, (6) the action will have no effect on the ability of NYB DPS Atlantic sturgeon to shelter and only an insignificant effect on individual foraging NYB DPS Atlantic sturgeon.

In certain instances an action that does not appreciably reduce the likelihood of a species survival (persistence) may affect its likelihood of recovery or the rate at which recovery is expected to occur. As explained above, NMFS has determined that the proposed action will not appreciably reduce the likelihood that NYB DPS Atlantic sturgeon will survive in the wild. Here, we consider the potential for the action to reduce the likelihood of recovery. As noted above, recovery is defined as the improvement in status such that listing is no longer appropriate. Section 4(a)(1) of the ESA requires listing of a species if it is in danger of extinction throughout all or a significant portion of its range (*i.e.*, "endangered"), or likely to become in danger of extinction throughout all or a significant portion of its range in the foreseeable future (*i.e.*, "threatened") because of any of the following five listing factors: (1) The present or threatened destruction, modification, or curtailment of its habitat or range, (2) overutilization for commercial, recreational, scientific, or educational purposes, (3) disease or predation, (4) the inadequacy of existing regulatory mechanisms, (5) other natural or manmade factors affecting its continued existence.

The proposed action is not expected to modify, curtail or destroy the range of the species since it will result in an extremely small reduction in the number of NYB DPS Atlantic sturgeon in any geographic area and thus, it will not affect the overall distribution of NYB DPS Atlantic sturgeon. The proposed action will not utilize NYB DPS Atlantic sturgeon for recreational, scientific or commercial purposes, affect the adequacy of existing regulatory mechanisms to protect this species or affect its continued existence. The proposed action is likely to result in the capture and injury of Atlantic sturgeon and the mortality of two juvenile or subadult NYB DPS Atlantic sturgeon; however, as explained above, the loss of these individuals and what would have been their progeny is not expected to affect the persistence of the NYB DPS. As the reduction in numbers and future reproduction is very small, the loss of these individuals will not change the status of NYB DPS Atlantic sturgeon. The effects of the proposed action will not delay the recovery timeline or otherwise decrease the likelihood of recovery since the action will cause the mortality of only a very small percentage of the species as a whole and these mortalities are not expected to result in the reduction of overall reproductive fitness for the species as a whole. The effects of the proposed action will also not reduce the likelihood that the status of the species can improve to the point where it is recovered and could be delisted. Therefore, the proposed action will not appreciably reduce the likelihood that NYB DPS can be brought to the point at which they are no longer listed as endangered or threatened. Based on the analysis presented herein, the proposed action, resulting in the mortality of one subadult NYB DPS Atlantic sturgeon, is not likely to appreciably reduce the survival and recovery of this species.

10.2.4 Chesapeake Bay DPS

Individuals originating from the CB DPS are likely to occur in the action area. The CB DPS has been listed as endangered. While Atlantic sturgeon occur in several rivers in the CB DPS, recent spawning has only been documented in the James River. Using fishery-dependent data, we have estimated that there are 329 adults in the James River population, 987 subadults and additional juveniles (which remain in the James River). Because the James River is the only river in this DPS known to support spawning, this is also an estimate of the total number of adults and subadults in the Chesapeake Bay DPS. We expect that 2% of the Atlantic sturgeon in the action area will originate from the GOM DPS. Most of these fish are expected to be subadults, with few adults from the GOM DPS expected to be present in the

Hudson River. Chesapeake Bay DPS origin Atlantic sturgeon are affected by numerous sources of human induced mortality and habitat disturbance throughout the riverine and marine portions of their range. There is currently not enough information to establish a trend for any life stage, for the James River spawning population or for the DPS as a whole.

We have estimated that the proposed bridge replacement project will result in the capture or injury of 73 or fewer Atlantic sturgeon for the short span option and 46 for the long span option, of which 3 and 2 are likely to be from the CB DPS, respectively. The following analysis applies to anticipated effects of capture and injury of up to 3 individuals, but given the nature of these effects (i.e., minor injuries that will have no impact on fitness), it applies equally well to the worst case, the unlikely scenario of all 73 captured or injured fish being from the CB DPS. We anticipate the mortality of two Atlantic sturgeon; these are both likely to originate from the NYB DPS; however, it is possible, although very unlikely, that one of these sturgeon could originate from the CB DPS; therefore, we consider the effects to the CB DPS from the loss of one subadult (>500mm TL <1,500 mm TL).

The death of one subadult Atlantic sturgeon from the CB DPS over a 5-year period represents a very small percentage of the subadult population (*i.e.*, approximately 0.1% of the population, just considering the minimum estimated number of subadults). While the death of one subadult Atlantic sturgeon will reduce the number of CB DPS Atlantic sturgeon compared to the number that would have been present absent the proposed action, it is not likely that this reduction in numbers will change the status of this species as this loss represents a very small percentage of the subadult population and an even smaller percentage of the overall population of the DPS (juveniles, subadults and adults combined). Even when converting this fish to an adult equivalent[15] (using a conversion rate of 0.48), and assuming no growth in the adult population, this mortality represent a very small percentage of the adult population (less than 0.2%).

The reproductive potential of the CB DPS will not be affected in any way other than through a reduction in numbers of individuals. The loss of one subadult would have the effect of reducing the amount of potential reproduction as any dead CB DPS Atlantic sturgeon would have no potential for future reproduction. This small reduction in potential future spawners is expected to result in an extremely small reduction in the number of eggs laid or larvae produced in future years and similarly, an extremely small effect on the strength of subsequent year classes. Even considering the potential future spawners that would be produced by the individual that would be killed as a result of the proposed action, any effect to future year classes is anticipated to be extremely small and would not change the status of this species. Reproductive potential of other captured or injured individuals is not expected to be affected in any way. Additionally, we have determined that any impacts to behavior will be minor and temporary and that there will not be any delay or disruption of any normal behavior including spawning; there will also be no reduction in individual fitness or any future reduction in numbers of individuals.

The proposed action will also not affect the spawning grounds within the rivers where CB DPS fish spawn. The action will also not create any barrier to pre-spawning sturgeon accessing the overwintering sites or the spawning grounds used by CB DPS fish.

The proposed action is not likely to reduce distribution because the action will not impede Atlantic sturgeon from accessing any seasonal concentration areas, including foraging areas within the Hudson

[15] The "adult equivalent" rate converts a number of subadults to adult equivalents (the number of subadults that would, through natural mortality, live to be adults; for Atlantic sturgeon, this is calculated as 0.48).

River that may be used by CB DPS subadults or adults. Further, the action is not expected to reduce the river by river distribution of Atlantic sturgeon. Any effects to distribution will be minor and temporary and limited to the temporary avoidance of the ensonified area.

Based on the information provided above, the death of no more than one CB DPS Atlantic sturgeon over a 5-year period resulting from the proposed construction of a bridge to replace the existing Tappan Zee Bridge, will not appreciably reduce the likelihood of survival of the CB DPS (*i.e.*, it will not decrease the likelihood that the species will continue to persist into the future with sufficient resilience to allow for the potential recovery from endangerment). The action will not affect CB DPS Atlantic sturgeon in a way that prevents the species from having a sufficient population, represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring, and it will not result in effects to the environment which would prevent Atlantic sturgeon from completing their entire life cycle, including reproduction, sustenance, and shelter. This is the case because: (1) the death of one subadult CB DPS Atlantic sturgeon over a 5-year period represents an extremely small percentage of the species as a whole; (2) the death of one subadult CB DPS Atlantic sturgeon will not change the status or trends of the species as a whole; (3) the loss of this subadult CB DPS Atlantic sturgeon is not likely to have an effect on the levels of genetic heterogeneity in the population; (4) the loss of this subadult CB DPS Atlantic sturgeon is likely to have such a small effect on reproductive output that the loss of this individual will not change the status or trends of the species; (5) the action will have only a minor and temporary effect on the distribution of CB DPS Atlantic sturgeon in the action area and no effect on the distribution of the species throughout its range; and, (6) the action will have no effect on the ability of CB DPS Atlantic sturgeon to shelter and only an insignificant effect on individual foraging CB DPS Atlantic sturgeon.

In certain instances an action that does not appreciably reduce the likelihood of a species survival (persistence) may affect its likelihood of recovery or the rate at which recovery is expected to occur. As explained above, we have determined that the proposed action will not appreciably reduce the likelihood that CB DPS Atlantic sturgeon will survive in the wild. Here, we consider the potential for the action to reduce the likelihood of recovery. As noted above, recovery is defined as the improvement in status such that listing is no longer appropriate. Section 4(a)(1) of the ESA requires listing of a species if it is in danger of extinction throughout all or a significant portion of its range (*i.e.*, "endangered"), or likely to become in danger of extinction throughout all or a significant portion of its range in the foreseeable future (*i.e.*, "threatened") because of any of the following five listing factors: (1) The present or threatened destruction, modification, or curtailment of its habitat or range, (2) overutilization for commercial, recreational, scientific, or educational purposes, (3) disease or predation, (4) the inadequacy of existing regulatory mechanisms, (5) other natural or manmade factors affecting its continued existence.

The proposed action is not expected to modify, curtail or destroy the range of the species since it will result in an extremely small reduction in the number of CB DPS Atlantic sturgeon in any geographic area and thus, it will not affect the overall distribution of CB DPS Atlantic sturgeon. The proposed action will not utilize CB DPS Atlantic sturgeon for recreational, scientific or commercial purposes, affect the adequacy of existing regulatory mechanisms to protect this species or affect its continued existence. The proposed action is likely to result in the capture and injury of Atlantic sturgeon and the mortality of no more than one subadult CB DPS Atlantic sturgeon; however, as explained above, the loss of this individual and what would have been their progeny is not expected to affect the persistence of the CB DPS. As the reduction in numbers and future reproduction is very small, the loss of these individuals will not change the status of CB DPS Atlantic sturgeon. The effects of the proposed action will not delay the recovery timeline or otherwise decrease the likelihood of recovery since the action will cause the mortality of only a very small percentage of the species as a whole and this mortality is not expected to result in the reduction of overall reproductive fitness for the species as a whole. The effects of the proposed action will also not reduce the likelihood that the status of the species can improve to the point where it is recovered and could be delisted. Therefore, the proposed action will not appreciably reduce the likelihood that the CB DPS can be brought to the point at which they are no longer listed as threatened. Based on the analysis presented herein, the proposed action, resulting in the mortality of one subadult CB DPS Atlantic sturgeon, is not likely to appreciably reduce the survival and recovery of this species.

11.0 CONCLUSION

After reviewing the best available information on the status of endangered and threatened species under NMFS jurisdiction, the environmental baseline for the action area, the effects of the proposed action, and the cumulative effects, it is NMFS' biological opinion that the proposed replacement of the Tappan Zee Bridge as described in section 3.0 of this Opinion, may adversely affect but is not likely to jeopardize the continued existence of shortnose sturgeon or any DPS of Atlantic sturgeon. We have also determined that the proposed action, specifically the disposal of dredged material at the HARS, may affect but is not likely to adversely affect any species of whale or sea turtle. No critical habitat is designated in the action area; therefore, none will be affected by the proposed action.

12.0 INCIDENTAL TAKE STATEMENT

Section 9 of the ESA prohibits the take of endangered species of fish and wildlife. "Fish and wildlife" is defined in the ESA "as any member of the animal kingdom, including without limitation any mammal, fish, bird (including any migratory, non-migratory, or endangered bird for which protection is also afforded by treaty or other international agreement), amphibian, reptile, mollusk, crustacean, arthropod or other invertebrate, and includes any part, product, egg, or offspring thereof, or the dead body or parts thereof." 16 U.S.C. 1532(8). "Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by NMFS to include any act which actually kills or injures fish or wildlife. Such an act may include significant habitat modification or degradation that actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns including breeding, spawning, rearing, migrating, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. "Otherwise lawful activities" are those actions that meet all State and Federal legal requirements except for the prohibition against taking in ESA Section 9 (51 FR 19936, June 3, 1986), which would include any state endangered species laws or regulations. Section 9(g) makes it unlawful for any person "to attempt to commit, solicit another to commit, or cause to be committed, any offense defined [in the ESA.]" 16 U.S.C. 1538(g). See also 16 U.S.C. 1532(13)(definition of "person"). Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited under the ESA provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement. The prohibitions against take for shortnose sturgeon and Atlantic sturgeon are in effect now. The measures described below are non-discretionary, and must be undertaken by FHWA so that they become binding conditions for the exemption in section 7(o)(2) to apply. FHWA has a continuing duty to regulate the activity covered by this Incidental Take Statement. If FHWA (1) fails to assume and implement the terms and conditions or (2) fails to require the project sponsor or their contractors to adhere to the terms and conditions of the Incidental Take Statement through enforceable terms that are added to grants, permits and/or contracts as appropriate, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, FHWA or the project sponsor must report the progress of the action and its impact on the species to the NMFS as specified in the Incidental Take Statement [50 CFR §402.14(i)(3)] (See U.S. Fish and Wildlife Service and National Marine Fisheries Service's Joint Endangered Species Act Section 7 Consultation Handbook (1998) at 4-49).

12.1 Amount or Extent of Take

Dredging to be carried out during the bridge replacement project is expected to result in the capture of three shortnose sturgeon and three Atlantic sturgeon (two New York Bight DPS and one Gulf or Maine or Chesapeake Bay DPS), with the injury or mortality of one of these shortnose sturgeon and one of these Atlantic sturgeon (originating from the New York Bight, Gulf of Maine or Chesapeake Bay DPS). This amount of take applies for either the short span or long span bridge replacement.

The amount of take resulting from pile driving depends on whether the short span or long span bridge replacement is chosen. Because the short span option involves the installation of more piles, more sturgeon are likely to be exposed to noise that could result in effects. Pile driving carried out for the short span bridge option is expected to result in the injury of 70 or fewer shortnose sturgeon and 70 or fewer Atlantic sturgeon (64 New York Bight DPS, four Chesapeake Bay DPS and two Gulf of Maine DPS), with one shortnose sturgeon and one Atlantic sturgeon experiencing serious injury or mortality. Pile driving carried out for the long span bridge option is expected to result in the injury of 43 or fewer shortnose sturgeon and 43 or fewer Atlantic sturgeon (40 New York Bight DPS, two Chesapeake Bay DPS and one Gulf of Maine DPS), with one shortnose sturgeon and one Atlantic sturgeon experiencing serious injury or mortality. The two Atlantic sturgeon that are likely to be seriously injured or killed during dredging and pile driving are likely to be New York Bight DPS; however it is possible that they could also originate from the Gulf of Maine or Chesapeake Bay DPS. As explained in the "Effects of the Action" section of the Opinion, with the exception of the one shortnose sturgeon and one Atlantic sturgeon, none of these sturgeon are expected to die, immediately or later, as a result of exposure to increased underwater noise levels resulting from pile driving. All other take is likely to be in the form of injury. All injuries are anticipated to be minor and any injured individuals are expected to make a full recovery with no impact to future survival or fitness.

As explained in the "Effects of the Action" section, effects of the bridge replacement project on shortnose and Atlantic sturgeon also include exposure to noise resulting from the installation of piles by vibration, drilling to facilitate the installation of some piles, potential exposure to contaminants, a localized increase in vessel traffic, effects to prey items, and effects of dredge disposal at HARS. We have determined that all behavioral effects will be insignificant and discountable. We do not anticipate any take of shortnose sturgeon due to any of the other effects including vessel traffic and dredge disposal.

This ITS exempts the following take:

Short Span Bridge Option		
	Shortnose Sturgeon	**Atlantic Sturgeon**
Type of Take		
Capture	3 (juvenile or adult)	3 total: 2 juvenile or subadult NYB DPS, one subadult GOM or CB DPS
Injury	70 (juvenile or adult)	70 total 64 NYB DPS (juvenile, subadult or adult) 4 GOM DPS (subadult or adult) 2 CB DPS (subadult or adult)
Mortality	2 (juvenile or adult)	2 total: 2 juvenile or subadult NYB DPS ***or*** 1 juvenile or subadult NYB DPS and 1 subadult GOM DPS or 1 subadult CB DPS

Long Span Bridge Option		
	Shortnose Sturgeon	**Atlantic Sturgeon**
Type of Take		
Capture	3 (juvenile or adult)	3 total: 2 juvenile or subadult NYB DPS, one subadult GOM or CB DPS
Injury	43 (juvenile or adult)	43 total 40 NYB DPS (juvenile, subadult or adult) 2 GOM DPS (subadult or adult) 1 CB DPS (subadult)
Mortality	2 (juvenile or adult)	2 total: 2 juvenile or subadult NYB DPS ***or*** 1 juvenile or subadult NYB DPS and 1 subadult GOM DPS or 1 subadult CB DPS

In the accompanying Opinion, NMFS determined that this level of anticipated take is not likely to result in jeopardy to shortnose sturgeon or to any DPS of Atlantic sturgeon.

Observers will be present to monitor all dredging activity; therefore, we expect that all take associated with dredging will be observed. While we have been able to estimate the likely number of shortnose and Atlantic sturgeon to be taken as a result of the bridge replacement project, it may be impossible to observe all sturgeon affected by the pile installation. This is because both shortnose and Atlantic sturgeon are aquatic species that spend the majority of their time near the bottom, making it very difficult to monitor movements of individual sturgeon in the action area to document changes in behavior or to capture all affected individuals to document injuries. Because of this, the likelihood of discovering take attributable to this proposed action is very limited. There is no practical way to monitor the entire ensonified area during test pile installations to document the number of sturgeon exposed to underwater noise. FHWA will carry out a monitoring plan during pile installation including monitoring the project area for the presence of injured or dead fish. We expect that any sturgeon that are seriously injured or killed would be detected because we expect that these fish would be present at the river surface and therefore, be observable. The difficulty is monitoring fish that remain underwater and experience minor injuries.

We considered several methods to monitor the validity of our estimates that there will be 70 or fewer or 43 or fewer (depending on the bridge design), shortnose and 70 or fewer, or 43 or fewer Atlantic sturgeon total from the New York Bight, Gulf of Maine and Chesapeake Bay DPSs exposed to underwater noise that would result in injury. We considered requiring monitoring for sturgeon with gillnets or trawls within the ensonified area; however, because we expect the pile driving noise to cause sturgeon to leave the area, this method would not likely provide us with relevant information regarding the number of sturgeon affected. We also considered requiring surveys outside of the ensonfied area; however, this would possibly intercept sturgeon that were displaced from the ensonified area as well as fish that were present in the area being sampled, but not because of displacement. Thus, using this approach, it would be difficult to determine anything meaningful about the number of sturgeon affected by the bridge replacement project. In addition, gillnets may be very effective at catching sturgeon; however, we chose a method of monitoring take that would not exacerbate adverse effects. Also, because we expect a wide variety of size classes of sturgeon to be present in the area near the bridge and different mesh sizes would be needed to catch different size fish, it would be difficult to establish a sampling design that would effectively capture fish of all size classes at all times. Sturgeon captured in trawls generally have a lower mortality rate than those captured in gillnets, however, there may be added stress upon capture. The fish, particularly larger fish, may also be able to avoid a trawl. We also considered whether monitoring of tagged sturgeon would allow us to monitor take. However, because we do not know what percentage of sturgeon in the action area are likely to be tagged, it is not possible to determine the total number of sturgeon affected by the action based on the number of tagged sturgeon detected in the area. Further, if no tagged sturgeon were detected, we could not use that information to determine that no sturgeon were affected because it may just mean that there were no tagged sturgeon in the area.

Because we have dismissed all of these monitoring methods as neither reasonable nor appropriate, we will use a means other than counting individuals to assess the level of take. In situations where we cannot observe the actual individuals affected, the proxy must be rationally connected to the taking and provide an obvious threshold of exempted take which, if exceeded, provides a basis for reinitiating consultation. For this proposed action, the spatial and temporal extent of the area where underwater noise levels will be greater than 206 dB re 1uPa peak provides a proxy for estimating the actual amount of incidental take. We expect that this proxy will be the primary method of determining whether incidental take has been exceeded, given the potential that stunned or injured fish will not be observed. However, in order to increase the chances of detecting when incidental take has been exceeded, we have identified other methods as well. Because all of the calculations that were used to generate the take estimates are based on worst-case scenarios, including: 100% installation of all piles with an impact hammer (when it is likely that all piles will be at least partially installed with a vibratory hammer); and, rounding up any estimates that generated fractions of a fish to whole fish, it is unlikely that we have underestimated take. We will consider incidental take exceeded if any of the following conditions are met:

i) More than 70 shortnose sturgeon are observed stunned or injured.

ii) More than one dead shortnose sturgeon or more than one dead Atlantic sturgeon (belonging to the NYB, CB or GOM DPS) are observed during pile driving with injuries that are attributable to project operations.

iii) More than 52 New York Bight DPS, three Chesapeake Bay DPS, and two Gulf of Maine DPS Atlantic sturgeon are observed stunned or injured.

iv) More than three shortnose sturgeon and more than three Atlantic sturgeon (two NYB DPS and one CB or GOM DPS) are observed captured during mechanical dredging.

v) More than one shortnose sturgeon or more than one Atlantic sturgeon (belonging to the NYB, CB or GOM DPS) are injured or killed during mechanical dredging.

Additionally, we will consider whether incidental take was exceeded if either of the following conditions are met for pile installation with an impact hammer:

(a) The geographic extent of the area where noise is greater than 206 dB re 1 μPa peak is greater than the area considered in the "Effects of the Action" section of this Opinion, which is related to the area used to calculate the number of takes anticipated, and is listed in Tables 12 and 13.

(b) We will consider whether incidental take was exceeded if the number of hours that impact pile driving occurs exceeds the amount of time listed in Tables 12 and 13, which is related to the amount of time used to calculate the number of takes anticipated.

Some of the methods above (iv, v and vi) would depend on the ability to obtain a fin clip for genetic testing and assignment of the fish to one of the DPSs. It is expected that genetic test results could be obtained in time to reinitiate consultation prior to completion of the bridge replacement project as we anticipate receiving genetic information within approximately one month of submitting samples for processing.

12.2 Reasonable and Prudent Measures

In order to effectively monitor the effects of this action, it is necessary to monitor the impacts of the proposed action to document the amount of incidental take (i.e., the number of shortnose and Atlantic sturgeon captured, collected, injured or killed) and to examine any sturgeon that are captured during this monitoring. Monitoring provides information on the characteristics of the sturgeon encountered and may provide data which will help develop more effective measures to avoid future interactions with listed species. We do not anticipate any additional injury or mortality to be caused by removing the fish from the water and examining them as required in the RPMs. Any live sturgeon are to be released back into the river, away from the pile driving or dredging activities.

We believe the following reasonable and prudent measures are necessary or appropriate for FHWA to minimize and monitor impacts of incidental take of listed shortnose and Atlantic sturgeon. Please note that these reasonable and prudent measures and terms and conditions are in addition to the Environmental Performance Commitments that FHWA has committed to employ during the project (see Section 3.3). Because the Environmental Performance Commitments will become mandatory requirements of any contracts issued, we do not repeat them here as they are considered to be part of the proposed action.

RPMs Specific to Dredging Activities:

1. FHWA must provide NMFS with notice prior to the start and at the completion of each dredge cycle. Any request to extend dredging beyond the August 1 – November 1 window must be coordinated with NMFS with the understanding that this is likely to require reinitiation of this

consultation.

2. FHWA must ensure a NMFS-approved endangered species observer is present to observe all mechanical dredging activities to monitor for any capture of shortnose and Atlantic sturgeon.

3. The FHWA must ensure that all measures are taken to protect any sturgeon that survive capture in the mechanical dredge.

RPMs Specific to Pile Driving Activities:

4. FHWA must implement a program to monitor underwater noise resulting from the installation of piles during pile installation operations.

5. FHWA must implement a program to monitor impacts to sturgeon resulting from pile installation throughout the duration of pile driving operations.

RPMs for all aspects of the project:

6. All live sturgeon captured during monitoring must be released back into the Hudson River at an appropriate location away from any bridge construction activity that minimizes the additional risk of death or injury.

7. All Atlantic sturgeon captured must have a fin clip taken for genetic analysis. This sample must be transferred to NMFS.

8. All shortnose and Atlantic sturgeon that are captured during the project must be scanned for the presence of Passive Integrated Transponder (PIT) tags. Tag numbers must be recorded and reported to NMFS. If no tag is present, a PIT tag of the appropriate size must be inserted.

9. Any dead sturgeon must be transferred to NMFS or an appropriately permitted research facility NMFS will identify so that a necropsy can be undertaken to attempt to determine the cause of death.

10. All sturgeon captures, injuries or mortalities associated with the bridge replacement project and any sturgeon sightings in the action area must be reported to NMFS within 24 hours.

12.3 Terms and Conditions

In order to be exempt from prohibitions of section 9 of the ESA, FHWA must comply with the following terms and conditions of the Incidental Take Statement, which implement the reasonable and prudent measures described above and outline required reporting/monitoring requirements. These terms and conditions are non-discretionary. Any taking that is in compliance with the terms and conditions specified in this Incidental Take Statement shall not be considered a prohibited taking of the species concerned (ESA Section 7(o)(2)). In carrying out all of these terms and conditions, FHWA as lead Federal agency in this consultation, is responsible for coordinating with the other Federal agencies that are party to the consultation, as well as with project sponsors and contractors.

1. To implement RPM #1, each year that dredging is undertaken, the FHWA in coordination with the ACOE, EPA, project sponsors and contractors as appropriate, must inform NMFS of the commencement of dredging operations at least one week prior to the actual start date and inform us of the number of dredges to be used, the area within the river to be dredged, the volume of material to be removed, the expected duration of dredging, and the disposal site to be used.

2. To implement RPM #1, at the end of each dredging operation, FHWA in coordination with the ACOE, EPA, project sponsors and contractors as appropriate, must provided us a report that summarizes dredge operations including information on the dates of dredging, the volume of material removed, the number of trips to the disposal site. This report must also contain copies of the dredge observer reports. This report must be submitted to us by December 31 of any year that dredging occurs.

3. To implement RPM#2, for mechanical dredging, the FHWA in coordination with the ACOE, EPA, project sponsors and contractors as appropriate, must ensure that observer coverage is sufficient for 100% monitoring of dredging operations. This monitoring coverage must involve the placement of a NMFS-approved observer on board the dredge for every day that dredging is occurring. The NMFS approved observer must observe all discharges of dredged material from the dredge bucket to the scow or hopper. All biological material must be documented by a NMFS-approved observer as outlined in Appendix A and be reported to NMFS by December 31 of any year that dredging occurs.

4. To implement RPM#2, at least two weeks prior to each dredge event, FHWA must submit to us the names and qualifications of any observers to be used on board the dredge(s). No observers can be deployed to the dredge site until FHWA has written confirmation from NMFS that they have met the qualifications to be a "NMFS-approved observer" as outlined in Appendix B. If substitute observers are required during dredging operations, FHWA must ensure that NMFS approval is obtain before those observers are deployed on dredges.

5. To implement RPM #3, FHWA, in coordination with the ACOE, EPA, project sponsors and contractors as appropriate, any sturgeon observed in the dredge bucket or dredge scow during mechanical dredging operations must be removed with a net and, if alive, returned to the river away from the project site.

6. To implement RPM #4, FHWA must ensure an acoustic monitoring program is implemented that is able to document the underwater noise associated with a representative number of each size of piles. The monitoring program must be sufficient to establish the peak sound level and distance from the pile to this sound level, the cumulative sound exposure level and the distance at which sound will be greater than 206 dB re 1 μPa Peak, 187 dB re 1 μPa^2-s cSEL and 150 dB re 1 μPa RMS. The monitoring program must also document the duration (i.e., minutes/hours) of time it takes to install each pile and the duration of time the area is ensonified during each 24 hour period.

7. To implement RPM #4, FHWA must ensure an acoustic monitoring program is implemented that is able to document the underwater noise associated with drilling rock to install any rock sockets. The monitoring program must be sufficient to establish the peak sound level and the cSEL during drilling.

8. To implement RPM#4, FHWA must ensure an acoustic monitoring program is implemented that is able to document the underwater noise associated with installing piles with a vibratory

method. The monitoring program must be sufficient to establish the peak sound level and the RMS level.

9. To implement RPM#4, FHWA must report results from the sound monitoring to NMFS as soon as practicable, but no less frequently than every 30 days. If there is any indication that peak noise levels have exceeded 206 dB re 1 μPa peak or 187 dB re 1 μPa^2-s cSEL for longer than anticipated or over a greater geographic area than anticipated, NMFS must be contacted immediately. Monthly reports must be provided to NMFS in a format that allows comparison to the information presented in tables 12 and 13 in the Opinion; therefore they must include the noise information and the duration of pile driving activities.

10. To implement RPM#5, FHWA must ensure acoustic telemetry equipment is utilized to monitor for the presence, residence time and movement of tagged Atlantic and shortnose sturgeon in the project area. FHWA must design a monitoring plan that would ensure the detection of any acoustically tagged shortnose or Atlantic sturgeon in the action area. This monitoring plan must be approved by NMFS prior to the installation of the first pile. FHWA must ensure all occurrences of tagged sturgeon in the project area are recorded. Information collected from any stationary receivers must be downloaded at least every thirty days. Preliminary reports containing information on the number of tagged sturgeon detected must be provided to NMFS on a regular basis, but no less frequently than every 60 days. If reports cannot be provided on that frequency, FHWA must provide an explanation to NMFS within the 60 day period and provide the report as soon as possible. On a quarterly basis, FHWA must provide NMFS a report that summarizes all available information from the monitoring equipment on sturgeon detections and movements for the previous 120 day period. This term and condition does not require FHWA to tag any sturgeon with telemetry tags.

11. To implement RPM#5, FHWA must ensure the project area is monitored for the presence of any floating dead or injured sturgeon. FHWA must design a monitoring plan that would ensure the detection of any floating stunned, injured or dead sturgeon. We anticipate that this would be accomplished by using at least one small boat to run transects through the project area during and after the installation of piles installed with impact hammers and at least one monitor on the barge next to the pile being driven with radio communication to the boat. The location of the transects must take tidal currents into consideration. This plan must be approved by NMFS prior to the installation of any piles by impact hammer. Preliminary reports containing information on the number of fish observed stunned or injured (including non-sturgeon species) must be reported to NMFS on a regular basis, but no less frequently than every 60 days. If reports can not be provided on that frequency, FHWA must provide an explanation to NMFS within the 60 day period and provide the report as soon as possible. On a quarterly basis, FHWA must provide NMFS a report that summarizes all available information from the monitoring program on all fish observed in the area during the previous 120 day period.

12. To implement RPM#6, FHWA must ensure any observed live sturgeon are collected with a net and are visually inspected for injuries. Unless the size of fish precludes holding, collected fish must be held on board a vessel with a flow through live well.

13. To implement RPM #7, FHWA must ensure that fin clips are taken (according to the procedure outlined in Appendix C) of any sturgeon captured during the project and that the fin clips are sent to NMFS for genetic analysis. Fin clips must be taken prior to preservation of other fish parts or whole bodies.

14. To implement RPM #8, FHWA must ensure all collected sturgeon must be inspected for a PIT tag with an appropriate PIT tag reader and tagged if no PIT tag is detected according to the protocol provided as Appendix D. Injured fish must be visually assessed, measured, photographed, released away from the site and reported to NMFS.
15. To implement RPM#9, FHWA must ensure that any observed dead sturgeon are collected with a net, reported to NMFS, preserved as appropriate to allow for necropsy, and that NMFS is contacted immediately to discuss necropsy and other procedures. NMFS may request that the specimen be transferred to NMFS or to an appropriately permitted researcher approved by NMFS so that a necropsy may be conducted. The form included as Appendix E must be completed and submitted to NMFS.
16. To implement RPM #10, if any live or dead sturgeon are observed or captured during any aspect of the proposed bridge replacement project, FHWA must ensure that NMFS (978-281-9328) is notified immediately and that an incident report (Appendix F) is completed by the observer and sent to the NMFS Section 7 Coordinator via FAX (978-281-9394) or e-mail (incidental.take@noaa.gov) within 24 hours of the take. FHWA must also ensure that every sturgeon is photographed. Information in Appendix G will assist in identification of shortnose and Atlantic sturgeon.

The reasonable and prudent measures, with their implementing terms and conditions, are designed to minimize and monitor the impact of incidental take that might otherwise result from the proposed action. Specifically, these RPMs and Terms and Conditions will ensure that FHWA monitors the impacts of the project on listed species and effects to shortnose and Atlantic sturgeon in a way that allows for the detection of any injured or killed sturgeon and to report all interactions to NMFS and to provide information on the likely cause of death of any shortnose and Atlantic sturgeon captured during the bridge replacement project. The discussion below explains why each of these RPMs and Terms and Conditions are necessary or appropriate to minimize or monitor the level of incidental take associated with the proposed action. The RPMs and terms and conditions involve only a minor change to the proposed action.

RPM #1 and Term and Condition #1 and #2 are necessary and appropriate because they will serve to ensure that NMFS is aware of the dates and locations of all dredging. This will allow NMFS to monitor the duration and seasonality of dredging activities as well as give NMFS an opportunity to provide FHWA with any updated contact information for NMFS staff. This is only a minor change because it is not expected to result in any delay to the project and will merely involve an occasional telephone call or e-mail between FHWA and NMFS staff.

RPM #2 and the implementing Term and Conditions (#3 and 4) are necessary and appropriate because they require that the FHWA have sufficient observer coverage to ensure the detection of any interactions with listed species during dredging. This is necessary for the monitoring of the level of take associated with the proposed action. The inclusion of these RPMs and Terms and Conditions is only a minor change as the FHWA included observer coverage in the original project description and this just serves to clarify the responsibilities of the observer and ensure that all observers are qualified for their duties. This will not result in any delays. These also represent only a minor change as in many instances they serve to clarify the duties of the observers.

RPM #3 and Term and Condition #5 are necessary and appropriate to ensure that sturgeon that survive capture in a mechanical dredge are given the maximum probability of remaining alive and not suffering additional injury or subsequent mortality through inappropriate handling. This represents only a minor change as following these procedures will not result in an increase in cost or any delays to the proposed project.

RPM #4 and #5 Term and Condition #6-11 are necessary and appropriate because they are specifically designed to monitor underwater noise associated with the pile driving. Because our calculation of take is tied to the geographic area where increased underwater noise will be experienced, it is critical that acoustic monitoring take place to allow FHWA to fulfill the requirement to monitor the actual level of incidental take associated with the pile driving and to allow NMFS and FHWA to determine if the level of incidental take is ever exceeded. Monitoring with acoustic receivers will detect the presence and movements of tagged sturgeon in the action area and should also provide us with information on residence times and movements within the action area. We expect this data will provide important information on the behavioral responses of tagged sturgeon to the pile driving activities. This represents only a minor change as following these procedures will have an insignificant impact on the cost of the project and will not result in any delays.

RPM#6-8 and Term and Condition #12-14 are necessary and appropriate to maximize the potential for detection of any affected sturgeon. These measures will ensure that any sturgeon that are observed injured are given the maximum probability of remaining alive and not suffering additional injury or subsequent mortality by being further subject to increased underwater noise. The taking of fin clips allows NMFS to run genetic analysis to determine the DPS of origin for Atlantic sturgeon. This allows us to determine if the actual level of take has been exceeded. Sampling of fin tissue is used for genetic sampling. This procedure does not harm sturgeon and is common practice in fisheries science. Tissue sampling does not appear to impair the sturgeon's ability to swim and is not thought to have any long-term adverse impact. Checking and tagging fish with PIT tags allows FHWA to determine the identity of detected fish and determine if the same fish is detected more than once. PIT tagging is not known to have any adverse impact to fish. NMFS has received no reports of injury or mortality to any sturgeon sampled or tagged in this way. This represents only a minor change as following these procedures will have an insignificant impact on the cost of the project and will not result in any delays.

RPM #9 and Term and Condition #15 are necessary and appropriate to determine the cause of death of any dead sturgeon observed during the bridge replacement project. This is necessary for the monitoring of the level of take associated with the proposed action. This represents only a minor change as following these procedures will have an insignificant impact on the cost of the project and will not result in any delays.

RPM #10 and Term and Condition #16 are necessary and appropriate to ensure the proper documentation and reporting of any interactions with listed species. This is only a minor change because it is not expected to result in any delay to the project and will merely involve an occasional telephone call or e-mail between FHWA and NMFS staff.

13.0 CONSERVATION RECOMMENDATIONS

In addition to Section 7(a)(2), which requires agencies to ensure that all projects will not jeopardize the continued existence of listed species, Section 7(a)(1) of the ESA places a responsibility on all federal agencies to "utilize their authorities in furtherance of the purposes of this Act by carrying out programs for the conservation of endangered species." Conservation Recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information. As such, NMFS recommends that the FHWA consider the following Conservation Recommendations:

1. The FHWA should use its authorities to ensure tissue analysis of any dead sturgeon removed from the Hudson River during the course of the bridge construction project to determine contaminant loads.
2. The FHWA should use its authorities to support studies on shortnose and Atlantic sturgeon distribution of individuals in the Tappan Zee reach of the Hudson River. Such studies could involve site specific surveying or monitoring, targeted at the collection of these species, in the months prior to any bridge replacement or other project, aimed at further documenting seasonal presence in the action area and further documenting the extent that individuals use different parts of the action area (i.e., the deepwater channel vs. shallower areas near the shoreline).
3. The FHWA should use its authorities to support studies on the distribution of shortnose and Atlantic sturgeon throughout different habitat types within the Hudson River. Such studies could include tagging and tracking studies and use of gross and fine scale acoustic telemetry equipment to monitor movements of individual fish throughout the river. This information would add to our knowledge of habitat selection and seasonal distribution throughout the river.
4. The FHWA should use its authorities to support studies necessary to update population estimates for the Hudson River population of shortnose sturgeon and the Hudson River population of Atlantic sturgeon.
5. The FHWA should use its authorities to conduct post-construction monitoring of the benthic environment to document recovery rates of benthic invertebrates in areas where temporary platforms were constructed, the existing bridge was removed and where dredging and/or armoring occurred.

14.0 REINITIATION OF CONSULTATION

This concludes formal consultation on the Tappan Zee Bridge replacement project. As provided in 50 CFR §402.16, reinitiation of formal consultation is required where discretionary federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of taking specified in the incidental take statement is exceeded; (2) new information reveals effects of the action that may not have been previously considered; (3) the identified action is subsequently modified in a manner that causes an effect to listed species; or (4) a new species is listed or critical habitat designated that may be affected by the identified action. In instances where the amount or extent of incidental take is exceeded, Section 7 consultation must be reinitiated immediately.

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APPENDIX A

MONITORING SPECIFICATIONS FOR MECHANICAL DREDGES

I. EQUIPMENT SPECIFICATIONS

A. Floodlights

Should dredging occur at night or in poor lighting conditions, floodlights must be installed to allow the NMFS-approved observer to safely observe and monitor dredge bucket and scow.

B. Intervals between dredging

Sufficient time must be allotted between each dredging cycle for the NMFS-approved observer to inspect the dredge bucket and scow for shortnose sturgeon and/or sturgeon parts and document the findings.

II. OBSERVER PROTOCOL

A. Basic Requirement

A NMFS-approved observer with demonstrated ability to identify shortnose sturgeon must be placed aboard the dredge(s) being used; starting immediately upon project commencement to monitor for the presence of listed species and/or parts being taken or present in the vicinity of dredge operations.

B. Duty Cycle

A NMFS-approved observers must be onboard during dredging until the project is completed. While onboard, observers shall provide the required inspection coverage to provide 100% coverage of all dredge-cycles.

C. Inspection of Dredge Spoils

During the required inspection coverage, the NMFS-approved observer shall observe the bucket as it comes out of the water and as the load is deposited into the scow during each dredge cycle for evidence of shortnose sturgeon. If any whole sturgeon (alive or dead) or sturgeon parts are taken incidental to the project(s), NMFS ((978) 281-9328) must be contacted by phone **within 24 hours** of the take. An incident report for sturgeon take shall also be completed by the observer and sent to NMFS via FAX (978) 281-9394 or e-mail (indicidental.take@noaa.gov) within 24 hours of the take. Incident reports shall be completed for every take regardless of the state of decomposition. Every incidental take (alive or dead, decomposed or fresh) must be photographed. A final report including all completed load sheets, photographs, and relevant incident reports are to be submitted to the attention of the Section 7 Coordinator, NMFS Protected Resources Division, 55 Great Republic Drive, Gloucester, MA 01930.

D. Inspection of Disposal

The NMFS-approved observer shall observe all disposal operations to inspect for any whole sturgeon or sturgeon parts that may have been missed when the load was deposited into the scow. If any whole sturgeon (alive or dead) or sturgeon parts are observed during disposal operation, the procedure for notification and documentation outlined above should be completed.

E. Disposition of Parts

As required above, NMFS must be contacted as soon as possible following a take. Any dead sturgeon should be held in cold storage until disposition can be discussed with NMFS. Under no circumstances should dead sturgeon be disposed of without confirmation of disposition details with NMFS.

APPENDIX B.

OBSERVER REQUIREMENTS

Submission of resumes of endangered species observer candidates to NMFS for final approval ensures that the observers placed onboard the dredges are qualified to document takes of endangered and threatened species, to confirm that incidental take levels are not exceeded, and to provide expert advice on ways to avoid impacting endangered and threatened species. NMFS does not offer certificates of approval for observers, but approves observers on a case-by-case basis.

A. Qualifications

Observers must be able to:

1) differentiate between shortnose (*Acipenser brevirostrum*) and Atlantic (*Acipenser oxyrinchus oxyrinchus*) sturgeon and their parts;
2) handle live sturgeon;
3) correctly measure the total length and width of live and whole dead sturgeon species;

B. Training

Ideally, the applicant will have educational background in biology, general experience aboard dredges, and hands-on field experience with the species of concern. For observer candidates who do not have sufficient experience or educational background to gain immediate approval as endangered species observers, we note below the observer training necessary to be considered admissible by NMFS. We can assist the FHWA by identifying groups or individuals capable of providing acceptable observer training. Therefore, at a minimum, observer training must include:

1) instruction on how to identify sturgeon and their parts;

2) instruction on appropriate screening on hopper dredges for the monitoring of sturgeon(whole or parts);

3) demonstration of the proper handling of live sturgeon incidentally captured during project operations;

4) instruction on standardized measurement methods for sturgeon lengths and widths; and
5) instruction on dredging operations and procedures, including safety precautions onboard.

APPENDIX C

Procedure for obtaining fin clips from sturgeon for genetic analysis

Obtaining Sample

1. Wash hands and use disposable gloves. Ensure that any knife, scalpel or scissors used for sampling has been thoroughly cleaned and wiped with alcohol to minimize the risk of contamination.

2. For any sturgeon, after the specimen has been measured and photographed, take a one-cm square clip from the pelvic fin.

3. Each fin clip should be placed into a vial of 95% non-denatured ethanol and the vial should be labeled with the species name, date, name of project and the fork length and total length of the fish along with a note identifying the fish to the appropriate observer report. All vials should be sealed with a lid and further secured with tape Please use permanent marker and cover any markings with tape to minimize the chance of smearing or erasure.

Storage of Sample

1. If possible, place the vial on ice for the first 24 hours. If ice is not available, please refrigerate the vial. Send as soon as possible as instructed below.

Sending of Sample

1. Vials should be placed into Ziploc or similar resealable plastic bags. Vials should be then wrapped in bubble wrap or newspaper (to prevent breakage) and sent to:

   Julie Carter
   NOAA/NOS – Marine Forensics
   219 Fort Johnson Road
   Charleston, SC 29412-9110
   Phone: 843-762-8547

   a. Prior to sending the sample, contact Russ Bohl at NMFS Northeast Regional Office (978-282-8493) to report that a sample is being sent and to discuss proper shipping procedures.

Appendix D.

PIT Tagging Procedures for Shortnose and Atlantic sturgeon
(adapted from Damon-Randall *et al.* 2010)

Passive integrated transponder (PIT) tags provide long term marks. These tags are injected into the musculature below the base of the dorsal fin and above the row of lateral scutes on the left side of the Atlantic sturgeon (Eyler *et al.* 2009), where sturgeon are believed to experience the least new muscle growth. Sturgeon should not be tagged in the cranial location. Until safe dorsal PIT tagging techniques are developed for sturgeon smaller than 300 mm, only sturgeon larger than 300 mm should receive PIT tags.

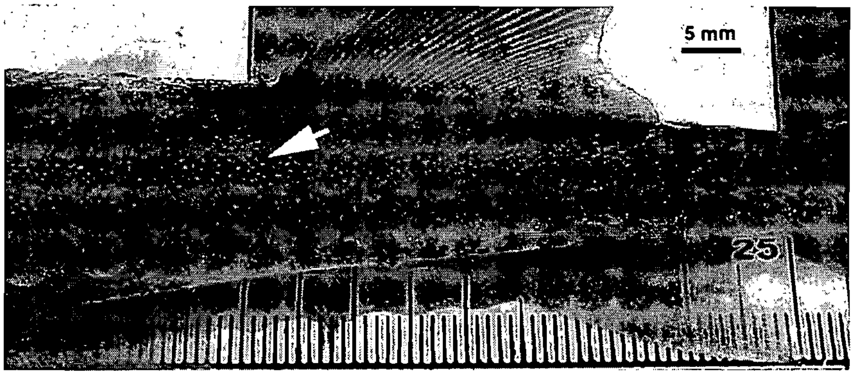
It is recommended that the needles and PIT tags be disinfected in isopropyl alcohol or equivalent rapid acting disinfectant. After any alcohol sterilization, we recommend that the instruments be air dried or rinsed in a sterile saline solution, as alcohol can irritate and dehydrate tissue (Joel Van Eenennam, University of California, pers. comm.). Tags should be inserted antennae first in the injection needle after being checked for operation with a PIT tag reader.

Sturgeon should be examined on the dorsal surface posterior to the desired PIT tag site to identify a location free of dermal scutes at the injection site. The needle should be pushed through the skin and into the dorsal musculature at approximately a 60 degree angle (Figure 15). After insertion into the musculature, the needle angle should be adjusted to close to parallel and pushed through to the target PIT tag site while injecting the tag. After withdrawing the needle, the tag should be scanned to check operation again and tag number recorded.

Some researchers check tags in advance and place them in individual 1.5 ml microcentrifuge tubes with the PIT number labeled to save time in the field.

Because of the previous lack of standardization in placement of PIT tags, we recommend that the entire dorsal surface of each fish be scanned with a PIT tag reader to ensure detection of fish tagged in other studies. Because of the long life span and large size attained, Atlantic sturgeon may grow around the PIT tag, making it difficult to get close enough to read the tag in later years. For this reason, full length (highest power) PIT tags should be used.

Fuller et al. (2008) provide guidance on the quality of currently available PIT tags and readers and offer recommendations on the most flexible systems that can be integrated into existing research efforts while providing a platform for standardizing PIT tagging programs for Atlantic sturgeon on the east coast. The results of this study were consulted to assess which PIT tags/readers should be recommended for distribution. To increase compatibility across the range of these species, the authors currently recommend the Destron TX1411 SST 134.2 kHz PIT tag and the AVID PT VIII, Destron FS 2001, and Destron PR EX tag readers. These readers can read multiple tags, but software must be used to convert the tag ID number read by the Destron PR EX. The FWS/Maryland Fishery Resources Office (MFRO) will collect data in the coastal tagging database and provide approved tags for distribution to researchers.



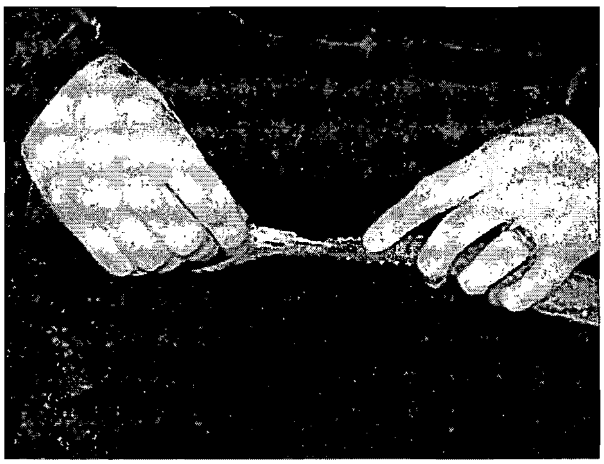


Figure 15. (from Damon-Randall *et al.* 2010). Illustration of PIT tag location (indicated by white arrow; top), and photo of a juvenile Atlantic sturgeon being injected with a PIT tag (bottom). *Photos courtesy of James Henne, US FWS.*

Appendix E

STURGEON SALVAGE FORM

For use in documenting dead sturgeon in the wild under ESA permit no. 1614 (version 05-16-2012)

INVESTIGATORS'S CONTACT INFORMATION
Name: First ______________ Last ____________________
Agency Affiliation ______________ Email ____________________
Address ____
____
Area code/Phone number ________________________________

UNIQUE IDENTIFIER (Assigned by NMFS)

DATE REPORTED:
Month ☐☐ Day☐☐ Year 20☐☐
DATE EXAMINED:
Month ☐☐ Day☐☐ Year 20☐☐

SPECIES: (check one)
☐ shortnose sturgeon
☐ Atlantic sturgeon
☐ Unidentified *Acipenser* species
Check "Unidentified" if uncertain.
See reverse side of this form for aid in identification.

LOCATION FOUND: ☐Offshore (Atlantic or Gulf beach) ☐Inshore (bay, river, sound, inlet, etc)
River/Body of Water______________ City____________________ State ____
Descriptive location (be specific)________________________________
____
____
Latitude ______________N (Dec. Degrees) Longitude ______________ W (Dec. Degrees)

CARCASS CONDITION at time examined: (check one)
☐ 1 = Fresh dead
☐ 2 = Moderately decomposed
☐ 3 = Severely decomposed
☐ 4 = Dried carcass
☐ 5 = Skeletal, scutes & cartilage

SEX:
☐ Undetermined
☐ Female ☐ Male
How was sex determined?
☐ Necropsy
☐ Eggs/milt present when pressed
☐ Borescope

MEASUREMENTS: **Circle unit**
Fork length ________ cm / in
Total length ________ cm / in
Length ☐ actual ☐ estimate
Mouth width (inside lips, see reverse side) ________ cm / in
Interorbital width (see reverse side) ________ cm / in
Weight ☐ actual ☐ estimate ________ kg / lb

TAGS PRESENT? **Examined for external tags including fin clips?** ☐ **Yes** ☐ **No** **Scanned for PIT tags?** ☐ **Yes** ☐ **No**

Tag #	Tag Type	Location of tag on carcass

CARCASS DISPOSITION: (check one or more)
☐1 = Left where found
☐2 = Buried
☐3 = Collected for necropsy/salvage
☐4 = Frozen for later examination
☐5 = Other (describe) ____________________

Carcass Necropsied?
☐Yes ☐No
Date Necropsied:____________
Necropsy Lead:
____

PHOTODOCUMENTATION:
Photos/vide taken? ☐ Yes ☐ No
Disposition of Photos/Video:__________
____
____

SAMPLES COLLECTED? ☐ **Yes** ☐ **No**

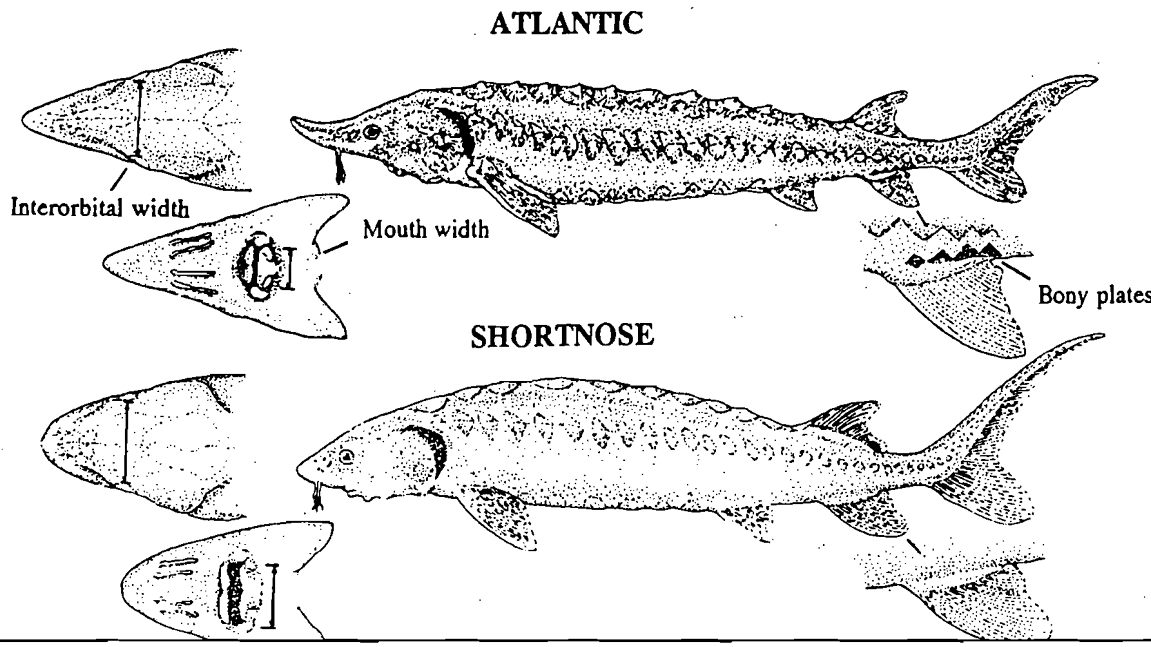
Sample	How preserved	Disposition (person, affiliation, use)

Comments:
____
____
____

Distinguishing Characteristics of Atlantic and Shortnose Sturgeon (version 07-20-2009)

Characteristic	Atlantic Sturgeon, *Acipenser oxyrinchus*	Shortnose Sturgeon, *Acipenser brevirostrum*
Maximum length	> 9 feet/ 274 cm	4 feet/ 122 cm
Mouth	Football shaped and small. Width inside lips < 55% of bony interorbital width	Wide and oval in shape. Width inside lips > 62% of bony interorbital width
*Pre-anal plates	Paired plates posterior to the rectum & anterior to the anal fin.	1-3 pre-anal plates almost always occurring as median structures (occurring singly)
Plates along the anal fin	Rhombic, bony plates found along the lateral base of the anal fin (see diagram below)	No plates along the base of anal fin
Habitat/Range	Anadromous; spawn in freshwater but primarily lead a marine existence	Freshwater amphidromous; found primarily in fresh water but does make some coastal migrations

* From Vecsei and Peterson, 2004



Describe any wounds / abnormalities (note tar or oil, gear or debris entanglement, propeller damage, etc.). **Please note if no wounds / abnormalities are found.**

____

____

____

____

____

Data Access Policy: Upon written request, information submitted to National Marine Fisheries Service (NOAA Fisheries) on this form will be released to the requestor provided that the requestor credit the collector of the information and NOAA Fisheries. NOAA Fisheries will notify the collector that these data have been requested and the intent of their use.

Submit completed forms (within 30 days of date of investigation) to: **Northeast Region Contacts** – Shortnose Sturgeon Recovery Coordinator (Jessica Pruden, Jessica.Pruden@noaa.gov, 978-282-8482) or Atlantic Sturgeon Recovery Coordinator (Lynn Lankshear, Lynn.Lankshear@noaa.gov, 978-282-8473); **Southeast Region Contacts**- Shortnose Sturgeon Recovery Coordinator (Stephania Bolden, Stephania.Bolden@noaa.gov, 727-824-5312) or Atlantic Sturgeon Recovery Coordinator (Kelly Shotts, Kelly.Shotts@noaa.gov, 727-551-5603).

APPENDIX F

Incident Report: Sturgeon Take – Tappan Zee Replacement Project

Photographs should be taken and the following information should be collected from all sturgeon (alive and dead) found in association with the TZ project. Please submit all necropsy results (including sex and stomach contents) to NMFS upon receipt.

Observer's full name:____
Reporter's full name:____

Species Identification:______________________________

Describe project activities (i.e., dredging, pile driving, etc.) ongoing within 24 hours of observation:____
____

Date animal observed:____________ Time animal observed: __________________
Date animal collected:____________ Time animal collected:__________________

Environmental conditions at time of observation (i.e., tidal stage, weather):
____
____

Water temperature (°C) at site and time of observation:__________________
Describe location of fish and how it was documented (i.e., observer on boat):
____

Sturgeon Information:
Species __________________________

Fork length (or total length) _________________ Weight __________________

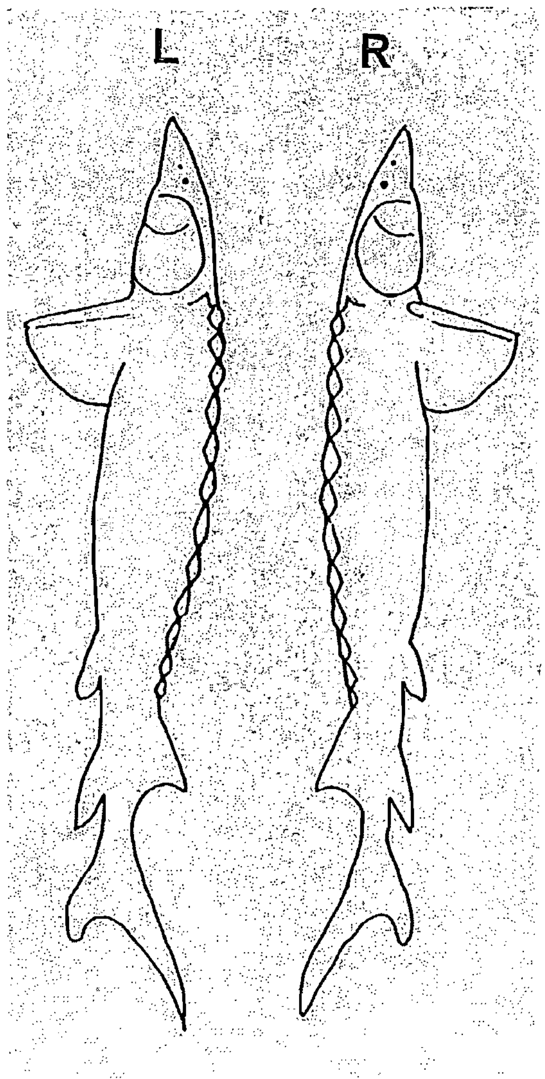
Condition of specimen/description of animal
____
____
____
____

Fish Decomposed: NO SLIGHTLY MODERATELY SEVERELY
Fish tagged: YES / NO *Please record all tag numbers.* Tag # ______________

Photograph attached: YES / NO
(please label *species, date, geographic site* and *vessel name* on back of photograph)

Appendix F, continued

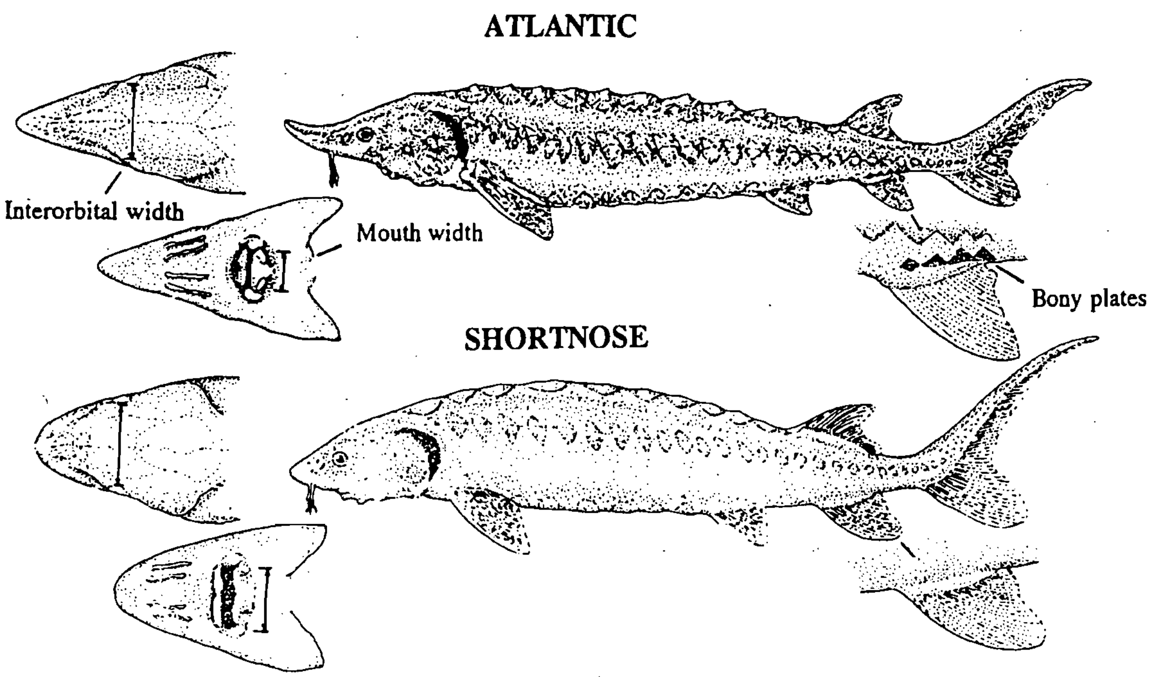
Draw wounds, abnormalities, tag locations on diagram and briefly describe below



Description of fish condition:

APPENDIX G

Identification Key for Sturgeon Found in Northeast U.S. Waters



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ıitat/Range	Anadromous; spawn in freshwater but primarily lead a marine existence	Freshwater amphidromous; found primarily in fresh water but does make some coastal migrations

From Vecsei and Peterson, 2004

Exhibit 3: Biological Assessment and Biological Opinion

3-3 Essential Fish Habitat (EFH) Assessment

Tappan Zee Hudson River Crossing Project

Rockland and Westchester Counties, New York
and
The Historic Area Remediation Site, New York Bight Apex

Essential Fish Habitat Assessment

Primary Agency and Contact:

Jonathan McDade, New York Division Administrator

Federal Highway Administration

In Coordination with:

New York State Department of Transportation

New York State Thruway Authority

Prepared by:

AKRF, Inc.

AECOM

Arthur Popper, Ph.D.

Revised April 2012

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New York State Department of Transportation

New York State Thruway Authority

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Chapter 1: Introduction and Federal Nexus

Essential fish habitat (EFH) is defined under the Magnuson-Stevens Fishery Conservation Management Act (16 USC §§ 1801 to 1883), as amended by the Sustainable Fisheries Act (SFA) of 1996, as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." "Waters" include aquatic areas and their physical, chemical and biological properties that are used by fish. "Substrate" includes sediment, hard bottom, structures, and associated biological communities that are under the water column. Waters and substrates necessary for fish spawning, breeding, feeding or growth to maturity—covering all stages within the life cycle of a particular species—refers to those habitats required to support a sustainable fishery and a particular species' contribution to a healthy ecosystem (50 Code of Federal Regulations (CFR) 600.10).

Section 303(a)(7) of the Magnuson-Stevens Act requires that the eight Regional Fishery Management Councils (RFMC) describe and identify EFH for each Federally managed species, and minimize adverse impacts from fishing activities on EFH. Section 305(b) (2)-(4) of the Magnuson-Stevens Act outlines the process for providing the National Marine Fisheries Service (NMFS) within the National Oceanic and Atmospheric Administration (NOAA), and the RFMC with the opportunity to comment on activities proposed by Federal agencies that have the potential to adversely impact EFH areas. Federal agencies are required to consult with NMFS (using existing consultation processes for the National Environmental Policy Act (NEPA), the Endangered Species Act, or the Fish and Wildlife Coordination Act) on any action that they authorize, fund or undertake that may adversely impact EFH.

Adverse effects to EFH, as defined in 50 CFR 600.910(A) include any impact that reduces the quality and/or quantity of EFH. Adverse effects may include:

- direct impacts such as physical disruption or the release of contaminants;
- indirect impacts such as the loss of prey, reduction in the fecundity (number of offspring produced) of a managed species; and
- site-specific or habitat wide impacts that may include individual, cumulative or synergetic consequences of a Federal action.

An EFH assessment of a Federal action that may adversely affect EFH must contain:

- a description of the proposed project;
- an analysis of the effects, including cumulative, on EFH, the managed species and associated species such as major prey species, and the life history stages that may be affected;
- the agency's conclusions regarding the effects of the action on EFH; and
- proposed mitigation if applicable (50 CFR 600.920(g)).

This EFH assessment has been prepared to demonstrate that the Tappan Zee Hudson River Crossing Project (the project) would be in compliance with the requirements of 50 CFR §660.920 implementing the Magnuson-Stevens Act, as amended by the Sustainable Fisheries Act of 1996 (Public Law 104-267).

The following sections provide:

- An overview of the Tappan Zee Replacement Bridge Alternative, including discussion of the proposed landings, approach spans, main spans, and ancillary facilities.
- A description of the aquatic habitat and aquatic biota within the two study areas for the Replacement Bridge Alternative—the Hudson River Bridge Construction Site and the Historic Area Remediation Site (HARS) proposed as the dredged material disposal site for the Tappan Zee Replacement Bridge Alternative.
- An assessment of the potential for construction and operation of the Replacement Bridge Alternative and disposal of dredged material at the HARS to adversely affect aquatic habitat and aquatic biota.
- A separate assessment of potential adverse impacts to the fish species for which EFH has been identified within the study areas for the Hudson River Bridge Construction Site and the HARS.
- An assessment of potential adverse impacts to non-EFH species with the potential to occur in the Hudson River in the vicinity of the project as seasonal transients including; striped bass, a Fish and Wildlife Coordination Act (FWCA) species; and four species of federally-listed threatened or endangered marine turtles. Shortnose sturgeon, a federal and state-listed endangered species; and Atlantic sturgeon, a species recently listed for federal protection under the Endangered Species Act and marine mammals are addressed separately in the Biological Assessment for the Tappan Zee Hudson River Crossing Project (see Appendix F-4 of the Tappan Zee Hudson River Crossing Project Draft Environmental Impact Statement (DEIS) (Federal Highway Administration in coordination with New York State Department of Transportation and New York State Thruway Authority 2012), and the more recent Revised Biological Assessment submitted to NMFS, dated April 2012. Consultations pursuant to Section 7 of the Endangered Species Act (ESA) have taken place for the area of the HARS during preparation of the Supplement to the Environmental Impact Statement for the HARS (USEPA 1997).
- A separate summary of potential direct, indirect and cumulative effects on EFH and the other species evaluated for the Hudson River Bridge Construction Site and the HARS study areas.

Chapter 2: Project Description

2.1 OVERVIEW

The Replacement Bridge Alternative would replace the existing Tappan Zee Bridge (see Figures 1 and 2) with two new structures to the north of its existing location. The existing bridge would be demolished and removed. The purpose of the project is to maintain a vital link in the regional and national transportation network by providing a Hudson River crossing between Rockland and Westchester Counties, New York, that addresses the limitations and shortcomings of the existing Governor Malcolm Wilson Tappan Zee Bridge. Constructed in 1955, the 3.1-mile-long Tappan Zee Bridge (**Figures 1 and 2**) and its highway connections have been the subject of numerous studies and subsequent transportation improvements. Despite these improvements, congestion has grown steadily over the years and the aging bridge structure has reached the point where major reconstruction and extensive measures are needed to sustain this vital link in the transportation system.

2.2 DESCRIPTION OF THE REPLACEMENT BRIDGE ALTERNATIVE

The Replacement Bridge Alternative (see **Figure 3**) would be located to the north of the existing Tappan Zee Bridge where there is available NY State Thruway Administration (NYSTA) right-of-way available on both sides of the river to accommodate construction of the crossing and bridge landings for construction storage and staging areas and allow for a straight approach to the Westchester toll plaza. It would include two separate spans to provide service redundancy—a 96-foot-wide deck for the superstructure that includes a shared-use path and an 87-foot-wide deck for the superstructure that does not include a shared-use path. The two spans would be an average of 40 feet apart.

The following sections describe the proposed landings, approach spans, main spans, and ancillary facilities of the Replacement Bridge Alternative.

2.2.1 LANDINGS

In Rockland and Westchester Counties, Interstate 87/287 would be shifted northward to meet the new abutments of the Replacement Bridge Alternative (see **Figure 3**). The two approach span options (Short Span and Long Span described below) would result in a different configuration of the Rockland County landing. Where notable differences between the Short Span and Long Span Options would occur at the landings, they are described below. **Figure 3** reflects the Rockland County landing for the Short Span Option.

2.2.2 APPROACH SPANS

There are two options for the approach spans, the sections of the bridge that link the landings with the main spans over the navigable channel. These options—Short Span and Long Span—differ in terms of the type of structure as well as the number of and distance between bridge piers. Both approach span options would not preclude future transit service across the Tappan Zee Hudson River Crossing.

2.2.2.1. Short Span Option

The Short Span Option would consist of two parallel bridge structures that would have a typical highway design with a road deck supported by girders and piers (see **Figures 4 and 5**). The decks of the parallel structures would be separated by a gap of about 70 feet for length of about 2,600 feet at the main span that would diminish closer to the shorelines. The following describes the general characteristics of the Rockland County and Westchester County approach spans for the Short Span Option:

- The Rockland County approach spans would extend 4,125 feet between the abutments and the main spans, and each would consist of 43 sections. The average distance between the piers of Rockland County approach spans would be 230 feet. There would be no gap between the parallel bridges at the abutments. The gap between the highway decks would widen to 70 feet at the main span.
- The Westchester County approach spans would extend 1,800 feet between the main spans and the abutments, and each would consist of 16 sections with an average distance between the piers of approximately 230 feet. The gap between the decks of the parallel bridges would range from 70 feet at the main span to about 40 feet at the abutments.

As the approach spans meet the main span, the road deck would be at an elevation of 175 feet above the Hudson River's mean high tide elevation.

2.2.2.2. Long Span Option

The Long Span Option would also consist of two parallel bridge structures. Each structure would have a truss supported by piers (see **Figures 4 and 6**). The road deck would be located on top of the trusses. As with the Short Span Option, the decks of the parallel structures would be separated by a gap of about 70 feet that would diminish closer to the shorelines. The following describes the general characteristics of the Rockland County and Westchester County approach spans for the Long Span Option:

- The Rockland County approach spans would extend 4,125 feet between the abutments and the main spans, and each would consist of 23 sections. The average distance between the piers of Rockland County approach spans would be about 430 feet. There would be no gap between the parallel bridges at the abutments. The gap between the highway decks would widen to 70 feet at the main spans.
- The Westchester County approach spans would extend 1,800 feet between the main spans and the abutments, and each would consist of 10 sections with an average distance between the piers of 430 feet. The gap between the parallel highway decks would range from 70 feet at the main spans to 40 feet at the abutments.

As the approach spans meet the main span, the road deck would be at an elevation of 195 feet above the Hudson River's mean high water elevation.

2.2.3 MAIN SPANS

The main spans—the portions of the bridge that cross the navigable channel of the Hudson River—would provide adequate vertical and horizontal clearance for marine transport.

- The horizontal clearance affects the width of the Hudson River's navigable channel for water craft and must be clear of bridge piers and other bridge infrastructure. The U.S. Coast Guard requires a minimum horizontal clearance of 600 feet through the Tappan Zee crossing. However, a clearance of 1,042 feet is preferred to provide a safety buffer for maritime navigation through the channel.
- The vertical clearance affects the height of the bridge as well as the hull-to-mast height of marine vessels that navigate under the bridge. The Replacement Bridge Alternative would provide for a vertical clearance of 139 at mean high water to maintain the existing maximum hull-to-mast height of vessels that travel beneath the Tappan Zee crossing.

The two options considered for the bridge's main spans over the navigable channel—Cable-stayed and Arch—would result in a horizontal clearance of at least 1,000 feet and a vertical clearance of 139 feet over the navigable channel at mean high water. Neither main span options would preclude future transit service across the Tappan Zee Hudson River Crossing.

2.2.4 CONSTRUCTION DURATION

The Replacement Bridge Alternative would be constructed over an approximately 4½- to 5½-year period for the Long Span and Short Span Options respectively. The various stages of construction are described in more detail below.

2.3 PROJECT SETTING

This assessment of the potential effects of the Tappan Zee Hudson River Crossing Project on EFH evaluates impacts to EFH within two study areas: the Hudson River bridge construction site, and the HARS, proposed as the dredged material disposal site for the Tappan Zee Hudson River Crossing Project. The Hudson River bridge-construction study area comprises the area extending ½ mile north and south of the Interstate 87/287 right-of-way generally between Interchange 10 (US Route 9W) in Rockland County and Interchange 9 (US Route 9) in Westchester County (see **Figure 7**). This study area incorporates the portions of the bridge, the Rockland and Westchester Bridge Staging Areas on the river, and the bridge landings. The study area for the evaluation of hydroacoustic effects of pile driving extended beyond this area to the limit of the ensonified area defined by the 187 SEL_{cum} re $1\mu Pa^2 \cdot s$ isopleths and is described in greater detail below. The HARS study area consists of the HARS (see **Figure 8**) which is located approximately 4 miles (3.4 nautical miles) east of Highlands, New Jersey and about 9 miles (7.7 nautical miles) south of Rockaway, Long Island.

2.3.1 HUDSON RIVER BRIDGE-CONSTRUCTION STUDY AREA

The approximately 3-mile-wide portion of the Hudson River within the study area is designated by the New York State Department of Environmental Conservation (NYSDEC) as a Class SB waterbody. Best usages of Class SB saline surface waters are primary and secondary contact recreation and fishing; these waters shall be suitable for fish propagation and survival. Within the study area, the Hudson River is included on the 2010 New York State 303(d) list due to the presence of contaminated sediment containing Polychlorinated Biphenyls (PCBs) (NYSDEC 2010a).

In the vicinity of the Tappan Zee Bridge, the river ranges in depth from less than 12 feet at mean lower low water (MLLW) along the western causeway to greater than 47 feet at MLLW in the shipping channel under the main span (see **Figure 9**). The Hudson River is tidally influenced from the Battery to the Federal Dam at Troy, New York. Tidal currents are generally greatest in the navigational channel. Results of field surveys conducted for the project in April 2007 and November 2008 indicate that peak vertically averaged tidal currents in the navigational channel are about 2.5 feet per second (ft/sec). Peak velocities during the spring freshet—a time of high freshwater inflows resulting from snow and ice melt in rivers—may be greater than 3 ft/sec. Velocities are generally lower in the western mud flats in the vicinity of the bridge, with peak velocities generally on the order of 1 to 2 ft/sec. The tidal excursion at the Tappan Zee Bridge is approximately 4.0 and 6.2 miles for the flood and ebb tide, respectively (DiLorenzo et al. 1999).

2.3.1.1. Water Quality

2.3.1.1.1. Salinity

The salt front, as defined by the USGS for the Hudson River estuary, is where chloride concentration begins to exceed 100 milligrams per liter (mg/L) (Devries and Weiss, 2001). Seawater has a chloride concentration of about 19,400 mg/L. With the exception of very large freshwater discharge events, there is always a salt front present in the Hudson River estuary, the location of which varies at a given time with tidal forcing and the magnitude of freshwater discharge. In general, the salt front is located between 15 and 75 miles upstream of the Battery. It is located farther upriver during the summer when there are low freshwater inflows, and farther downriver during the spring when freshwater flows are greatest.

The term salt wedge is a more generic term that describes the tendency for saltwater to intrude beneath freshwater without substantial mixing. A salt wedge is marked by a steep salinity gradient, or halocline, in the vertical direction. The presence of a salt wedge does not indicate an immediate horizontal transition from fresh to salt water. In the Hudson River estuary, the transition is often 50 miles long.

Figure 10 shows average salinities in Practical Salinity Units (PSU) over a 16-year period at the USGS gauge at Hastings-on-Hudson (#1376304), which is about 6 miles downstream of the Tappan Zee Bridge. Although salinity concentrations are somewhat lower at the Tappan Zee Bridge, the salinity at Hastings-on-Hudson is indicative of the magnitude and yearly variation of salinity at the bridge. At the Hastings-on-Hudson station, salinity ranged from about 2 to 6 PSU during high freshwater flow periods in the spring to a high of about 8 to 10 PSU during low freshwater flow periods in the summer. Salinities in the winter varied between 4 and 6 PSU. Salinities recorded during the 2006 and 2008 sampling program conducted for the project were similar to those recorded at Hastings-on-Hudson.

2.3.1.1.2. Temperature

Water temperatures are relatively uniform throughout the freshwater reach of the Hudson River estuary, and follow a similar cycle each year. At the mouth of the Hudson River estuary, near the Battery, temperatures are substantially affected by the inflow of water from the New York Bight and tend to exhibit a milder degree of variation throughout the year. **Figure 11** demonstrates the average yearly cycle in water temperature in the upper reach of the Hudson River estuary near Albany, and near its mouth, near the Battery over a period of 2002-2009. The NOAA Gauge at the Battery (#8518750) is 26.5 miles downstream of the bridge. The USGS gauge at Albany (#1359139) is 118 miles upstream of the bridge.

In the lower reaches of the Hudson River estuary and near the Tappan Zee Bridge, ocean water intrudes beneath fresh water to form a salt wedge, often resulting in a large degree of stratification in the water column. In these areas large vertical variations in temperature may be present. Average water temperatures at the Tappan Zee Bridge are generally close to the average of temperatures at the Battery and Albany, NY, ranging from below close to 0º Celsius (C) (32º Fahrenheit (F)) in the winter to about 25º C (77º F) in the summer, with temperatures in the spring ranging between 2º C and 10º C (36º F to 50º F).

2.3.1.1.3. Suspended Solids

Generally, suspended solids concentrations (SSC) show a strong correlation with water-column depth, with higher concentrations near the bottom of the river. Significant variation based on a variety of river conditions can also be expected, with the tidal cycle and magnitude of freshwater discharge being the most dominant factors. During the spring freshet sediment concentrations much higher than normal can be expected.

The USGS operates an Acoustic Doppler Current Profiler (ADCP) at the Hudson River estuary gauge station south of Poughkeepsie, approximately 27 miles north of the bridge. The station uses backscatter information from the ADCP to estimate suspended solids concentration (Wall et al. 2006). Using the SSC data combined with the current data measured by the device, an estimate of total sediment discharge is also calculated. This gauge has been monitoring SSC almost continuously since 2002, and represents the most complete data set of sediment concentration and sediment loading in the Hudson River estuary.

For the purposes of impact evaluation, an understanding of the typical sediment concentrations at the study area, and their variability, is useful. To aid in this understanding, the yearly variation of the depth-averaged SSC concentration at the USGS gauge south of Poughkeepsie is presented in **Figure 12** for the period 2002 through 2009. It is expected that the suspended sediment concentration at the Tappan Zee Bridge will be similarly inherently variable and seasonally dependent, as indicated by the USGS gauge upstream. Depth averaged SSC measurements made during field surveys of the Tappan Zee were similar in magnitude to those recorded at the Poughkeepsie station (see **Figure 12**).

SSC was recorded during water quality sampling conducted from late October through early December 2008 within the study area. Results showed that increases in SSC with depth were more dramatic at deep locations than at shallow water locations. Fluctuations in SSC occurred over each tidal cycle, with the highest SSC observed at max flood and max ebb tides. SSC recorded during this time frame generally ranged from about 10 to 75 mg/L, with maximum concentrations recorded of about 140 mg/L. Depth averaged water-column sediment samples in the vicinity of the Tappan Zee Bridge appear to range from 15 to 50 (mg/L) under normal conditions, and may exceed 100 mg/L during large freshwater events.

2.3.1.1.4. Sediment Characteristics

Bottom sediments in the Hudson River in the vicinity of the bridge comprise primarily clayey silt (see **Figure 13**). Accumulations of sand, silt and clay material are also observed along the causeway section of the existing bridge. Gravelly sediments are also found extensively near the eastern shore of the Hudson River and across a large swath of the mud flats north of the existing causeway section.

Due to releases from industrial activity, sediments deposited on the river bottom during the twentieth century are more likely to exhibit signs of contamination. Examples of industrial contamination include heavy metals, volatile or semivolatile organic compounds (VOCs or SVOCs), pesticides, and PCBs. Industrial-era sediments were identified through a combination of seismic-profiling data and the concentration of lead in sediment samples. The thickness of industrial era sediment deposits in the vicinity of the Tappan Zee Bridge is shown on **Figure 14**. While recently deposited sediments (i.e., from the 20th and 21st centuries) can be found throughout much of the study area. Deposition of recent sediments north of the existing bridge is limited, ranging from no deposition to a depth of about 2 feet, with most of the recent deposits occurring between 0 and about 8 inches. South of the bridge, deposition of recent sediments is limited on the western margin (ranging from 0 to 8 inches) with some areas of deeper deposition further east along the causeway (2 to 4 feet), deposition along the eastern margin appears to be greater (ranging from 0 to at least 6 feet). On the basis of the evaluation of recent sediment deposits, the net rate of deposition within the vicinity of the existing bridge is estimated to range from 0 inches per year to as high as 1 inch per year in the eastern margin south of the existing bridge.

Results from the 2006/2008 sediment sampling conducted for the project within the study area were compared to results found for historic Hudson River sampling conducted by Llanso et al (2003). These data are summarized in the Tappan Zee Hudson River Crossing Project Draft Environmental Impact Statement (DEIS) and in **Tables 1, 2, and 3**. In general, levels of contaminants such as metals, pesticides, and PCBs in the sediment samples collected within the study area are similar to average levels found elsewhere in the Hudson River as indicated by the Hudson River Benthic Mapping Project. On the basis of the results of the laboratory analysis of 2006 and 2008 sediment cores, the upper few feet of river sediment would be characterized as moderately contaminated following NYSDEC Technical and Operational Guidance Series (TOGS) 5.1.9, (NYSDEC 2004) with the exception of a few locations near the western and eastern Hudson River shorelines and south of the main span bridge piers where higher concentrations appear to have accumulated. The concentration of contaminants within the sediments is typically lower with increased depth.

Table 1
Sediment Chemistry Summary – Metals

Parameter	Sediment Criteria		Hudson River Average[2]	Number of Samples Analyzed	Detection Rate	Minimum (mg/kg)	Average (mg/kg)	Median (mg/kg)	95th Percentile (mg/kg)	Maximum (mg/kg)
	ERL[1] (mg/kg)	ERM[1] (mg/kg)								
Aluminum	NC	NC	10256.9	313	100%	483	11,714	11,700	17,300	21,700
Antimony	NC	NC	--	156	0%	ND	ND	ND	ND	ND
Arsenic	8.2	70	7.2	313	97%	ND	8.06[A]	7.4[A]	14[B]	26.4[B]
Barium	NC	NC	--	313	92%	ND	43	32.9	91.04	190
Beryllium	NC	NC	--	313	47%	ND	0.79	0.76	1.1	2.61
Cadmium	1.2	9.6	1.0	313	46%	ND	1.9[B]	1.92[B]	3.2[B]	6[B]
Calcium	NC	NC	--	313	98%	ND	4,919	2,620	16,550	64,600
Chromium	81	370	38.1	313	100%	1.17	31	21.9	85.86	116
Cobalt	NC	NC	--	313	96%	ND	10	9.8	13.7	17.3
Copper	34	270	42.4	313	99%	ND	32[A]	12.4[A]	102.55[B]	1,550[C]
Iron	NC	NC	--	313	100%	1380	24,227	24,200	32,600	40,900
Lead	46.7	218	44.6	313	100%	1.42[A]	36[A]	10.9[A]	137.4[B]	604[C]
Magnesium	NC	NC	--	313	100%	252	5,765	5,760	7,476	39,600
Manganese	NC	NC	--	313	100%	21.8	626	587	1,170	1,600
Mercury	0.15	0.71	0.38	313	37%	ND	0.89[B]	0.53[B]	2.46[C]	6.33[C]
Nickel	20.9	51.9	21.5	313	99%	ND	21	20.6	32.6	38.3
Potassium	NC	NC	--	313	97%	ND	2181	2,130	3,257	4,460
Selenium	NC	NC	--	313	43%	ND	4.01	3.945	6.2775	12.6
Silver	1	3.7	1.5	156	17%	ND	2.02	1.9	3.04	3.3
Sodium	NC	NC	--	313	94%	ND	2,229	2,035	3,761.50	5,730
Thallium	NC	NC	--	156	1%	ND	12.4	12.4	12.4	12.4
Vanadium	NC	NC	--	313	99%	ND	24.7	23.7	36.3	54.1
Zinc	150	410	129.2	313	100%	8.74	90	65	221	399

Notes: mg/kg = milligrams per kilogram; NC = no criteria; ND = not detected, -- = not available.

Sources:

[1] NYSDEC 1999

[2] Llanso et al. 2003

[A] Concentration falls within Class A - no appreciable contamination/no toxicity to aquatic life (NYSDEC 2004).

[B] Concentration falls within Class B - moderate contamination/chronic toxicity to aquatic life (NYSDEC 2004).

[C] Concentration falls within Class C - high contamination/acute toxicity to aquatic life (NYSDEC 2004).

Table 2
Sediment Chemistry Summary – SVOCs

Parameter	Sediment Criteria		Hudson River Average[3]	Number of Samples Analyzed	Detection Rate	Minimum (µg/kg)	Average (µg/kg)	Median (µg/kg)	95th Percentile (µg/kg)	Maximum (µg/kg)
	ERL[1] (µg/kg)	ERM[1] (µg/kg)								
Acenaphthene	16	500	289.4	156	8%	ND	36	ND	89	3,270
Acenaphthylene	44	640	139.2	156	16%	ND	13	ND	111	206
Anthracene	85.3	1,100	283.2	156	27%	ND	47	ND	155	2,030
Benzo(a)anthracene	261	1,600	176.4	156	43%	ND	130	ND	418	3,760
Benzo(a)pyrene	430	1,600	174.1	156	51%	ND	133	37	496	3,020
Benzo(b)fluoranthene	NC	NC	184.7	156	42%	ND	110	ND	445	2,460
Benzo(g,h,i)perylene	NC	NC	123.5	156	42%	ND	64	ND	260	1,530
Benzo(k)fluoranthene	NC	NC	163.4	156	42%	ND	91	ND	328	2,370
Chrysene	384	2,800	178.7	156	44%	ND	134	ND	487	3,490
Dibenzo(a,h)anthracene	63.4	260	--	156	15%	ND	14	ND	78	456
Fluoranthene	600	5,100	218.9	156	49%	ND	333	ND	994	13,300
Fluorene	19	540	291.2	156	10%	ND	28	ND	81	2,210
Indeno(1,2,3-c,d)pyrene	NC	NC	104.8	156	33%	ND	53	ND	220	1,510
2-Methylnaphthalene	70	670	--	156	1%	ND	0.96	ND	ND	113
Naphthalene	160	2,100	111.0	156	9%	ND	11	ND	49	504
Phenanthrene	240	1,500	299.1	156	40%	ND	163	ND	539	7,030
Pyrene	665	2,600	265.7	156	48%	ND	288	ND	999	9,570
Total PAHs (sum of above)	4,020	44,792	3,003	156	--	22.8[A]	1,673[A]	113[A]	6,079[B]	48,211[C]
bis(2-Ethylhexyl)phthalate	NC	NC	--	156	33%	ND	82	ND	259	4,240
Butyl benzyl phthalate	NC	NC	--	156	12%	ND	101	ND	289	5,140
Carbazole	NC	NC	--	156	3%	ND	5.25	ND	ND	349
Dibenzofuran	NC	NC	--	156	5%	ND	20	ND	6.6	2,660
Di-n-butyl phthalate	NC	NC	--	156	3%	ND	30	ND	ND	4,360

Notes: µg/kg = micrograms per kilogram; NC = no criteria; ND = not detected; -- = not available.

Sources:

[1] NYSDEC 1999; [2] NYSDEC 1999; [3] Llanso et al. 2003

[A] Concentration falls within Class A - no appreciable contamination/no toxicity to aquatic life (NYSDEC 2004).

[B] Concentration falls within Class B - moderate contamination/chronic toxicity to aquatic life (NYSDEC 2004).

[C] Concentration falls within Class C - high contamination/acute toxicity to aquatic life (NYSDEC 2004).

Table 3
Sediment Chemistry Summary – Pesticides, PCBs, and Dioxins

Parameter	Sediment Criteria: ERL[1] (µg/kg)	ERM[1] (µg/kg)	BA- Chronic[1] (µg/gOC)	BA- Acute[1] (µg/gOC)	WA[1] (µg/gOC)	Hudson River Average[2]	Number of Samples Analyzed	Detection Rate	Minimum (µg/kg)	Average (µg/kg)	Median (µg/kg)	95th Percentile (µg/kg)	Maximum (µg/kg)
alpha-Chlordane	NC	NC	NC	NC	0.006	--	156	1%	ND	0.1	ND	ND	16
gamma-Chlordane	NC	NC	NC	NC	0.006	--	156	1%	ND	0.09	ND	ND	15
Chlordane (sum of above)	NC	NC	0.002	0.05		--	156	--	--	0.19[A]	--	--	31[B]
Dieldrin	NC	NC	17.0	NC	NC	--	156	1%	ND	0.03[A]	ND	ND	4.8[A]
4,4'-DDD	NC	NC	-	-	NC	5.7	156	14%	ND	2.07	ND	12	54
4,4'-DDE	2.2	27	-	-	NC	--	156	7%	ND	0.47	ND	3.85	17
4,4'-DDT	1	7	1	130	NC	19.7	156	5%	ND	2.47	ND	0.73	352
Sum of DDT, DDD, and DDE	1.58	46.1	-	-		25.4	156	--	--	5.01[B]	--	16.58[B]	423[C]
Aroclor 1242	NC	NC	NC	NC	NC	--	156	13%	ND	51	ND	280	1,520
Aroclor 1248	NC	NC	NC	NC	NC	--	156	8%	ND	35	ND	239	1,200
Aroclor 1254	NC	NC	NC	NC	NC	--	156	4%	ND	6.13	ND	ND	221
Total PCBs	22.7	180	-	-	NC	726.8	156	--	40[A]	169.95*[B]	64[A]	682.25[B]	1,520*[C]
TCDD TEQ (pptr)	NC	NC	NC	NC	0.0002	--	17	100%	0.069[A]	11.84[C]	0.89[A]	54.2[C]	94.67[C]

Notes: µg/gOC = micrograms per gram of organic carbon; µg/kg = micrograms per kilogram; NC = no criteria; ND = not detected; BA = Benthic Aquatic; WA = Wildlife Accumulation; -- = not available; - ERM/ ERL applies.

Sources:

1 NYSDEC1999

2 Llanso et al. 2003

* The sum of PCBs is multiplied by two to determine the total PCB concentration (NYSDEC 2004).

A Concentration falls within Class A - no appreciable contamination/no toxicity to aquatic life (NYSDEC 2004).

B Concentration falls within Class B - moderate contamination/chronic toxicity to aquatic life (NYSDEC 2004).

C Concentration falls within Class C - high contamination/acute toxicity to aquatic life (NYSDEC 2004).

2.3.1.2. Aquatic Habitat

The Hudson River bridge construction study area encompasses intertidal and subtidal habitats of varying depths, ranging from shallow intertidal shorelines to shallow subtidal shoals and deeper channel habitats. There are no vegetated tidal wetlands present within the study area. The NYSDEC has mapped areas south of the existing bridge as littoral zone tidal wetlands (i.e., depths of no more than 6 feet at mean low water (MLW)). No NYSDEC tidal wetlands are mapped north of the bridge.

On the west side of the river, the shoreline typically consists of unvegetated intertidal beaches composed of coarse sand with scattered boulders. Immediately north of the bridge the shoreline is bulkheaded. Shallow water environments occur near the shorelines and along the western and eastern causeways, while deep water habitat occurs within and near the shipping channel and the main bridge span. Shallows attract aquatic organisms that prefer greater sunlight and less water depth for part or all of their life cycles, while deeper water areas attract organisms with deeper water column needs. The region under the existing bridge attracts certain organisms that use the pier structures as habitat, or that seek the organisms that adhere to the structures as food resources.

2.3.1.3. Aquatic Biota

The tidal action of the Hudson River, currents, and the seasonal variation in the amount of freshwater contributed to it by precipitation and runoff, make it a highly dynamic and unstable system. As a result, the ecosystem is typically dominated by a few well adapted species. The Tappan Zee section of the Hudson River is the major site of river water mixing with ocean water in the Lower Hudson River Estuary. This productive estuary area is a regionally significant nursery and wintering habitat for a number of anadromous, estuarine, and marine fish species, including the striped bass. It is also a migratory and feeding area for birds and fish that feed on the abundant fish and benthic invertebrate resources in this area. In 1992, the Habitat Work Group of the New York-New Jersey Harbor Estuary Program, administered by USEPA, requested that USFWS identify significant coastal habitats warranting special protection (USFWS 2011).

2.3.1.3.1. Phytoplankton

Diatoms are generally the most widely represented class of phytoplankton, accounting for 78 percent of the different taxa collected, with green algae (15 percent), blue-green algae (cyanobacteria) (3 percent), golden algae (Chrysophyceae) (2.5 percent), dinoflagellates (1 percent), and Cryptophyceae (a type of flagellate algae) (0.6 percent) comprising the remainder of the phytoplankton community. High turbidity and rapid mixing of the Hudson River (which lower light availability) limit primary production by phytoplankton (Smith et al. 1998).

2.3.1.3.2. Submerged Aquatic Vegetation and Benthic Algae

Submerged aquatic vegetation (SAV) are rooted aquatic plants that are often found in shallow areas of estuaries, at water depths of up to six feet at low water (New York's Sea Grant Extension Program undated). These communities exhibit high rates of primary productivity and are known to support abundant and diverse epifaunal and benthic communities. These organisms are important because they provide nursery and refuge habitat for fish. Light penetration, turbidity and nutrient concentrations are all important factors in determining SAV and benthic algae productivity and biomass.

NYSDEC has mapped the distribution of SAV in the Hudson River from Hastings-on-Hudson to Troy using 1997, 2002, and 2007 data. No SAV is mapped in the vicinity of the Replacement Bridge Alternative (see **Figure 15**), although SAV is mapped within the ½-mile study area on either side of the Replacement Bridge Alternative. SAV surveys were conducted as part of the project in 2009 to confirm the locations of SAV identified on the NYSDEC maps. The dominant species of SAV collected as part of the surveys is the native water celery (*Vallisneria americana*); two other species were collected in the vicinity of the project area, including Eurasian water-milfoil (*Myriophyllum spicatum*) and sago palmweed (*Potamogeton pectinatus*). SAV beds were found along the western bank of the river; on the east bank, SAV was only found north of the bridge.

2.3.1.3.3. Zooplankton

Zooplankton are an integral component of aquatic food webs—they are primary grazers on phytoplankton and detritus material, and are themselves used by organisms of higher trophic levels as food. Copepods, cladocerans, and rotifers are the primary representatives of zooplankton species in the Hudson River. Zooplankton also include life stages of other organisms such as fish eggs and larvae (i.e., ichthyoplankton) that spend only part of their life cycle as plankton. Analysis of long-term data from the Hudson River Utilities Long River Sampling Monitoring Program indicates larval Atlantic tomcod (*Microgadus tomcod*), bay anchovy (*Anchoa mitchilli*), striped bass, and white perch (*Morone americana*) as the dominant ichthyoplankton species. The higher-level consumers of zooplankton typically include forage fish, such as bay anchovy, as well as commercially and recreationally important species, such as striped bass and white perch during their early life stages.

2.3.1.3.4. Benthic Invertebrates

Versar (Llanso et al. 2003) collected benthic samples from the lower Hudson River estuary (river miles (RM11 to 40) in 2000 and 2001 which included the vicinity of the study area. In general, they found greatest numbers of species per sample in the lower portions of the study area (south of the Tappan Zee Bridge) and lowest numbers north of the bridge. Greatest benthic biomass occurred in shallow regions of Croton Bay and north of Piermont Pier on the western side of the river. Taxa which showed the greatest densities included the oligochaete worm *Tubificoides* spp., the clam *Rangia cuneata*, and the amphipod *Leptocheirus plumulosus*. They also found the barnacle *Balanus improvisus* and the pollution tolerant polychaete worms *Marenzelleria viridis* and *Heteromastus filiformis* to be present in relatively high abundances.

Bimonthly sampling of benthic resources in the study area for the project was conducted between March 2007 and January 2008. Samples were taken in the vicinity of the existing bridge and the footprint of the Replacement Bridge Alternative. A total of 48 species were collected during the benthic sampling program. Generally, the species richness and numbers of individuals were lower in late winter and early spring and higher in the summer and fall. Species diversity, while relatively constant throughout the year, was observed to be highest in July and lowest in January. The barnacle *Balanus* spp. and the amphipod *Leptocheirus plumulosus* were two of the dominant taxa collected in each of the six sampled months.

Benthic invertebrate sampling of the existing bridge piers conducted for the project in 2007 identified a total of 8 taxa and 2 taxa of benthic algae. The polychaete worm *Nereis* spp., amphipods, barnacles, grass shrimp, mud crabs, isopods, oysters, and ribbed mussels were collected from the piers, as well as red and green algae. These organisms were collected in similar densities on three types of pier structure, namely, steel, concrete and timber.

Surveys (side-scan sonar and seismic profiling combined with grab samples) identified seven potential oyster (*Crassostrea virginica*) beds south of the bridge and six potential beds to the north. All identified oyster beds except one were confirmed to contain at least some live organisms with beds exhibiting differences in terms of oyster density, amount of shell hash, gravel, or sandstone fragments, etc.

2.3.1.3.5. Fishes

The Hudson River estuary's fish community is species-rich. The estuary's species diversity is enhanced by its mid-latitude location on the Atlantic Coast. Southern tropical marine forms enter the Hudson River during the summer, and a number of northern fishes are near their southern limit. The Hudson River fish community, particularly in the estuarine reach, is a mixture of both temperate and tropical marine forms, freshwater forms, and intentional and accidental introductions (ASA 2006). Despite the large number of species that are occasionally found in the estuary, the majority of the fish represent only a limited number of species. More than 99 percent of the total fish community comprises only 10 to 15 percent of the species. In stable ecosystems, low species diversity may be an indicator of environmental stress. However, in highly dynamic and unstable ecosystems such as the Hudson River estuary, the biological community may be dominated by only a few species that are well adapted to such naturally dynamic conditions (ASA 2006).

Each of the fish species that occurs in the River can be classified by its salinity tolerance. Marine species live in the open Atlantic Ocean and nearshore waters and venture into the estuary during the warmer months of the year when salinity is relatively high. These species typically occupy the lower reaches of the estuary. Estuarine species occupy a large portion of the brackish estuary year-round and may be occasionally found in freshwater and marine reaches. Freshwater species live in the Hudson River and rarely, if ever, venture into low-salinity areas of the estuary such as the region in the vicinity of the Tappan Zee Bridge. Several fish species that occur in the Hudson River migrate from the Atlantic Ocean into freshwater habitats of the River, typically for spawning (anadromous), or leave the river to spawn in the open ocean (catadromous).

The dominant marine species in the Tappan Zee region is the bay anchovy. An analysis of the Fall Shoals data from 1998-2007 indicated that numerically, bay anchovy comprised about 82 percent of the total fish standing stock. Bay anchovy are found in salinities ranging from fresh to seawater and may be the most abundant species in the western north Atlantic (Newberger and Houde 1995). Other marine species which were at times abundant in the Utilities sampling program included weakfish (*Cynoscion regalis*), Atlantic menhaden (*Brevoortia tyrannus*), Atlantic croaker (*Micropogonias undulatus*), butterfish (*Peprillus triacanthus*) and bluefish (*Pomatomis saltatrix*).

Estuarine species are generally euryhaline (i.e. tolerant of wide salinity ranges), and are year-round residents of the saline portions of the Hudson River. Abundant estuarine species collected by the utilities' monitoring program included white perch, banded killifish (*Fundulus diaphanus*), Atlantic silverside (*Menidia menidia*), and hogchoker (*Trinectes maculatus*).

Anadromous species that use the estuary as spawning and nursery grounds include alewife (*Alosa pseudoharengus*), American shad (*Alosa sapidissima*), shortnose sturgeon, Atlantic sturgeon, Atlantic tomcod, blueback herring (*Alosa aestivalis*), and striped bass. Adults typically enter the estuary in the spring and migrate upstream to low-salinity brackish and freshwater areas to spawn. The young fish then use the near-shore shoal areas for food and habitat as they make their way downstream, and generally leave the estuary in the fall. American eel (*Anguilla rostrata*) is the only catadromous species that occur in the Hudson. Although the Utilities data indicate that there are wide variations in the annual totals of collected eels, overall there has been a sharp decline in the number of individuals captured during these surveys since the mid 1980s.- The U.S. Fish and Wildlife Service and NMFS are currently reviewing the status of American eel to determine whether it should be proposed for listing as a protected species.

A number of changes in abundance trends within the Hudson River fish community have occurred in recent years. Heimbuch (2008) reported that average biomass of age 1 and older striped bass has increased over fivefold during the periods 1981–1990 and 1991–2005. This increase has been accompanied by declines in the populations of blueback herring, alewife, white perch, and Atlantic tomcod. Blueback herring and alewife have also been designated as candidate species under the ESA on November 2, 2011 due to population declines. It has been postulated that the increase in the predatory demand of striped bass could have been responsible for the decline of these other species (Heimbuch 2008). These five species comprised 85 percent of the catch of estuarine and diadromous species collected by beach seines from 1980 through 2000 (Hurst et al. 2004). Also, a stock assessment performed on American shad in 2007 indicated that the spawning stock, including the Hudson River population, has substantially declined (ASMFC 2007). Since March 2010 recreational and commercial fishing for American shad has been prohibited. This can be contrasted with the ASMFC's assessment of bluefish which considered the coastal stock to be rebuilt and not overfished (ASMFC 2009a).

A year-long fish survey was conducted for the project between April 2007 and May 2008 to further characterize the fish community within the study area and examine seasonal differences in abundance. These surveys combined hydroacoustics, gill nets, and trap nets to characterize the species composition, relative abundances, and distributions of fish populations within the project area.

Results of the hydroacoustic surveys indicate that the horizontal, vertical, and geographical distribution of fishes within the Tappan Zee region and in the project area, in particular, is substantially influenced by temperature and salinity. In the colder months of the year (December through April), the fish populations are concentrated in deeper waters with higher salinities. In the late winter and early spring, a distinct halocline (i.e., salinity gradient) was observed at a depth of approximately 19.7 feet (6 meters), below which fish densities increased. As the water temperature increased during late spring, the halocline dissipated and the salinity in the project area increased in the shallower depths. Also observed was a marked increase in the abundance of fishes at those depths, although the greatest abundances continued to occur in the deepest portion of the channel. In the warmer summer months of the year, early life stages of many species were present within the study area. Presumably these concentrations are salinity driven. A large percentage of the individuals that were captured were members of schooling species.

A total of 25 species (see **Table 4**) and just over 2,000 individual fishes and hundreds of blue crabs were collected during approximately 700 hours of gill-net sampling conducted for the project within the study area between April 2007 and May 2008. Fish were caught throughout the year at all of the sampling locations within the study area. However the total number of fish caught in the colder months was markedly lower than during the warmer months. Moreover, there were higher numbers of fish caught at the sampling locations with greater water depths. Anadromous and estuarine fishes were captured in every sampling event. Marine fishes were only captured in the warmer months of the year.

Table 4
List of Fish Species Occurring within the Project Area Based on Gill-net Sampling, 2007-2008

Common name	Scientific name	Assemblage
Alewife	*Alosa pseudoharengus*	Anadromous
American eel*	*Anguilla rostrata*	Catadromous
American shad	*Alosa sapidissima*	Anadromous
Atlantic butterfish	***Peprilus triacanthus***	**Marine**
Atlantic menhaden	*Brevoortia tyrannus*	Marine
Atlantic tomcod	*Microgadus tomcod*	Estuarine
Bluefish	***Pomatomus saltatrix***	**Marine**
Blueback herring	*Alosa aestivalis*	Anadromous
Blue runner	*Caranx crysos*	Marine
Common carp	*Cyprinus carpio*	Freshwater
Gizzard shad	*Dorosoma cepedianum*	Freshwater
Hickory shad	*Alosa mediocris*	Marine
Hogchoker	*Trinectes maculatus*	Estuarine
Naked goby*	*Gobiosoma bosci*	Estuarine/Marine
Northern kingfish	*Menticirrhus saxatilis*	Estuarine/Marine
Northern sea robin	*Prionotus carolinus*	Marine
Oyster toad fish*	*Opsanus tau*	Estuarine/Marine
Porgy	Family Sparidae	Marine
Shortnose sturgeon	*Acipenser brevirostrum*	Anadromous
Spot	*Leiostomus xanthurus*	Estuarine/Marine
Striped bass	*Morone saxatilis*	Anadromous
Summer flounder	***Paralichthys dentatus***	**Estuarine/Marine**
Weakfish	*Cynoscion regalis*	Estuarine
White catfish	*Ameiurus catus*	Freshwater
White perch	*Morone americana*	Estuarine

Note:
* Species only captured in fish traps.
Species in Bold are Essential Fish Habitat Designated Species for Hudson River

2.3.2 THE HARS

The HARS (see **Figure 8**) is jointly managed by the U.S. Army Corps of Engineers (USACE) New York District and the U.S. Environmental Protection Agency (USEPA) Region 2 in accordance with the *Site Management and Monitoring Plan for the Historic Area Remediation Site* revised May 5, 2009 (SMMP)(USACE and USEPA 2009).

The SMMP:

- provides guidelines to document remediation of required areas within the HARS resulting from placement of an approximately 3-foot (1 meter) minimum required cap thickness of Remediation Material;
- specifies the collection of data to ensure that no significant adverse environmental impacts occur from the placement of Remediation Material at the HARS;
- enforces compliance with Marine Protection, Research and Sanctuaries Act of 1972 (MPRSA) permit conditions;
- provides a baseline assessment of conditions at the HARS;
- provides a program for monitoring the HARS;
- describes special management conditions/practices to be implemented at the HARS;
- specifies the quantity of Remediation Material to be placed at the HARS and the presence, nature, and bioavailability of the contaminants in Remediation Material;
- specifies the anticipated use of the HARS, including the closure date; and
- provides a schedule for review and revision of the HARS SMMP.

Under MPRSA, the USACE and USEPA share responsibility for permitting and HARS designation and management. Placement of dredged material as Remediation Material at the HARS requires a permit from USACE under Section 103 of the MRPSA, subject to USEPA review and concurrence that the material meets applicable ocean disposal criteria. Placement of non-dredged material as Remediation Material at the HARS requires a permit from the USEPA under Section 102 of the MPRSA. To receive the permit, the materials must be suitable for remediation, in that they meet certain criteria related to contaminants based on sediment toxicity and bioaccumulation tests. In addition, in accordance with 40 CFR §227.16, the USEPA must evaluate alternative disposal options before permitting placement of dredged material at the HARS, and must find that there are no practicable alternative locations and methods of disposal or recycling available. In support of this required finding, and alternatives analysis can be found in Appendix H-5 to the Draft Environmental Impact Statement documenting that there are no practicable alternative locations for the placement of the dredged material at the HARS site.

The HARS comprises about 20 square miles (15.7 square nautical miles) within the apex of the New York Bight[1] that includes the approximately 3-square-mile (2.2-square nautical mile) Mud

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[1] The New York Bight is a region defined as ranging from Cape Cod, MA, to Cape May, NJ, and includes Buzzard's Bay, Long Island Sound, New York Harbor and the New Jersey shore (http://web2.uconn.edu/seagrantnybight/).

Dump Site (MDS). The HARS is located on the shallow continental shelf within the New York Bight. Water depths at the HARS range from 46 to 138 feet. Over the past century, dredged material from the Port of New York and New Jersey was routinely disposed of at the MDS. The USEPA formally designated the MDS as an "interim" ocean dredged material disposal site in 1973, and gave it final designation in 1984. On September 29, 1997, the USEPA under 40 CFR §228, closed MDS and simultaneously re-designated the site and surrounding areas that were used historically as disposal sites for contaminated dredged material as the HARS, and proposed that the site be managed to reduce impacts to acceptable levels (in accordance with 40 CFR §228.1(c)) (62 FR 46142) through remediation with uncontaminated dredged material (Remediation Material)(i.e., dredged material that meets current Category I standards[1] and will not cause significant undesirable effects, including through bioaccumulation)(USACE and USEPA 2009). USEPA published final rule 67 FR 62659 on March 17, 2003, to modify the designation of the HARS to establish a HARS-specific worm tissue polychlorinated biphenyl (PCB) criterion of 113 parts per billion (ppb) for use in determining the suitability of proposed dredged material for use as Remediation Material. This amendment to the HARS designation established a pass/fail criterion for evaluating PCBs in worm tissue from bioaccumulation tests performed on dredged material proposed for use at the HARS as Remediation Material (USACE and USEPA 2009).

The HARS comprises three areas (see **Figure 16**): Priority Remediation Area (PRA), a 12 square-mile (9 square nautical miles) area to be remediated with at least about 3 feet (1 meter) of Remediation Material which is divided into 9 areas; a Buffer Zone, a 0.3-mile-wide (0.27 nautical miles) band around the PRA in which no placement of Remediation Material will be allowed, but may receive Remediation Material that incidentally spreads out of the PRA; and No Discharge Zone, an approximately 1.3-square-mile (1 square nautical mile) area in which no placement or incidental spread of Remediation material is allowed. From 1997 through December 2008, approximately 36 million cubic yards (MCY) of Remediation Material from 61 dredging projects have been placed at the HARS as part of the remediation. These remediation projects have included private and Federal maintenance dredging and deepening projects, with the majority of the Remediation Material (approximately 26 MCY) from Federal Deepening projects. Of the nine PRAs at the HARS, only the western PRAS (PRAS 1 through 4) have been remediated. As of 2008, about 13 percent, 17 percent, 64 percent, and 86 percent of the area in PRAs 1, 2, 3, and 4, respectively, and PRAs 5 through 9 are available for Remediation Material.

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[1] USEPA Region 2 and USACE New York District classify dredged material into three categories on the basis of sediment toxicity and bioaccumulation tests:

- Category I: Sediments that meet ocean disposal criteria. Test results indicate no unacceptable toxicity or bioaccumulation. These sediments are acceptable for "unrestricted" ocean disposal. There are no potential short-term (acute) impacts or long-term (chronic) impacts; no special precautionary measures are required during disposal.

-Category II: Sediments that meet ocean disposal criteria. Test results indicate no significant toxicity but a potential for bioaccumulation. To protect from this potential, EPA and the USACE will require appropriate management practices such as capping. This is referred to as "restricted" ocean disposal.

-Category III: Sediments that do not meet ocean disposal criteria. These sediments are those that fail acute toxicity testing or pose a threat of significant bioaccumulation that cannot be addressed through available disposal management practices. These sediments cannot be disposed in the ocean.

Circulation in the New York Bight is complex with temporal and regional variability. Low frequency meteorological forcing, over 3 to 10 day periods, is responsible for much of the current fluctuations over the shelf. During spring and summer the wind energy is reduced and the water column is stratified. The magnitude of the currents increases with the distance offshore and decreases with depth (Beardsely and Boicourt 1981 in USACE 2002). Circulation in the Bight is dominated by a relatively slow flow to the southwest (0.1 feet per second (fps)) with an occasional clockwise bottom gyre. The southerly flow of the Hudson River plume along the New Jersey shoreline forces an opposing northward flow of more saline waters to the east (USEPA 1982 in USACE and USEPA 2009). Near bottom oscillatory tidal currents at the HARS are relatively weak, with maximum speeds of 0.3 fps. Mean currents are also less than 0.3 fps with directions that are dependent upon location, water depth and bottom topography (SAIC 1994b in USACE and USEPA 2009). Surface waves are generally less than about 7 feet in height except during major storms which are most common in the fall and winter (SAIC 1995c in USACE and USEPA 2009). Wave-induced near-bottom currents are greater than 0.7 fps only when surface wave heights are greater than 10 feet and storm centers are to the east or southeast. These wave conditions would occur less than 3 percent of the time in fall and winter, and less than 1 percent of the time in spring and summer (SAIC 1994a in USACE and USEPA 2009).

2.3.2.1. Water Quality

2.3.2.1.1. Salinity

Salinities at the HARS are significantly greater than those at the bridge-construction site. Maximum salinities (33 to 34 parts per thousand [ppt]) occur inshore during the winter (February and March) when sub-freezing conditions reduce river runoff. Surface salinity, particularly near shore decreases with spring thaw and strong vertical gradients may develop. In summer, surface salinities are at the annual minimum (27 to 31 ppt) with bottom salinities of 27 to 29 ppt (USEPA 1982 in USACE and USEPA 2009).

2.3.2.1.2. Temperature

During the winter months, water temperatures are relatively uniform within the HARS (USACE 2002). During spring and summer months, waters at the HARS become thermally stratified with warmer waters at the surface and cooler waters at the bottom. The thermocline dissipates in the fall as bottom waters begin to warm. Thermal stratification acts to contain bottom sediments and prevent re-suspension.

2.3.2.1.3. Suspended Solids

Turbidity at the HARS is low through the water column with a small mid-depth maximum in the central portion of the HARS. The effects of dredged material placement on water quality of the New York Bight have been observed to be minimal, with contaminant concentrations in disposal plumes at the MDS dissipating quickly (less than one hour) to background levels. While plume behavior varies with the grain size of the dredged material, total suspended solids near the center of the dredged material placement plume body have been observed to reach near background levels in 35 to 45 minutes (Battele 1994 in USACE and USEPA 2009). Dissolved oxygen concentrations are consistently above 2.0 milligrams per liter (USACE 2002).

2.3.2.1.4. Sediment Characteristics

Use of the New York Bight Apex as a disposal area over the past 100 years has influenced sediment characteristics within the HARS (USACE 2009). The HARS is dominated by mounded dredged material that rises up to 40 feet from the historic sea floor in some areas (USEPA 1997 in USACE 2002). Surface sediments are heterogeneous, ranging from areas dominated by muddy (fine-grained) sediments to areas covered with coarse sediments (primarily sand) at the former cellar dirt site (USACE 2002). Toxicity testing of the sediments at HARS using amphipods found a wide range of survival percentage (Battele 1996 in USACE 2002). Sediments exhibiting significant toxicity were generally located across the middle of the HARS (USACE 2002).

2.3.2.2. Aquatic Habitat

The study area encompasses offshore habitats at depths ranging from 46 to 138 feet. The bathymetry of the HARS site is characterized by large mounds of deposited dredge material composed of a range of sediment grain sizes from fine silt and clay to coarse sand and gravel as high as 40 feet.

2.3.2.3. Aquatic Biota

Within the HARS, sampling of benthic invertebrates indicated the majority of the species to be annelids (61 percent, including *Prionospio steenstrupi*, a surface deposit feeder, *Polygordius*, and *Pherusa*, a surface-deposit feeder) followed by crustaceans (17 percent) and mollusks (11 percent) (USACE and USEPA 2009).

The New York Bight Apex of the Atlantic Ocean is a transitional region for many species of fish and shellfish. Finfish known to occur in the region include:

- Demersal species—silver hake, red hake, yellowtail flounder, scup, summer flounder, winter flounder, tautog, cod, black sea bass, little skate, windowpane flounder, four spot flounder, ocean pout, cunner, spiny dogfish, spotted hake, northern sea robin, gulf stream flounder, sea raven and longhorn sculpin.
- Pelagic species—butterfish, Atlantic herring, bluefish, and weakfish.
- Pelagic/Anadromous—American shad, alewife and striped bass (USACE and USEPA 2009).

Shellfish include surf clam, sea scallop, American lobster, long-finned squid, rock crab, horseshoe crab, short-finned squid, and Jonah crab (USACE and USEPA 2009).

2.4 DESCRIPTION OF CONSTRUCTION ACTIVITIES

2.4.1 SCHEDULE

Construction of the Short Span Option would take approximately 5½ years. Throughout the construction period roadway work would be required at various times. During that time, the approach roadways would be shifted and remain in the new location for an extended period before being shifted again. The dredging (see **Figure 17**) would occur in three 3-month phases from August 1 through November 1 over a 4-year period, and construction of the main span would consist of approximately 3½ years of construction. Completion of the short span approaches would involve approximately 3½ to 4 years of construction. Demolition of the existing Tappan Zee Bridge would be expected to span approximately 1 year.

Construction of the Long Span Option would last approximately 4½ years. The construction sequence and schedule would be similar to that of the Short-Span Option with the exception of the construction of the approaches, which would be expected to take approximately 2½ to 3 years.

2.4.2 BRIDGE ELEMENTS

2.4.2.1. Landings

Landings would employ typical highway construction techniques and would be completed on both the Westchester and Rockland sides of the Hudson River upland from the bridge abutment to the tie in with the existing roadway. Construction of the landings would occur throughout the duration of the construction. The alterations to the landings would consist of changes in roadway grade, elevation, direction, and general configuration.

2.4.2.2. Approaches

Beginning at the abutments, the approaches carry traffic from the land to the main span of the bridge. Construction of the approaches would last for approximately three and a half to four years for the short-span alternative, and two and a half to three years for the long-span alternative. The piles, pile caps, piers, and deck that compose this segment of the bridge would be built sequentially so that as a new pile is being constructed, a completed pile would be undergoing further transformation with, for example, the addition of a pile cap.

2.4.2.3. Main Span

The main span would stretch between the Westchester and Rockland approaches. It is the segment of the bridge that would be defined largely by its superstructure design as an arch or cable stayed bridge. Within its substructure, the piers would be more substantial than those of the approaches. All main span work would be done sequentially and in a similar manner as that of the approaches. The piles, pile caps, pylons, and deck construction would last approximately three and a half years.

2.4.3 CONSTRUCTION OF KEY ELEMENTS

Construction of either option of the Replacement Bridge Alternative would require a wide range of activities on both sides of the river as well as from within the waterway itself. In addition, due to the lack of available land along the waterfront in the vicinity of the bridge, staging areas at some distance from the construction site would be required. Furthermore, it is likely that some bridge components would be pre-fabricated well outside the study area and transported to the site via barge.

To support construction of the main span and bridge approaches, materials, equipment, and crews would be transported from upland staging areas in Westchester and Rockland counties (see **Figure 18**) to temporary platforms that would be constructed on the shoreline of the river within the Bridge Landing Areas (see **Figures 19 and 20**). Dredged channels (see **Figure 17**) would provide access to the two work areas in the shallow portion of the river crossing: the Rockland and Westchester approaches. Substructure construction would establish the foundation of the bridge through the processes of pile driving, construction of pile caps, and construction of columns. Superstructure construction would then take place either with a gantry that would move from pier to pier lifting segments from barges below (as in the case of the short-span design option) or a short pier-head truss segment would be lifted atop the next open pier column and secured (as in the case of the long-span option). The following sections describe the construction activities with the potential to affect EFH within the study area.

2.4.3.1. Waterfront Construction Staging

The shoreline areas near the proposed bridge site are limited by adjacent development. In order to provide space for the docking of vessels, the transfer of materials and personnel, and the preparation of construction elements, temporary platforms (approximately 9 acres) would be extended out from the shoreline over the Hudson River (see **Figures 19 and 20**). The —1.35 acre permanent portion of the Rockland platform would also enable the continued maintenance of the original Tappan Zee Bridge while the Replacement Bridge Alternative is being constructed, as well as provide continued support for the New York State Thruway Authority (NYSTA) Dockside Maintenance facility operation. Steel piles would be driven to support the platforms. These platforms would provide access to the Replacement Bridge site via temporary trestles. Their main purposes would be to facilitate delivery of heavy duty bridge elements from an offsite fabrication facility, receive deliveries from the concrete batch plant, receive deliveries (i.e., construction equipment and light duty bridge elements) from the staging areas, and allow for barge-mounted cranes to erect heavy duty bridge elements. Upon completion of construction, the temporary platforms and the piles that support them would be removed. The permanent platform which would also be constructed on piles within the Rockland Bridge Staging Area would remain.

As the construction of the temporary platforms and access trestles would begin at the shoreline, an access road and work area near the shore would also be constructed. A channel would be dredged specifically to provide barge access to the temporary platforms from in-river work sites.

2.4.3.2. Dredged Access Channel

Since the proposed bridge alignment spans extensive shallows, it would be necessary to dredge an access channel for tugboats and barges to use during construction of the approach spans. These vessels would be used for the installation of cofferdams, pile driving, the construction of pile caps and bridge piers, and the erection of bridge decks and other superstructure components. As noted earlier, temporary, trestle-type access platforms would be constructed near the shoreline to provide access for construction vehicles that would operate on the trestles. With the installation of the temporary platforms, dredging of the near-shoreline area would be avoided.

Two alternate construction methods were evaluated in an effort to avoid the need to dredge an access channel. One method involved the use of overhead gantries for the construction of foundations and the other consisted of the implementation of a full-length temporary trestle for access. Both of these alternatives were found to be impractical: the former because it is not practicable for the heavy-duty pile-driving requirements of the replacement bridge and the latter because the deep soft soils in the shallow waters of the construction zone would require foundations that would be expensive and time-consuming to construct.

As shown in **Figure 17**, dredging would be conducted in three stages over a 4-year period for a duration of three months each year from August 1 to November 1, a dredging period selected to minimize impacts to aquatic resources. The purpose of the first two dredging stages (Years 1 and 2) would be to provide access for bridge construction, while the final dredging stage (Year 4) would provide access for demolition of portions of the existing bridge allowing completion of the remaining portions of the new structure. Each of these three-month spans would occur during the August 1 to November 1 window. All dredging would be done using environmental bucket with no barge overflow, and no double handling of dredged material.

Based on an analysis of the types, number, size and operation of vessels that would operate in the access channel during construction, it was determined that a clear draft of 14 feet at MLLW would be required within the access channel. To avoid the potential for grounding of vessels, an additional two feet would be added to provide a working channel depth of 16 feet at MLLW.

The likelihood of resuspending fine sediment material due to movement of vessels, particularly tugboats, within the dredged channel will be further minimized by placing a layer of sand and gravel (referred to as “armor”) at the bottom of the channel following dredging. The sediments in the vicinity of the area to be dredged are highly susceptible to resuspension into the water column. Without “armoring,” prop scour from working tugboats in the channel would result in the generation of suspended sediment at rates several orders of magnitude greater than what would occur from the dredging operation itself. Therefore, it was concluded that this level of sediment resuspension and ultimate transport into the river would pose an unnecessary and potentially substantial adverse effect to the marine environment.

The installation of the sand and gravel would take place as soon as the dredging for that section of the channel was completed, forming a protective layer to keep sediment from further disturbance. Without this protective layer, additional dredging would be required to create a deeper work zone. The stone or gravel materials used for the armoring would be delivered by barges or scows, and would be placed within the channel in a manner that minimizes resuspension of bottom material during placement. The materials would not be removed after the project completion, since they would become fully buried by the gradual deposition of river sediments over time. The dredging depth required assumes that two feet of stone or gravel armor is placed on the bottom. In total, the channel would be dredged to a depth corresponding to 16 feet below MLLW.

Table 5 shows the amount of material to be dredged during each stage for the two bridge design options. For either design option, the channel width would measure approximately 475 to 530 feet, and it would extend approximately 7,000 feet from the Rockland County side into deeper waters and 2,000 feet from the Tarrytown temporary platform into deeper waters. Because the long span alternative would occupy a wider footprint, a slightly larger area must be dredged for that alternative. It is estimated that approximately 1.68 and 1.74 million cubic yards of sediment would be dredged for the short and long span options, respectively.

Environmental Performance Commitments (EPCs) to be implemented during dredging operations include:

- adherence to a 3-month fall window of August 1 to November 1 when dredging would be allowed;

- use of an environmental bucket with no barge overflow and no double handling of dredged material
- armoring of the channel to prevent re-suspension of sediment during the movement of construction vessels, installation and removal of cofferdams, and pile driving.
- in-water suspended sediment/turbidity monitoring in accordance with NYSDEC-determined requirements.

Table 5
Dredging Quantities for the Replacement Bridge Alternatives

Construction Stage	Short Span		Long Span	
	Quantity (million CY)	Percent of Total	Quantity (million CY)	Percent of Total
Stage 1	1.08	64%	1.12	64%
Stage 2	0.42	25%	0.43	25%
Stage 3	0.18	11%	0.19	11%
Total	1.68	100%	1.74	100%

Notes:
CY = cubic yards
Dredging for bridge demolition (Stage 3) includes that portion of the bridge which must be removed to complete the Replacement Bridge Alternative tie-in.

2.4.3.3. Transport and Disposal of Dredged Material

During each three-month period when dredging is occurring, dredged materials would be collected from the bottom of the river by barge-mounted cranes with an environmental bucket and placed into hopper scows, which are boats with a capacity of approximately 2,500 cubic yards. To ensure that the scows do not exceed the maximum allowable draft of the river work zone, they would be limited to 80 percent of their maximum load, or 2,000 cubic yards per load.

Each dredging stage would occur during a 90-day period. During that period, it is estimated that dredging would occur up to 75 of the 90 days, with two dredge operations occurring at a time. During the most extensive dredging stage, Stage 1, up to approximately 15,000 cubic yards of materials would be dredged each day. **Table 6** presents the estimated daily volumes of materials removed for each dredging stage for the two replacement bridge alternatives.

Certain activities related to project construction are left to the discretion of the contractor. One of these specific activities would be the ultimate transport and disposal of dredged materials from construction of the access channel. Transport by ocean scow and placement in the HARS in the New York Bight would offer a number of benefits to the project including cost, schedule, logistics and the avoidance of impacts to the surrounding residential communities on the Rockland and/or Westchester shorelines.

Table 6
Daily Materials Removal by Construction Stage

Construction Stage	Short Span Daily Volume (cubic yards/day)	Long Span Daily Volume (cubic yards/day)
Stage 1	14,600	15,000
Stage 2	5,700	5,800
Stage 3	2,400	2,600

In this option, the dredged materials would be placed in shallow draft dredge scows and transferred to the ocean scows in the deeper water adjacent to the navigation channel with a large barge-mounted excavator positioned between the two scows. Silt curtains would be set up around the three barges to minimize dispersion of suspended sediment. In order to increase the economic loading[1] the contractor may elect to allow the dredged material to settle in the shallow scows before transferring the material to the ocean scow. The water from the dredge scow would be decanted to a second tank or scow to settle out the suspended sediments before being discharged back to the Hudson River. Monitoring of decant water would be conducted in accordance with the requirements established by the NYSDEC on the basis of the toxicity and bioaccumulation test results submitted to demonstrate suitability of the dredged material for placement at the HARS.

Following decanting, the dredged material would be transferred from the dredge scow to the ocean scow. Measures would be implemented during this transfer process to minimize loss of dredged material to the Hudson River and associated increases in suspended sediment (e.g., turbidity curtains).

The deeper draft ocean scows (vessels with a larger draft, typically up to 18 feet, and a larger capacity [up to 4,500 cubic yards] that are too deep for the construction channel) would then transport the material to the HARS, located about 4 miles east of Sandy Hook, NJ., where materials would be placed at the site in accordance with the permit conditions for that placement. An assessment of potential effects from the placement of dredged material from the project at the HARS is presented in Chapter 7 of this EFH. The HARS is overseen by the U.S. Army Corps of Engineers (USACE) and the U.S. Environmental Protection Agency (USEPA). This site was historically used for ocean disposal of dredged material and a variety of waste products, including some contaminated materials. Today, the site is being remediated through a

[1] "Economic load is the load in a dredge hopper or scow that corresponds to the minimum unit dredging cost. Economic load is dependent on the material dredged, equipment used, distance to disposal site, and other site-specific factors. Economic load does not necessarily correspond to the maximum load or highest density load that can be obtained." (Palermo, M.R., and R.E. Randall. 1990. *Practices and Problems Associated with Economic Loading and Overflow of Dredge Hoppers and Scows*. Dredging Research Program, Technical Report DRP-90-1. Department of the Army, Environmental Laboratory, Waterways Experiment Station, Vicksburg, Mississippi)

program to cap those historic sediments with cleaner sediments dredged from New York Harbor that meet certain criteria established by the Ocean Dumping Act.

A permit is required for dredged material to be placed at the HARS from the USACE for that placement. To receive the permit, the materials must be suitable for remediation, in that they meet certain criteria related to contaminants based on sediment toxicity and bioaccumulation tests. In addition, in accordance with 40 CFR §227.16, the USEPA must evaluate alternative disposal options before permitting placement of dredged material at the HARS, and must find that there are no practicable alternative locations and methods of disposal or recycling available. In support of this required finding, an alternatives analysis can be found in Appendix F-4 to the Draft Environmental Impact Statement documenting that there are no practicable alternative locations for the placement of the dredged material at the HARS site.

In recognition of the many benefits offered by the HARS site, the project is proceeding with sampling and analysis of the dredged material in support of a permit under Section 103 of the Marine Protection, Research, and Sanctuaries Act of 1972 from the USACE.

If the permit application for the use of the HARS is denied in whole or part, the contractor would be required to dispose of the dredged material at an approved upland facility in accordance with all applicable laws and regulations. However, due to the estimated number of truck trips that would be required (nearly 800 round trips daily) and the potential for adverse traffic, air quality and noise impacts on the local community the contractor would not be allowed to transport the dredged material by truck from the waterfront staging areas in Rockland or Westchester Counties. The contract documents would specify that alternate means of transport of the dredged material such as barge or barge to rail would be required for disposal.

2.4.3.4. Substructure Construction

Substructure construction would vary as a function of water depth and sediment conditions at each location. Work on the foundations can be categorized into three segments referred to as Zone A, Zone B, and Zone C (see **Figures 5 and 6**). Pile installation would typically be performed one row of piles at a time. The actual pile driving is done one pile at a time. As shown in **Table 7**, a total of 1,326 piles for Piers 1 to 57 would be required for the Short Span Option. **Table 8** includes similar information for the Long Span Option at Piers 1 thru 32. The Long Span Option would require 836 piles. In terms of the largest piles, the number of the 10-foot piles would be the same (50) for either option. The greatest difference between the two options would be the number of smaller 4-foot piles with the Sport Span Option requiring approximately 346 more piles than the Long Span Option. The Long Span Option would also require 104 less 6-foot piles and 40 less 8-foot piles for a total difference of 490 piles. Under either option, the driving of the largest piles (8- and 10-foot) would only occur for a few months in the first year of construction. During April 1 to August 1, driving of 8- or 10-foot diameter piles with an impact hammer would be limited to 5 hours per day within in-water construction Zone C (deeper than 18 feet at MLLW).

Table 7
Pile Driving, Short Span Option

Pier No.	Substructure Zone	Pile Size (diameter ft)	No. of Piles Within each Pier	Total No. of Piles
1-3	A1	6	4	24
4-8	B1	6	6	60
9 - 14	B1	4	20	240
15-32	B1	4	20	720
33-35	B1	8	4	24
36-43	C	8	4	64
44-45	C	10	25	50
46-50	C	6	6	60
51-57	B2	6	6	84
			Total	**1,326**

Table 8
Pile Driving, Long Span Option

Pier No.	Substructure Zone	Pile Size (diameter ft)	No. of Piles Within each Pier	Total No. of Piles
1-2	A1	6	4	16
3	A1	6	6	12
4	B1	6	6	12
5-17	B1	4	25	614
18-21	B1	8	4	32
22-23	C	8	4	16
24-25	C	10	25	50
26-28	C	6	6	36
29-30	B2	6	6	24
31-32	A2	6	6	24
			Total	**836**

EPCs to be employed during construction of the substructure include:

- Driving the largest (10 and 8 ft) diameter piles within the first few months of the project thereby limiting the duration of time that piles with the greatest potential impact are utilized.
- Using cofferdams and silt curtains, where feasible, to minimize discharge of sediment into the river.
- Using a vibratory pile driver to the extent feasible (i.e., all piles would be vibrated at least to depth of 120 feet or to vibration refusal) particularly for the initial pile segment.
- Using bubble curtain, cofferdams, isolation casings, Gunderboom, or other technologies to achieve a reduction of at least 10 dB of noise attenuation.

- Using the results of the Hudson River site specific Pile Installation Demonstration Project (PIDP) to inform the project on the effectiveness of BMP technologies for reducing sound levels, and implementing BMPs to achieve maximum sound reduction.
- Limiting the periods of pile driving to no more than 12-hours/day.
- Limiting driving of 8- and 1-foot diameter piles with an impact hammer within Zone C (water depths greater than 18 feet at MLLW) to 5 hours per day during the period of spawning migration for shortnose, Atlantic sturgeon, and other anadromous fish species (April 1 to August 1).
- Maintaining a corridor where the sound level is below the West Coast threshold for onset of physiological effects to fish totaling at least 5000 feet at all times during impact hammer pile driving. This corridor shall be continuous to the maximum extent possible but at no point shall any contributing section be smaller than 1500 feet.
- Pile tapping (i.e., a series of minimal energy strikes) for an initial period to frighten fish from the region of the pile being driven.
- Development of a comprehensive monitoring plan. Elements would include:
    1. Monitoring water quality parameters such as temperature, salinity, and suspended sediment concentrations in the vicinity of the pile driving.
    2. Monitoring fish mortality and inspection of fish for types of injury, as well as a program for determining contaminant levels in dead sturgeon through tissue analysis methods.
    3. Monitoring the rate of recovery of the benthic community within the dredged area and armored bottom and also providing site specific information on sedimentation processes and time of recovery of soft bottom habitat following construction and temporary modification of bottom habitat.
    4. Supporting the Atlantic and shortnose sturgeon sonic tagging program through coordination with NMFS and NYSDEC. This may include placement of telemetry receivers in the project area.
    5. Monitoring predation levels by gulls and other piscivorous birds, which would indicate an increased number of dead or dying fish at the surface.
    6. Preparing a Standard Operating Procedures Manual outlining the monitoring and reporting methods to be implemented during the program.

2.4.3.4.1. Foundation Zone A

The two areas of shallowest water depth extend from the shorelines on the Rockland and Westchester sides of the Hudson. These areas, where the water depth is less than 7 feet, are labeled as Zone A. The area adjacent to the Rockland shoreline is labeled Zone A1; the area adjacent to the Westchester shoreline is Zone A2. Zone A substructure elements would be constructed within cofferdams from adjacent temporary trestle platforms. These cofferdams would be constructed prior to pile driving the bridge foundation piles. The cofferdam would remain flooded during pile installation.

Cofferdams

A cofferdam is a watertight chamber designed to facilitate construction in an area that would otherwise be underwater. In this case, the cofferdams would be composed of interlocking sheet piles extending into the riverbed a distance of up to 20 feet. Upon completion of the cofferdam, foundation piles would be driven into the riverbed prior to dewatering. The remaining work of pile cap and pier construction would follow the dewatering process.

Pile installation

Prior to pile driving, a template to guide piles would be placed within the cofferdam to ensure that the piles are in position and to hold them when pile driving is not taking place. Once all piles are driven, the template and its supports would be removed and transitioned to the next cofferdam. A quick, low-noise, moderate-energy vibratory hammer would be used to install much of the length of the pile, after which a high efficiency hydraulic impact hammer suspended from cranes operating on the two temporary shoreline access trestles would be used to apply force to the tops of the piles so as to deliver the piles more deeply into the riverbed. It should be noted that the use of vibratory hammers for the entire driving operation is not possible due to the excessive depth to bedrock. Feasibility of using vibratory hammers to drive piles deeper than originally proposed in order to reduce the duration of impact hammering will be tested in the PIDP. It is anticipated that the initial set for these deep piles cannot be overcome after pile sections are spliced. Using the vibratory hammer rather than the impact hammer to accomplish the majority of the pile driving would require the addition of substantially more pilings than originally proposed in order to achieve the desired weight-bearing capacity and settlement of pilings into the substrate. The extent of vibratory piling will be reconsidered after the results from the PIDP are available.

A 300-ton crawler crane would suspend the 150-foot pile sections and support the pile driving hammer during operation. Upon completion of pile installation, the soil within each pile would be excavated and transported to an off-site disposal facility. Finally, a tremie concrete plug, which braces the bottom of the sheet pile cofferdam and provides a seal at the base of the cofferdam to allow for dewatering of the cofferdam, would be poured inside the pile and a steel reinforcing cage would be inserted into the pile. Since the water within the cofferdam would be of the same quality as the water outside the cofferdam, treatment during the dewatering process is not proposed but would be done if required by the NYSDEC.

Pile caps

As previously mentioned, a tremie concrete plug would be poured into the hollowed pile. The pile itself would be dewatered down to the plug. Prior to the installation of the pile cap, pier reinforcement, post tensioning ducts, and pile reinforcement would be secured. A pile cap, which is a reinforced concrete slab constructed atop a cluster of foundations piles, would then be constructed to form a single structural element that would allow for even distribution of the weight that the piles bear, avoiding over stressing any individual component. These slabs would also provide a larger area for the construction of the columns that they will support.

2.4.3.4.2. Foundation Zone B

The water depths in Zone B range from 5 to 18 feet, and the zone is characterized by a relatively deep soft-soil profile. Zones B1 (close to the Rockland shoreline) and B2 (close to the Westchester shoreline) are located adjacent to Zones A1 and A2 and are closer to the centerline of the river. The functions performed in Zone B substructure construction would take place in cofferdams, as in Zone A, but the tasks would be completed from barges and support vessels rather than the temporary platforms.

Pile Installation

Piles, which would be transported in two pieces to Zone B by barge, would measure between 250 and 300 feet due to the relatively deep soft-soil profile within the zone. Pile driving would begin immediately upon completion of the cofferdam construction. As in Zone A, a 300 ton crawler crane would lift the pile sections. A pile-driving rig would supply a hammer suspended from the barge mounted crane. The template would be positioned to guide the lower pile section into proper position before the pile would be allowed to delve into the soft stratum under its own weight. The depth achieved in this manner would be considerable, and should the application of further pressure be called for, a vibratory hammer would be used to drive the remainder of the pile into place. Upon the placement of the lower segment of the pile, preparations to begin welding the two segments together will commence. In order for the two segments to be joined, the upper segment would be hovered over the lower until the automated welding process was complete. Upon the completion and inspection of the welding, the remaining length of the conjoined pile would be driven to required depth or specified penetration resistance with a hydraulic hammer. As in Zone A, the soil within the pile would be excavated and transported to an off-site disposal facility in order to create space for the tremie plug and steel reinforcing cage.

Pile caps

The construction process of pile caps in Zone B would be similar to that of Zone A. One difference would be that a granular fill material would be distributed inside of the cofferdam to enable the tremie seal to be poured to its planned elevation. This granular material would remain after the removal of the cofferdam.

2.4.3.4.3. Foundation Zone C

Foundation Zone C lies between Zones B1 and B2, connecting the two sides of the river. This zone is defined by the greatest water depths, which range from 18 to 45 feet. Construction in this zone would encompass the construction of the main span as well as that of both approaches.

The first substructure construction activity in Zone C would be the installation of the foundation piles. In this zone, due to the greater depths than Zones A or B, cofferdam construction would follow the pile installation, thus requiring that the cofferdam be constructed around the installed pile to create a dry environment in which to construct the tremie seal. The cofferdam in Zone C would be constructed using a different method than that utilized in Zones A and B. This alternative method, the “hanging cofferdam method,” would begin with the installation of a temporary support structure above the foundation piles on which the cofferdam would be assembled. The cofferdam components would then be pieced together from pulleys secured to the top beams of the support structure. After the placement of the cofferdam, the tremie slab would be poured onto a steel deck acting as the cofferdam floor. Divers would seal the gaps between the piles and the cofferdam deck before the dewatering process. The tremie slab would then be poured, and the unreinforced slab would bond the piles to the cofferdam pending the construction of the reinforced pile cap.

2.4.3.5. Construction of Bridge Superstructure

Completion of the bridge superstructure would include piers, columns, pylons (for a cable-stayed option), bridge deck, roadway finishes, lighting, and the shared use path. Much of the material would be pre-fabricated at various locations and delivered to the project site via barge. At the construction site, these elements would be lifted into place by gantries and cranes operating on barges, the temporary work platforms, or completed portions of the structure.

2.4.3.6. Existing Bridge Demolition

The existing Tappan Zee Bridge contains five segments: causeway, east trestle, east deck truss, west deck truss, and main spans. The demolition of the existing bridge will be performed in two stages. The first stage will include partial demolition to allow for construction of the new bridge, and the second stage will occur after the completion of the new bridge. No blasting of the existing structure would occur.

2.4.3.6.1. Causeway and East Trestle Spans

The causeway is a simple span construction composed of 166 spans measuring 50 feet, with the exception of one 100-foot span. The east trestle consists of 6 spans. Within its simple span construction, the causeway contains a stringer and deck superstructure and a substructure of concrete columns and footings on timber piles. Initially, the deck and stringers would be lifted out and placed onto awaiting barges. Then, the protective dolphins would be cut so as to offer unrestricted access for pier removal. Columns and footings would either be cut with diamond wire or broken by pneumatic hammers. Finally, the timber piles forming the causeway foundation would be cut to just below the mud line. All materials would be transported to an appropriate permitted off-site disposal facility, and a turbidity curtain would be utilized to ensure that demolition debris would not be dispersed. Side-scan sonar surveys would be performed in order to verify that all generated debris would be removed from the river.

2.4.3.6.2. Deck Truss Spans

The deck truss spans, including 13 east deck, 7 west deck, and all approach truss spans, each contain a deck slab, steel trusses, and concrete piers supported on buoyant foundations or caissons. The deck slabs would be removed and transported off-site by an awaiting barge. A channel would then be dredged in Stage 3 to provide access to the trusses near the Westchester shoreline, and steelwork would either be removed by barge-mounted crane or a crane mounted on an adjacent in-tact span. Caisson-supported piers would be demolished using the same process as in the causeway and east trestle spans, and would then be removed to the mud line using diamond cutting wire devices or pneumatic hammers. Steel H piles would remain below the mud line. Turbidity curtains and netting would also be used in this stage.

2.4.3.6.3. Main Span

The main span stretches 2,412 feet and is structurally formed by a through truss above a deck supported by four latticework piers on buoyant foundations, ice deflectors around the two central piers, and pre-stressed concrete beams on 30-inch diameter steel piles. Initially, the main span deck slab would be lifted and removed off-site by barge. Then, the entire suspended span would be lowered onto a barge via a strand jack or winch system. Conventional barge-mounted cranes would then deconstruct the anchor span steelwork piece by piece and the ice-breaker and fender structures protecting the main span piers would be demolished by divers and barge-mounted cranes. The pier steelwork would also be removed piece by piece, and the buoyant caissons would be cut and flooded. Following main span demolition, a barge-mounted crane operated clam shell bucket would clear the river bottom of debris. Side-scan sonar surveys would verify that all debris and concrete were removed from the river.

Chapter 3: EFH Designations—Hudson River Bridge Construction Study Area

To delineate EFH, coastal littoral and continental shelf waters were first mapped by the regional Fisheries Management Councils (FMCs) and then superimposed within ten minute-by-ten minute (10’ by 10’) square coordinate grids. Finally, survey data, gray literature, peer-review literature, and reviews by academic and government fisheries experts were used by the FMCs to determine whether these 10’ X 10’ grids support EFH for federally managed species. The Mie-Atlantic Fisheries Management Council (MAFMC) has designated EFH in the lower portion of the Hudson River. The study area is within a portion of the Hudson River/Raritan/Sandy Hook Bays, New York/New Jersey Estuary. **Table 9** lists the species and life stages of fishes identified as having EFH within the Hudson River Bridge Construction Study Area. Chapter 8, “EFH Assessment for Placement of Project Dredged Material at HARS,” identifies the EFH designated species for the HARS and assesses the potential impacts to EFH from the proposed placement of dredged material from the Tappan Zee Hudson River Crossing Project.

Table 9
Essential Fish Habitat Designated Species for the Hudson River

Species	Eggs	Larvae	Juveniles	Adults/ Spawning Adults
Red hake (*Urophycis chuss*)		M, S	M, S	M, S /
Winter flounder (*Pseudopleuronectes americanus*)	M, S	M, S	M, S	M, S / M, S
Windowpane flounder (*Scophthalmus aquosus*)	M, S	M, S	M, S	M, S / M, S
Atlantic herring (*Clupea harengus*)		M, S	M, S	M, S /
Bluefish (*Pomatomus saltatrix*)			M, S	M, S /
Atlantic butterfish (*Peprilus triacanthus*)		M	M, S	M, S /
Atlantic mackerel (*Scomber scombrus*)			S	S /
Summer flounder (*Paralichthys dentatus*)		F, M, S	M, S	M, S /
Scup (*Stenotomus chrysops*)	S	S	S	S /
Black sea bass (*Centropristis striata*)	n/a		M, S	M, S /
King mackerel (*Scomberomorus cavalla*)	x	x	x	x
Spanish mackerel (*Scomberomorus maculatus*)	x	x	x	x
Cobia (*Rachycentron canadum*)	x	x	x	x
Clearnose skate (*Raja eglanteria*)			x	x /
Little skate (*Leucoraja erinacea*)			x	x /
Winter skate (*Leucoraja ocellata*)			x	x /

Source: National Marine Fisheries Service. “Summary of Essential Fish Habitat (EFH) Designation” posted on the Internet at http://www.nero.noaa.gov/hcd/ny3.html
M=The EFH designation for this species includes the mixing water/brackish salinity zone of the Hudson River estuary (0.5ppt<salinity<25.0 ppt)
F=The EFH designation for this species includes the tidal freshwater salinity zone of the Hudson River estuary (0.0 ppt<or=salinity<or=0.5 ppt)
S=The EFH designation for this species includes the seawater salinity zone of the Hudson River estuary (salinity> or=25.0 ppt)
Blank cells indicate that no EFH designation occurs for the particular life stage.
x= EFH has been designated for this species and lifestage.

Detailed descriptions of the life histories, habitat requirements, and potential project impacts to these species, as well as to marine turtles and mammals and striped bass within the Hudson River bridge construction study area are provided below following the general discussion of potential aquatic impacts from the proposed project.

Chapter 4: Potential Impacts to EFH—Hudson River Bridge Construction Study Area

4.1 GENERAL DISCUSSION OF POTENTIAL AQUATIC IMPACTS FROM THE CONSTRUCTION OF THE PROPOSED PROJECT

4.1.1 WATER QUALITY

For the Hudson River, the principal water quality resources issues for the construction of the Replacement Bridge Alternative is the resuspension of river sediments during construction and removal of the existing bridge foundations, and the transport and eventual deposition of this resuspended sediment elsewhere in the Hudson River. While the sand fraction of river sediment settles out relatively quickly after being resuspended, the finer sediment fractions will remain suspended and will be transported away from the construction area and will be deposited elsewhere in the estuary or leave the estuary altogether. Hydrodynamic modeling was used to project the plume of resuspended sediment that would result from sediment disturbing construction activities and the fate and transport of this plume within the Hudson River estuary. Two public domain models were employed in the modeling; the Environmental Fluid Dynamics Code (EFDC) model and Research Management Associates (RMA) model. The EFDC is a state-of-the-art hydrodynamic model that can be used to simulate aquatic systems in one, two, and three dimensions. It is one of the most widely used and technically defensible hydrodynamic models in the world (www. Epa.gov/Athens/wwqtsc/html/efdc.html). The EFDC model and technical support is available from the USEPA and is the most widely used hydrodynamic model. The RMA model is a dynamic two-dimensional depth-averaged finite element hydrodynamic model that was developed for the USACE and is used extensively for bridge scour evaluations in estuaries. It is one component of the US Army Corps of Engineers TABS-MD System (US Geological Service (USGS) Surface Water and Water Quality Models Information Clearinghouse (http://smig.usgs.gov/cgi-bin/SMIC/model_home_pages/model_home?selection=rma2).

As indicated in the construction timeline presented in **Figure 17**, there are periods when sediment disturbing activities evaluated in the hydrodynamic modeling would occur concurrently, with the majority of the potential for sediment resuspension occurring during the first two dredging periods. The hydrodynamic modeling results evaluated in this EFH comprise conservative scenarios that would be expected to result in the greatest sediment resuspension:

- stage 1 dredging with pile driving for the main span (Zone C) and trestles;
- pile driving and cofferdam installation and dewatering for Zones C and B, movement of construction vessels, and trestle construction after Stage 1 dredging is complete; and
- stage 2 dredging combined with pile driving and cofferdam installation and dewatering for Zones C and B, and movement of construction vessels.

4.1.1.1. Sediment Resuspension and Transport

The Long Span Option would have fewer total number of piers (35) than the Short Span Option (62), resulting in a shorter construction duration (4½ years) than the short span option (5½ years). While the number of main span piers is the same between the two options, the long span option has far fewer piers in the approaches.

Sediment disturbing construction activities include dredging, cofferdam construction, and pile driving within Substructure Zones A and B, pile driving within Substructure Zone C (see **Figures 5 and 6** for the location of these zones) and the movement of construction vessels within the construction access channel for the Long and Short Span options. Within Construction Zones A and B (see **Figures 5 and 6**) pile driving would occur within the cofferdams and would not have the potential to re-suspend sediment within the river. Within Zone C, piles would be driven first and then the pile caps installed within hanging cofferdams. Therefore, only the Zone C piles would have the potential to result in additional sediment re-suspension. Hydrodynamic modeling was used to project the plume of resuspended sediment that would result from these concurrent sediment disturbing construction activities and the fate and transport of this plume within the river estuary.

The results of the modeling of the scenarios expected to result in the greatest resuspension of sediment indicated in **Figures 21 through 24** are similar for the Long Span and Short Span Options and indicate that total suspended sediment concentrations in the range of 50 to 100 mg/L above ambient conditions would only occur in the immediate vicinity of the dredges. This level of increase would be expected to occur within the allowable mixing zone for dredging. Other sediment disturbing construction activities would result in a much smaller contribution of suspended sediment (i.e., driving of piles for the cofferdams, pile driving, vessel movement and cofferdam dewatering). On flood and ebb tides, concentrations of 10 mg/L above ambient conditions may extend in a relatively thin band approximately 1,000 to 2,000 feet from the dredges, while concentrations of 5 mg/L may extend a greater distance. Total suspended sediment concentrations recorded during sampling conducted for the project ranged from 13 to 111 mg/L. Additionally, the approximately 8-year record of suspended sediment concentration (SSC) recorded by the USGS at Poughkeepsie (see **Figure 12)** indicates there is considerable variation in the suspended sediment concentration within the Hudson River, as would be expected with an estuarine environment. During periods of higher freshwater flow the differences between low and high SSCs range between approximately 20 to 40 mg/L, during periods of low freshwater inflow the differences between low and high SSCs range from about 5 to 20 mg/L.

Therefore, the projected increases in suspended sediment due to dredging concurrent with other sediment-disturbing construction activities would be well within the natural variation in suspended sediment concentration and would not result in adverse impacts to water quality and would be expected to meet the turbidity standard for Class SB waters at the edge of the mixing zone. Concentrations of total suspended sediment from cofferdam construction (which include the discharge of river water recovered during dewatering) and pile driving would be approximately 5 to 10 mg/L in the immediate vicinity of the activity (within a few hundred feet) which would be much less than that projected to result from dredging and would not result in adverse water quality impacts. Concentrations of total suspended sediment resulting from construction vessel movement are projected to be less than 5 mg/L. Increases of total suspended sediment concentration above ambient would be greatest during slack tide, without tidal action to disperse it (see **Figures 21 and 23**).

Placement of the sand/gravel armoring material within the dredged area, similar to the placement of granular capping material over contaminated sediment, has the potential to result in sediment resuspension when the capping material is deposited upon the sediment, but would not be expected to affect the magnitude of sediment resuspension projected through the hydrodynamic modeling. Results of monitoring conducted during placement of granular capping material on soft sediment indicated that resuspended sediment plumes were due to fines washed of the sand cap material and not due to resuspension of bottom sediment as the capping material was put in place (USACE 2005). Measures would be implemented during placement of the sand layer of the armoring to minimize resuspension of the newly exposed sediment. These measures are the same type of measures that have been demonstrated to successfully cap contaminated sediment with minimal mixing of the cap with contaminated sediment (Palermo et al. 2011), and for the capping of subaqueous dredged material (Palermo et al. 1998). They include both mechanical (dry sand capping material with bottom-dump barge, side-casting, bucket/clamshell, tremie (gravity-fed downpipe)) and hydraulical (wet/slurry of sand placed from a pipe or tremie, or from a spreader barge) placement of the capping material (USACE 2005 and 2006, USEPA 1994, Palermo et al. 2011). Mechanical methods rely on the gravity settling of the granular capping materials in the water column (Palermo et al. 2011) which can result in less water column dispersion than discharge of hydraulically-handled cap material because it settles faster in the water column (USACE 1991). Hydraulic methods can allow for a more precise placement of the material at the surface or depth but may require use of a dissipation devise to reduce sediment resuspension (Palermo et al. 2011, USACE 1991).

Placing sand capping material in layers has been found to allow gentle spreading, resulting in a more stable sand cap (Ling and Leshchinsky undated), and avoiding displacement of or mixing with the underlying sediment (USEPA 2005). This results in a decrease in the turbidity plume with each successive cap layer. The reduction in sediment resuspension observed by placing granular capping material in lifts or layers may afford the ability to place subsequent layers using an alternative methodology that may allow faster placement (USEPA 2008). Therefore, once the sand layer of the proposed armoring is in place, the placement of the gravel would have limited potential to result in sediment resuspension. With the implementation of these methods of placement of granular capping material that have been proven to reduce sediment resuspension during placement, additional sediment resuspension that would occur during the placement of the armoring material would be minimized and would not be expected to result in adverse water quality impacts.

In summary, the results of the hydrodynamic modeling of changes in suspended sediment resulting from construction activities—dredging, pile driving, cofferdam construction, and vessel movement—indicate that with the exception of the portion of the mixing zone within the immediate vicinity of the dredge, increases in suspended sediment would be minimal for the Long and Short Span Options and within the natural range of variation of suspended sediment concentration within this portion of the river. Sediment resuspension resulting from dredging and other sediment disturbing activities would be expected to meet the Class SB turbidity standard at the edge of the mixing zone. Resuspended sediment would dissipate shortly after the completion of the dredging activities, and would not result in adverse impacts to water quality. During the periods of in-water construction when no dredging is occurring, the limited sediment resuspension during pile driving, cofferdam installation and removal, and vessel movement would be localized, would be expected to dissipate shortly after the completion of in-water construction activity and would not result in adverse water quality impacts. Similarly, with the implementation of measures demonstrated to minimize sediment resuspension during placement of capping or armoring material, the placement of the armoring material within the dredged area would not result in adverse water quality impacts. For all of the reasons presented above the increase in suspended sediment projected to result from dredging and other in-water sediment-disturbing construction activities, even under the worst case scenarios, and the placement of armoring within the dredged channel, would not result in adverse impacts to water quality of the Hudson River.

4.1.1.2. Sediment Quality and Water Quality Impacts Due to Resuspension

As described under *Project Setting*, the moderate levels of contaminants indicated through laboratory analysis of sediment samples collected within the study area in 2006 and 2008 typically apply to only the upper few feet and the concentrations of these contaminants decline to those that would be considered to have no appreciable contamination according to NYSDEC TOGS 5.1.9. within a few feet of the mudline. Resuspension of sediments during dredging can also affect water quality through the release of contaminants dissolved in the sediment pore water (i.e., the water occupying the spaces between sediment particles). Considering the limited plume of increased suspended sediment above ambient concentrations projected to occur during the three-month dredging periods, and the limited area of sediments with low to moderate levels of contamination within the area to be dredged, the release of any contaminants would not result in adverse impacts to water quality.

These findings are supported in an evaluation conducted by Hayes (2012) for the Tappan Zee Hudson River Crossing. Using the DREDGE model, Dr. Hayes evaluated projected dissolved concentrations of certain contaminants present within sediments of the Hudson River bridge construction study area, as described in Section 2.3.1 of this EFH Assessment. The dissolved contaminant concentrations were evaluated at the edge of a 500-foot mixing zone and compared to acute water quality criteria for Class SB waters. The results of this analysis indicate that dissolved water column concentrations of the sediment contaminants (arsenic, cadmium, copper, lead, mercury, total PCBs and Total PAHs) predicted by the DREDGE model are all substantially less than their acute water quality criterion for aquatic exposure.

The other in-water construction activities with the potential to result in sediment resuspension (pile driving, installation of the cofferdam and vessel movement) for the Long and Short Span Options are projected to result in a minimal increase in SSC above ambient concentrations. These projected increases would actually be much lower, because within Zones A and B, the sand/gravel armoring layer installed throughout these two zones to minimize scouring would also minimize any resuspension of sediment resulting from the installation of the cofferdams. River water recovered during dewatering of the cofferdams would be treated (e.g., tanks to settle out any suspended sediments and water filtration system as necessary) and discharged back to the Hudson River in accordance with conditions issued by the NYSDEC under the Section 401 water quality certification for the project and would not result in adverse impacts to water quality of the Hudson River.

4.1.1.3. Existing Bridge Demolition

Bridge demolition would occur in two stages. The first stage includes partial demolition to allow for construction of the replacement bridge in the vicinity of the Westchester shoreline. The second stage includes the remaining demolition after completion of the replacement bridge. Use of turbidity curtains during removal of the columns and footings and cutting of the timber piles would minimize the potential for sediment resuspended during the bridge removal activities to adversely affect water quality. Following removal of the existing bridge, sediment that has been deposited within mounds in the vicinity of the existing bridge piers may erode over time until reaching a new equilibrium elevation. Because the Tappan Zee portion of the Hudson River is considered to be neither a depositional or erosional environment (i.e., in equilibrium) (Nitsche et al. 2007) as indicated by the results of the 20th century sediment mapping presented in **Figure 14**, the erosion of these sediments in the vicinity of the existing bridge would be limited under normal river conditions and would most likely occur during high flow events. While some of these sediment deposits have elevated concentrations of certain contaminants (NYSDEC TOGS 5.1.9 Class B or Class C categories), these elevated concentrations do not extend more than a few feet below the mudline. Therefore, the gradual erosion of some areas of contaminated sediment following the removal of the bridge would not be expected to result in adverse impacts to water quality or result in water quality conditions that fail to meet the Class SB standards. These findings are also supported by the previously discussed results of the DREDGE modeling that indicated that dredging of the sediments within the Hudson River bridge construction study area would result in dissolved concentrations of contaminants at the edge of a 500-foot mixing zone that are far below the acute water quality criteria for Class SB waters (Hayes 2012). Gradual erosion of some areas of contaminated sediment would be expected to result in less resuspension of bottom sediment than dredging, and even lower concentrations of dissolved contaminants than dredging.

4.1.2 AQUATIC BIOTA

Construction of the project has the potential to affect benthic macroinvertebrates, fish, and EFH due to loss of habitat from dredging, pier installation (e.g., pile driving, installation of cofferdams and fendering), the temporary change in bottom habitat resulting from dredging and subsequent placement of armoring, temporary increases in suspended sediment due to dredging and other sediment disturbing construction activities, and hydroacoustic effects on fish and benthic macroinvertebrates, as discussed in detail below.

4.1.2.1. Benthic Macroinvertebrates

Tables 10 and 11 indicate permanent and temporary impacts to benthic macroinvertebrates due to platform coverage, dredging and armoring. Temporary increases in suspended sediment and changes to the hydroacoustic environment have the potential to affect benthic macroinvertebrate resources.

4.1.2.1.1. Dredging

The primary impact to benthic macroinvertebrates from dredging is the loss of the habitat and animals associated with the dredged material (Hirsch et al. 1978). Dredging can also cause the conversion of shallow subtidal habitat to deeper subtidal habitat and can result in temporary increases of suspended sediment due to resuspension of bottom sediment. This section addresses the potential impacts to benthic macroinvertebrates from the loss of habitat and individuals. Potential impacts associated with increased suspended sediment are evaluated under *In-water Construction Activities*. The frequency of dredging or disturbance of an area affects the invertebrate community and its ability to recover following each dredging event. Benthic communities found in environments with a great deal of variability such as estuaries have higher rates of recovery from disturbance. Recovery rates of benthic macroinvertebrate communities following dredging range from only a few weeks or months to a few years, depending upon the type of project, the type of bottom material, the physical characteristics of the environment and the timing of disturbance (Hirsch et al. 1978, LaSalle et al. 1991). In a two year study in the lower Hudson River, Bain et al. (2006) reported that within a few months following dredging, the fish and benthic communities at a dredged location were no different from seven nearby sites that had not been dredged. The results of monitoring did not indicate a lasting effect at the dredged site.

Dredging activities for the project have the potential to remove benthic macroinvertebrates, including oyster beds, and the food resources they provide to other aquatic resources. Approximately 165 to 175 acres of bottom habitat—including about 5.3 acres of NYSDEC regulated littoral zone tidal wetland and 160-170 acres of open water benthic habitat—would be dredged during three 3-month phases, from August 1 through November 1, over a four year period (see **Figure 17**). The dredging period of August 1 to November 1 would avoid periods of anadromous fish spawning migrations and peak biological activity. In addition, the trench would be armored following dredging and the benthic habitat within the dredge zone which was primarily soft sediment would be changed to a substrate of sand overlain with gravel. Since armoring would occur up to 20 feet of the side slope, approximately 155 to 165 acres of sand/gravel bottom would result from the project.

Table 10
Overwater Coverage from Platforms

	Habitat	Acres
Temporary Overwater Coverage		
West Platform-Storage Platform Area	Open Water	4.26
East Platform-Storage Platform Area	Open Water	2.30
East Platform-Docking Platform Area	Open Water	1.84
East Platform-Access Road	Littoral Zone	0.50
	TOTAL	**8.9**
Permanent Overwater Coverage		
Permanent Platform	Littoral Zone	0.00
Permanent Platform	Open Water	2.44
	TOTAL	**2.44**

Table 11
Potential Loss of River Bottom, Wetlands, and Adjacent Area Habitats due to Project Activities

	Possible Freshwater Wetland Areas (acres)	NYSDEC Littoral Zone Tidal Wetlands (acres)	NYSDEC Tidal Wetland Adjacent Area (acres)	Open Water Benthic Habitat (acres)	Total Short Span (acres)	Total Long Span (acres)
Temporary						
West Platform-Storage Platform Area	-	-	-	0.21	0.21	0.21
East Platform-Storage Platform Area	-	-	-	0.12	0.12	0.12
East Platform-Docking Platform Area	-	-	-	0.09	0.09	0.09
East Platform-Access Road	0.15	0.03	0.4	-	0.58	0.58
Dredging/Armoring	-	5.3	-	160-170/ 155-165	175/165	165/160
West Nyack Staging Area	2.0	-	-	-	2.0	2.0
Tilcon Quarry Staging Area	-	-	-	-	-	0
TOTAL TEMPORARY	**3.5**	**5.3**	**0.4**	**160.4-170.4**	**178**	**168**
Permanent						
Permanent Platform-Pile-Supported	-	-	-	0.12	0.12	0.12
Permanent Maintenance Area Fill to be Removed	-	-	-	(0.10)	(0.10)	(0.10)
New Bridge	-	-	-	6.5-8.0	8	6.5
Removal of Existing Structure	-	-	-	(7.1)	(7.1)	(7.1)
TOTAL PERMANENT	**0**	**0**	**0**	**(0.58)-0.92**	**0.92**	**(0.58)**

While the dredging would result in the loss of individual macroinvertebrates, it is not expected to result in any permanent adverse impacts on these species at the population level within the Hudson River Estuary. The majority of the bottom habitat and associated benthic macroinvertebrates within the area impacted is the soft sediment community which dominates the Upper New York Harbor and Hudson River. Calculations indicate that deposition within the dredged channel following completion of construction will occur at a rate of about one foot per year. Other studies in the Hudson River region have reported somewhat lower desposition rates on the order of approximately 1 to 5 inches per year (Nitsche et al 2010; Bokuniewicz, H. J. 1988; Wilber and Icco 2003). In any case, recolonization by benthic organisms adapted to softer sediments could be expected to begin within a few months after completion of construction in any given area. Prior to the deposition of sufficient sediment to support a soft substrate benthic invertebrate community, some recolonization of the gravel armor material would be expected occur. Organisms within the nearby gravel substrate located within the main channel (NYSDEC benthic mapper http://www.dec.ny.gov/lands/33596.html, and Nitsche et al. 2007) would serve as a source of organisms to colonize the gravel capping material until the soft sediment is of a sufficient depth to be colonized by soft substrate organisms. Although the area affected by dredging is substantial, the effects to the soft sediment habitat, which is the dominant sediment type in the lower estuary, should be viewed as temporary and not indicative of a permanent adverse impact.

4.1.2.1.2. In-Water Construction Activities

In-water construction activities have the potential to result in temporary and permanent habitat loss, habitat modification, and temporary increases in suspended sediment due to resuspension of bottom sediment as described below.

<u>Pier Construction</u>

During construction, a total of approximately 8 acres and 7 acres of open water benthic habitat would be lost within the footprint pilecaps and fendering for the Short Span and Long Span Options, respectively.

<u>Temporary Platforms within Bridge Staging Areas</u>

Impacts to benthic habitat would also occur due to the construction of two temporary work platforms north of the existing bridge within the Bridge Staging Areas. Temporary platforms would be constructed on the east and west sides of the river. Since the work platforms for the two bridge replacement options would be the same, approximately 9 acres of open water benthic habitat would be temporarily affected due to overwater coverage, and about 0.3 acres of open water benthic habitat would be temporarily lost within the footprint of the piles supporting the temporary platforms. After construction, these temporary platforms would be removed and the supporting piles cut at the mudline.

<u>Permanent Platform Within the Rockland Bridge Staging Area</u>

As discussed above, a permanent work platform would also be constructed on piles within the Rockland Landing Staging Area. The permanent work platform would result in about 2.44 acres of overwater habitat that would be shaded by the platform. The footprint of the piles associated with the docking and maintenance areas of the permanent platform would result in a loss of 0.12 acres of bottom habitat. However, this loss would be mostly offset by the removal of existing fill within the current maintenance area, creating 0.10 acres of new benthic and associated open water habitat.

4.1.2.1.3. Temporary Increases in Suspended Sediment from Construction Activities

Construction activities that are expected to contribute to sediment resuspension include dredging, vessel movements, cofferdam construction, pile driving and demolition of the existing bridge. A wide array of benthic macroinvertebrates occurs near the bridge; they vary from motile to sessile benthic organisms and include mollusks (e.g., oysters and clams), annelids (i.e., worms), and arthropod crustaceans such as mysid shrimp, amphipods, isopods, crabs, and other species. Although estuarine benthos have developed behavioral and physiological mechanisms for dealing with variable concentrations of suspended sediment and are well adapted to changes in sedimentation and resuspension processes, certain organisms could be impacted by high levels of water column TSS interfering with their methods of feeding (e.g., filter feeders) and/or causing possible habitat impairment. With respect to shellfish, negative impacts to oyster egg development have been observed at TSS concentrations of 188 mg/L and impacts to clam egg development at 1,000 mg/L (Clarke and Wilber 2000). NOAA, NMFS has identified 390 mg/L (NMFS 2011a) as a concentration below which adverse impacts to benthos are not anticipated.

In studies of the tolerance of crustaceans to suspended sediments that lasted up to two weeks, nearly all mortality was caused by extremely high suspended sediment concentrations (greater than 10,000 mg/L) (Clarke and Wilber 2000), levels which would not occur from the in-water work associated with the proposed project.

Background concentrations of TSS in the bridge vicinity generally vary between 15 mg/L and 50 mg/L throughout the year. The increase in TSS levels predicted to occur as a result sediment-disturbing activities would range from 50-100 mg/L in the immediate vicinity of the dredging to 5 mg/L to 10 mg/L over a relatively limited river area near the replacement bridge construction site. Such increases in water column solids loads would be within the normal variation occurring in the Hudson River and well below levels that would be expected to affect normal life functions of benthic invertebrates. Thus, impacts to benthic invertebrates due to increased water column suspended sediments from construction activities are expected to be minimal and would not result in adverse impacts to benthic communities.

Adverse impacts would occur due to the permanent loss of up to 13 acres of oyster beds caused by dredging and in-water construction activities for the new bridge piers. As discussed in Chapter 18 of the DEIS, “Construction Impacts,” mitigation for loss of oyster reefs and impacts to benthic habitat would be finalized after consultation with NYSDEC, USACE, and NMFS.

4.1.2.1.4. Bridge Demolition

As discussed above, demolition of the bridge could cause turbidity and the potential resuspension of contaminated sediments. Turbidity curtains would be used during removal of the columns and footings and cutting of the timber piles would minimize the potential for sediment that may be resuspended during bridge removal activities to affect benthic macroinvertebrates and other aquatic biota. Since the benthic sampling program for the project indicated similar benthic community structure in bottom sediments at both existing and proposed bridge location, and because the demolition is not expected to substantially alter sediment characteristics, the benthic community recolonizing the restored bottom habitat following bridge demolition would be expected to be similar to that lost as a result of dredging. Demolition of the existing bridge would also remove the benthic invertebrates and algae that are attached to the bridge, which provide forage and structural habitat for fish. However, the new bridge would offset much of these losses by providing similar structural habitat for these species. Impacts to benthic invertebrates due to increased water column suspended sediments from bridge demolition activities are expected to be minimal and would not result in adverse impacts to benthic communities.

4.1.2.1.5. Hydroacoustic Effects

Limited information is available on how benthic invertebrates may use sound (e.g., Popper et al. 2003) and there is little information indicating whether sounds from construction would have any impact on invertebrate behavior. The one available study on effects of seismic exploration on shrimp suggests no behavioral effects at sound levels, with a source level of about 196 dB re 1 μPa rms at 1 meter (Andriguetto-Filho et al. 2005).

There is also no substantive evidence on whether the high sound levels from pile driving or any anthropogenic sound would have physiological effects on benthic invertebrates. The only potentially relevant data are from a study on the effects of seismic exploration on snow crabs on the east coast of Canada (Boudreau et al. 2009). The preponderance of evidence from this study showed no short- or long-term effects of seismic exposure in adult or juvenile animals, or on eggs.

The lack of any internal air bubbles (equivalent to the fish swim bladder) that would be set in motion by high intensity sounds would suggest that there would be little impact on benthic invertebrates. However, like fish, if the benthic invertebrates are very close to the source, the shock wave from the source might have an impact on survival.

Impacts to benthic invertebrates due to increased water column suspended sediments from hydroacoustic effects associated with pile driving activities are expected to be minimal and would not result in adverse impacts to benthic communities.

4.1.2.1.6. Summary

In summary, the temporary and permanent losses of benthic habitat articulated above and in Table 11 would not result in a permanent adverse impact to populations of benthic macroinvertebrates within the lower Hudson River estuary.

4.1.2.2. Submerged Aquatic Vegetation (SAV)

The nearest SAV beds to the replacement bridge construction site are small and located north of the project area (see **Figure 15**). Therefore, dredging and temporary platform construction for the project would not directly impact SAV, but would have the potential to result in indirect impacts due to potential temporary increases in suspended sediment levels and sedimentation rates within these beds. However, dredging operations would occur during the later portion of the SAV growing season, minimizing potential adverse impacts to this resource. Additionally, as discussed above under *Water Quality,* cumulative increases in suspended sediment due to dredging and other in-water construction activities are projected to be within the range of normal variation in SSC within this portion of the Hudson River. Therefore, construction of the project would not result in adverse environmental impacts to SAV within the Hudson River.

4.1.2.3. Fishes

4.1.2.3.1. Dredging

Where access channels are dredged, there would be a temporary loss of habitat that could impact fish that use the dredged area. These impacts would occur, in part, as a result of a localized reduction in benthic fauna. However, the dredging footprint represents a small percentage (1.2%) of the soft bottom habitat within the Tappan Zee Region (RM 24-33) as defined by the Hudson River Utilities, and a much smaller amount of the soft bottom habitat of the Hudson River Estuary. Additionally, dredging would occur from August 1 to November 1, a period that would minimize the potential for impacts to anadromous fish spawning migration and outside the peak period of biological activity within this portion of the Hudson River when there is the greatest potential for EFH species to occur. Thus, the temporary reduction of benthic fauna within the dredged area would not substantially reduce foraging opportunities for the river’s fish populations. Once construction is completed, the dredged channels would be restored over time to their original elevations by action of natural sedimentation, and the river’s benthic community would recolonize those areas as well.

4.1.2.3.2. Temporary and Permanent Platforms Within the Bridge Staging Areas

Approximately 8 acres of temporary platforms would be erected within the Bridge Staging Areas in the Hudson River to facilitate bridge construction. These platforms would be supported by an array of small piles driven into the river substrate. The piles would occupy approximately 0.4 acres of benthic habitat representing a minor reduction of foraging opportunities for fish near the construction site. An approximately 2.44-acre permanent platform would be built on piles and also result in potential shading effects. However, the supporting piles for the platforms would provide a substrate for encrusting organisms which would provide some additional foraging opportunities for fish. Moreover, fish are widely known to seek structures for shelter and the temporary and permanent platforms could represent a favorable diversity in habitat that currently is a large flat, silty bottom. Therefore, the minimal modification of foraging habitat, and the temporary and permanent coverage of aquatic habitat by overwater structures would not result in adverse impacts to fish within the Lower Hudson River estuary.

4.1.2.3.3. Temporary Increases in Suspended Sediment from Construction Activities

As described above under Benthic Macroinvertebrates, construction activities expected to contribute to sediment resuspension include dredging, vessel movements, cofferdam construction, pile driving and demolition of the existing bridge.

Resuspension of sediments can have a range of impacts to fish depending on the species and life stages being considered. Lethal levels of TSS vary widely among species; one study found that the tolerance of adult fish for suspended solids ranged from 580 mg/L to 24,500 mg/L (Sherk et al. 1975 as cited in NMFS 2003). Common impacts to fish are the abrasion of gill membranes resulting in an inability to collect oxygen, impairment of feeding, reduction in dissolved oxygen, and fatal impacts to early life stages. Increased TSS can inhibit migratory movements as well. A study conducted by NOAA concluded that TSS concentrations as low as 350 mg/L could block upstream migrations of various species (NOAA 2001). Fish, however, are mobile and generally avoid unsuitable conditions in the field, such as large increases in suspended sediment and noise (Clarke and Wilber 2000). Fish also have the ability to expel materials that may clog their gills when they return to cleaner, less sediment-laden waters.

Burton (1993) indicated that concentrations of suspended solids can reach thousands of milligrams per liter before an acute toxic reaction is reached. Lethal effects were demonstrated between concentrations of 580 to 700,000 mg/L depending on species, (580 mg/L for sensitive species and 1,000 as more typical). Striped bass did not avoid concentrations of 954 to 1,920 mg/L to reach spawning sites (Summerfelt and Mosier 1976; Burton 1993) which are well above the levels likely to be encountered during dredging operations.

Larval stage fish also have a wide suspended sediment tolerance range. Kiorboe et al. 1981 (as cited in Clarke and Wilber 2000), indicate that hatching of striped bass and white perch can be delayed if daily sediment concentrations reach 100 mg/L. Wilbur and Clarke 2001 (as cited in NMFS 2003), indicate that hatching is delayed for striped bass and white perch at concentrations of 800 mg/L and 100 mg/L, respectively. In a 2003 Biological Opinion, the NMFS indicated that TSS concentrations below 100 mg/L are not likely to affect eggs and larvae—at least over short durations (NMFS 2003).

The TSS projected to occur as a result of the project's construction would be below the physiological impact thresholds of adult and larval fish and also below concentrations that would be expected to impact migration. Furthermore, anadromous fish such as striped bass, American shad, blueback herring, and alewife spawn well upriver and their most vulnerable early life stages such as eggs and yolk-sac larvae would not be expected to occur in the Tappan Zee vicinity. Impacts due to increased water column suspended sediments are expected to be minimal and would not result in adverse impacts to fish within the Lower Hudson River estuary.

Given the tolerance of the EFH species with the potential to occur in the study area to high concentrations of suspended sediments, the turbid nature of the Hudson River under ambient conditions, the limited area over which turbidity would be increased, and the lack of impacts from the release of contaminants due to the resuspension of sediments, the resuspension of bottom sediment that would result from construction of the project would not result in adverse impacts to EFH species.

4.1.2.3.4. Hydroacoustic Effects

Sound in water follows the same physical principles as sound in air, however, due to higher density of water, sound in water travels about 4.5 times faster than in air (approximately 4,900 feet per second versus 1,100 feet per second in air), and attenuates much less rapidly over distance from the source than in air. As a result of the greater speed, the wavelength of a particular sound frequency is about 4.5 times longer in water than in air (Rogers and Cox 1988; Bass and Clarke 2003).

The most commonly considered aspects of sound are frequency (i.e., number of cycles per unit of time, with hertz (Hz) as the unit of measurement) and amplitude (loudness, measured in decibels, or dB). The frequencies of primary relevance to humans are those in their hearing range, which is from about 20 Hz to 20,000 Hz in a child and perhaps 20 Hz to 10,000 Hz in an older adult. When considering fish, the hearing range to be considered may extend from as low as 20 Hz to, in most species, perhaps 800 to 1,000 Hz. Most fish in the Hudson River fit into this hearing range, although catfish may hear to about 3 or 4 kHz and some of the herring-like fishes (and specifically the American shad) can hear to over 100 kHz (Popper et al. 2003; Bass and Ladich 2008; Popper and Schilt 2008).

In addition, an acoustic field from any source consists of a propagating pressure wave, generated from particle motions in the medium that causes compression and rarefaction. This sound wave consists of both pressure and particle motion components that propagate from the source. All fishes have sensory systems to detect the particle motion component of a sound field, while fishes with a swim bladder (a chamber of air in the abdominal cavity) may also be able to detect the pressure component. Pressure detection is primarily found in fishes where the swim bladder (or other air chamber) lies very close to the ear, whereas fishes in which there is no air chamber near the ear primarily detect particle motion (Popper et al. 2003; Popper and Schilt 2009; Popper and Fay 2010).

The level of a sound in water can be expressed in several different ways, but always in terms of dB relative to 1 micro-Pascal (μPa). Decibels, a log scale, is used to "compress" very large differences of sound level (e.g., from a whisper to cracking of thunder) into more manageable numbers. As a consequence, a doubling of sound pressure level (whether in air or water) is seen as a change of just a few dB. Thus, each 10 dB increase is a ten-fold increase in sound pressure. Accordingly, a 10 dB increase is a 10x increase in sound pressure, and a 20 dB increase is a 100x increase in sound pressure.

For the purposes of this EFH, the following measures are defined:

- Peak sound pressure level (SPL) is the maximum sound pressure level in a signal measured in dB re 1 µPa.
- Sound exposure level (SEL) is the integral of the squared sound pressure over the duration of the pulse – in this case a full pile driving strike. Measured in dB re $1\mu Pa^2 \cdot s$.
- SEL_{cum} is the energy accumulated over multiple strikes. The rapidity with which the SEL_{cum} accumulates depends on the level of the single strike SEL (SEL_{SS}). The actual level of accumulated energy (SEL_{cum}) is the logarithmic sum of the total number of single strike SELs. Thus, SEL_{cum} (dB) = Single-strike SEL + 10log10(N); where N is the number of strikes.

Sound levels are analyzed in several different ways. The most common approach is "root mean square" (rms) pressure level which is the average level of a sound signal over a specific period of time, such as the average level 90 percent of the time of the whole signal. Alternatively, one may measure "Peak" sound level, which is the highest level of sound within a signal. Peak is most often used to give an indication of the maximum level of a sound, but it does not give a good picture of the overall sound energy in a signal.

The frequencies in the impulsive signal that is typical of a single strike from a pile driving operation are primarily below about 500 Hz. In order to attempt to better characterize the full extent of energy in the signal, acousticians developed the concept of Sound Exposure Level (SEL), which is simply the integration over time of the square of the acoustic pressure in the signal. Thus the SEL is an indication of the total acoustic energy received by an organism from a particular source (such as pile strikes).

SEL is generally expressed as the total energy in a signal over one second. There are two ways of looking at SEL that are relevant to the issue of pile driving. First is what is referred to as "single strike" SEL – the amount of energy in one strike of a pile (SEL_{ss}). The second is "cumulative SEL" (or SEL_{cum}), which represents the summed energy in all strikes over some period of time or, perhaps, during the driving of a single pile. SEL_{cum} is particularly useful since it indicates the full energy to which an animal is exposed during any kind of signal (assuming the animal remains in the same place for the duration of the signal – such as for all strikes to embed a single pile), and thus it is possible to use this measure to compare total sound exposure between two signals with waveforms that are very different than one another, such as between a pile driving strike and a burst of sonar.

Physiological Effects

The current interim criteria for onset of physiological effects on fish were agreed to in a Memorandum of Agreement (MOA) by FHWA, USFWS, NMFS, CalTrans and the Washington Department of Transportation on June 12, 2008. As a result of the MOA a set of interim criteria was established for the acoustic levels at which there could be a potential onset of physiological effects to fish. The criteria are referred to as the interim West Coast criteria (reviewed in Woodbury and Stadler 2008; Stadler and Woodbury 2009). These criteria are intended to reflect the onset of physiological effects (Stadler and Woodbury 2009), and not levels at which fish are mortally damaged. Indeed, the onset of physiological effects may be minimal changes in fish tissues that have no biological consequence (Halvorsen et al. 2011). The interim criteria are:

Peak SPL: 206 decibels relative to 1 micro-Pascal (dB re 1 µPa).

SEL_{cum}: 187 decibels relative to 1 micro-Pascal-squared second (dB re $1\mu Pa^2\cdot s$) for fishes above 2 grams (0.07 ounces).

SEL_{cum}: 183 dB re $1\mu Pa^2\cdot s$ for fishes below 2 grams (0.07 ounces).

Behavioral Effects

For purposes of assessing behavioral effects of pile driving at several West Coast projects, NMFS employs a 150 dB re 1µPa rms SPL criterion, although it is pointed out in Caltrans (2009) that, at least on the West Coast, "…NOAA Fisheries staff informally indicated … that they do not expect exceedance of the 150 dB RMS behavior threshold to trigger any mitigation."

Recent Results Relevant to the Interim Criteria for Onset of Physiological Effects

A recent peer-reviewed study from the Transportation Research Board (TRB) of the National Research Council of the National Academies of Science describes the first carefully controlled experimental study of the effects of pile driving sounds on fish (Halvorsen et al. 2011). This investigation was funded by National Cooperative Highway Research Program (NCHRP) of the TRB, Caltrans, and the Bureau of Ocean Energy Management (BOEM), as well as by the Canadian Department of Fisheries and Oceans (DFO), and was developed and overseen by individuals from highway programs throughout the United States as well as leading experts in underwater acoustics and hearing from the U.S. and abroad. The study was the first to document effects of pile driving sounds (recorded by actual pile driving operations) under simulated free-field acoustic conditions where fish could be exposed to signals that were precisely controlled in terms of number of strikes, strike intensity, and other parameters. The acoustic field simulated one that would take place beyond about 33 ft from a source. Sufficient number of animals exposed to the source, as well as controls (treated identically to experimental other than for their being exposed to sound), were used to provide a strong statistical base. Subsequent to treatment, animals were subject to extensive necropsy (autopsy) to determine the types of physiological effects and the sound exposure levels at which these would show up.

The study was conducted on Chinook salmon (*Oncorhynchus tshawytscha*), an endangered species on the US West Coast. The study considered the onset of a wide variety of potential physiological effects that ranged from small amounts of hemorrhage at the base of fins to severe hemorrhage or rupture of the swim bladder and surrounding body tissues (kidney, liver, spleen, etc.). It was determined that very small effects, such as small hemorrhages at the base of fins are not life threatening nor would they have any short or long-term effect on fish, unlike damage such as swim bladder rupture which would result in mortality. Based on a thorough statistical analysis of results, with extensive controls, it was determined that onset of physiological effects that have the potential of reduced fitness, and thus a potential effect on survival, started at above 210 dB re 1 $\mu Pa^2\cdot s$ SEL_{cum}, a level that is about 23 dB above the current West Coast interim onset criteria. The peak level for effects is about the same as the current West Coast level.

Subsequent work, using the identical methodology has demonstrated that there is complete recovery from effects on Chinook salmon exposed to sounds as high as 216 dB re $1\mu Pa^2\cdot s$ SEL_{cum} when fish were kept in the laboratory (higher levels could not be used in that particular study. In addition, other studies have shown that similar results to those reported for Chinook salmon were also found in several other species, including lake sturgeon (*Acipenser fulvescens*). There was small variation in the onset level for physiological effects, but all were well above 200 203 dB re $1\mu Pa^2\cdot s$ SEL_{cum} or levels well above the West Coast interim criteria.

Sound and Effects on Fish

Sound is a critical source of environmental information for most vertebrates (e.g., Fay and Popper 2000). While we most often think in terms of sound for communication (e.g., speech), perhaps the most important use of sound is to learn about one's environment. Indeed, humans and all other vertebrates have auditory systems that listen to the "auditory scene" and can, from this, learn a great deal about the environment, and the things in it (Fay and Popper 2000; Bass and Ladich 2008). Although the "visual scene" is restricted by the field of view of the eyes and light level, the auditory scene provides a three-dimensional, long distance sense that works under most all environmental conditions. It is, therefore, likely that hearing evolved for detection of the auditory scene (Fay and Popper 2000), and that fishes use sound to learn about their general environment, the presence of predators and prey, and, in many species, for acoustic communication. As a consequence, sound is important for fish survival, and anything that impedes the ability of fish to detect a biologically relevant sound could affect individual fish rather than survival of the species.

Richardson et al. (1995) defined different zones around a sound source that could result in different types of effects on fishes. There are a variety of different potential effects from any sound, with a decreasing range of effects at greater distances from the source. Thus, very close to the source, effects may range from mortality to behavioral changes. Somewhat further from the source, mortality is no longer an issue, and the effects range from physiological to behavioral. As one gets even further, the potential effects decline even further. The actual nature of effects, and the distance from the source will vary and depend on a large number of factors, such as fish hearing sensitivity, source level, how the sounds propagate away from the source and the resultant sound level at the fish, whether the fish stays in the vicinity of the source, the motivation level of the fish, etc.

Sound Sources from Which Different Effects Might Occur

There are limited data from other projects to demonstrate the circumstances under which immediate mortality occurs: mortality appears to occur when fish are close [(within a meter to 9 m (a few ft to 30 ft)] to driving of relatively large diameter piles. Studies conducted by California Department of Transportation (Caltrans, 2001) showed some mortality for several different species of wild fish exposed to driving of steel pipe piles 2.4 m (8 ft) in diameter, whereas Ruggerone et al. (2008) found no mortality to caged yearling coho salmon (*Oncorhynchus kisutch*) placed as close as 0.6 m (2 ft) from a 0.45 m (1.5 ft) diameter pile and exposed to over 1,600 strikes. Thus, in the overall range of effects on fish in ecosystems such as the Tappan Zee, only a very small fraction of a fish population likely will be close enough to a pile to be subject to immediate mortality.

Of greater relevance than immediate mortality to aquatic organisms caused by pile driving and other intense sound sources is the potential for physiological effects that could potentially result in delayed mortality. At the same time, many of the physiological effects of exposure to pile driving sound are highly unlikely to have any effect on fish survival. Indeed, the potential physiological effects are highly diverse, and range from very small ruptures of capillaries in fins (which are not likely to have any effect on fitness or survival) to severe hemorrhaging of major organ systems such as the liver, kidney, or brain (Stephenson et al. 2010). Other potential effects include rupture of the swim bladder (the bubble of air in the abdominal cavity of most fish species that is involved in maintenance of buoyancy). (See Halvorsen et al. 2011 for a review of potential injuries from pile driving.)

Effects on body tissues may result from barotrauma or result from rapid oscillations of air bubbles. Barotrauma occurs when there is a rapid change in pressure that directly affects the body gasses. Gas in the swim bladder, blood, and tissue of fish can experience a change in state, expand and contract during rapid pressure changes, which can lead to tissue damage and organ failure (Stephenson et al. 2010).

Related to this are changes that result from very rapid and substantial excursions (oscillations) of the walls of air-filled chambers, such as the swim bladder, striking near-by structures. By way of example, under normal circumstances the walls of the swim bladder do not move very far during changes in depth or when impinged upon by normal sounds. However, very intense sounds, and particularly those with very sharp onsets (also called “rise time”), will cause the swim bladder walls to move greater distances and thereby strike near-by tissues such as the kidney or liver. Rapid and frequent striking (as during one or more sound exposures) can result in bruising, and ultimately in damage, to the nearby tissues.

At the same time, there are data showing that very intense signals may not necessarily have substantial physiological effects and that the extent of effect will vary depending on a number of factors including sound level, rise time of the signal, duration of the signal, signal intensity, etc. For example, investigations on the effects of very high intensity sonar showed no damage whatsoever to ears and other tissues of several different fish species (Kane et al. 2010).

Moreover, studies involving exposure of fish to sounds from seismic air guns, signal sources that have very sharp onset times, as found in pile driving, also did not result in any tissue damage (Popper et al. 2007; Song et al. 2008; although see McCauley et al. 2000, 2003 for an instance of inner ear hair cell damage to seismic air guns). Finally, recent studies of the effects of pile driving sounds on fish showed that there is a clear relationship between onset of physiological effects and single strike and cumulative sound exposure level, and that the initial effects are very small and would not harm an animal (and from which there is rapid and complete recovery), whereas the most intense signals (e.g., >210 dB SEL_{cum}) may result in tissue damage that could have long-term mortal effects (Halvorsen et al. 2011).

<u>Approach to Estimating Hydroacoustic Effects on Fish</u>

The current NMFS West Coast criteria stipulates that the onset of physiological effects occurs at an SEL_{cum} of 187 dB re 1µPa^2•s. Furthermore, in the recent PIDP BO, NMFS (2012) viewed this level as one at which there are no impacts on sturgeon fitness. Moreover, recent studies on Chinook salmon (Halvorsen et al. 2011) show that there are no effects at all on fish at an SEL_{cum} of well over 203 dB re 1µPa^2•s.[1] These data also show that onset of physiological effects in Chinook salmon occurs at about 210 dB re 1µPa^2•s, but the effects at this level are not likely to affect fitness. It is only until SEL_{cum} gets close to 216 dB re 1µPa^2•s that potentially harmful effects start to be encountered.

Based on the recent pile driving studies and discussions with NMFS, and as is incorporated in the Revised Biological Assessment prepared for the Tappan Zee Hudson River Crossing Project (FHWA 2012), it is proposed that there are three hierarchical SEL_{cums} in determining numbers of

[1] The value for Chinook salmon is actually an SEL_{cum} of 210 dB, but the level for other species varies by a few dB and so the 203 dB value is used here to be very conservative and consider the potential “worst case” for onset of physiological effects until even more data are available.

animals potentially taken as a result of pile driving. While these levels of injury were used in determining take for sturgeon species, they would presumably apply to EFH species and other species of fish as well. These three levels are highly conservative, even in light of the Halvorsen et al. (2011) data. Each level is associated with an increasing effect level. (1) Level for potential onset of physiological effects without any impact on fitness - 187 dB re $1\mu Pa^2$•s, (2) potential onset of recoverable physical injury such as external tissue effects, e.g., minor hemorrhage - 197 dB re $1\mu Pa^2$•s, and (3) potential onset of mortal injuries - 207 dB re $1\mu Pa^2$•s.

The rationale for these levels is as follows. The selection of an SEL_{cum} of 187 dB re $1\mu Pa^2$•s is based on current West Coast criteria. This value is, as discussed above, used in determination of the areas around pile driving at which fish have the potential to have the start of physiological effects, but without any changes in fitness. The SEL_{cum} of 197 dB re $1\mu Pa^2$•s, is 10 times the lower level of 187 dB re $1\mu Pa^2$•s and still 13 dB lower than the level that Halvorsen et al. (2011) showed to be the onset of minor physiological effects that are likely not to result in changes in fitness. Finally, the SEL_{cum} of 207 dB re $1\mu Pa^2$•s, is 100 times greater energy than the current criteria and yet still well below the actual results from Halvorsen et al. (2011) and others for the onset of mortality.

Hydroacoustic Modeling

In order to analyze the potential impacts of the project's pile driving on Hudson River aquatic resources, the likely hydroacoustic scale of pile driving was modeled (JASCO 2011) (see **Figures 25 through 29**). The extent of the sound pattern generated by pile driving for the project was determined by application of three different sound propagation modeling approaches (i.e., MONM, VSTACK, and FWRAM). The models account for the frequency composition of the source signal and the physics of acoustic propagation in the Hudson River and underlying geological substrates. This type of modeling differs from generalized and empirical acoustic models, such as "practical spreading loss" models (Caltrans, 2009), that do not take into full account the source characteristics or the many site-specific factors that could influence the rate of noise transmission such as water depth and substrate transmission characteristics.

Various pile driving scenarios were used to generate the cumulative sound exposure level (SEL_{cum}) for each day over the construction period. Maximum and typical pile driving scenarios were analyzed (see **Figures 25 through 29**). In addition, the application of Best Management Practices (BMPs) that provided a 10 dB reduction in sound was incorporated into the acoustic modeling effort. These practices represent various methods to reduce the extent to which a waterbody would be ensonified by pile driving operations. Various BMPs have been employed on pile driving operations around the country, including air bubble curtains of various forms, isolation casings, Gunderbooms, and dewatered cofferdams. The Project Sponsors have committed to the use of BMPs to attenuate the potential impacts of sound associated with pile driving, and rely on the results of the PIDP to inform the project for making decisions regarding BMP implementation. The results of the hydroacoustic modeling are depicted in **Figures 22 through 29**, as described below.

Figure 25 presents the peak SPL, with BMPs, for 4-, 6-, 8-, and 10-ft piles being driven at representative locations along the alignment of the replacement bridge. The figure illustrates the transmission loss that would occur as distance from the pile driving site increases. Transmission loss is not uniform across the different size piles since the piles would be driven at locations where water depth and other environmental factors vary. For the 4-ft piles, sound above the interim 206 dB peak threshold encompasses a distance of about 30 ft; for the 10-ft piles the 206 dB peak SPL the distance increases to approximately 300 ft.

The following figures present accumulated energy (SEL_{cum}) for driving a pile over the time for driving the pile and should be understood that way. Thus, the information in these figures does *not* represent the energy from a single strike or the instantaneous level of sound at any one moment in time (as represented for rms levels in **Figure 25**). Moreover, the accumulated energy in the following figures represents the received energy for an animal *only* if the animal stays in the same location for the duration of the pile driving activity.

Figure 26 presents the SEL_{cum} metric for installing two 10-ft piles at the replacement bridge main span over the number of strikes that are predicted to be needed to fully seat the piles. The proposed schedule for concurrent placement of two 10-ft piles would be the same for both the Short and Long Span Options. The concentric "circles" (or isopleths) of different colors represent distances from the pile driving activity at which various SEL_{cum} levels would be attained during the driving of the two piles. For example, the 187 dB isopleths extends over a mile in each direction north and south of the point of pile driving and 49 percent of the cross sectional width of the river. This can be contrasted with the 187 dB re 1 $\mu Pa^2 \cdot s$ isopleth profile for installing four 4-ft piles at the replacement bridge main span in one day, which does not extend substantial distances in any direction (see **Figure 27**).

Figure 28 indicates the cross sectional area of the river that would be ensonified by the 187 dB re 1$\mu Pa^2 \cdot s$ isopleths over the duration of the construction period for the Short Span Option, and assumes a BMP reduction of 10 dB. During the period of driving the 10 foot piles, 49 percent of the river cross sectional width would be occupied within the 187dB re 1$\mu Pa^2 \cdot s$ isopleth. This ensonified area would be between 43 and 61 percent during the four-month period when 4, 6, and 8 ft piles are all being driven, sometimes simultaneously. The figure indicates that driving of the 10 and 8 ft piles would take place in the first few months of the first year of construction, limiting the period of time of greatest potential impact, During the remaining years of the construction period, the affected cross section of the river is considerably less, on the order of 14 to 38 percent. Given that the river is approximately 3 miles wide, there would always be a considerable portion of the river that remains below the threshold noise criteria, thereby insuring adequate corridors for migration and movement of fish through the region. **Figure 29** indicates the cross sectional area of the river that would be ensonified by the 187 dB re 1$\mu Pa^2 \cdot s$ isopleths over the duration of the construction period for the Long Span Option.

Results of Hydroacoustic Modeling

The results of the hydroacoustic modeling performed in the DEIS and the BA indicate that there is potential for physiological effects (at 187 dB re 1$\mu Pa^2 \cdot s$), recoverable injury (197 dB re 1$\mu Pa^2 \cdot s$) and onset of mortality (207 dB re 1$\mu Pa^2 \cdot s$) to individual fish in the immediate vicinity of the pile driving, Since potential effects to a variety of species were assessed (shortnose sturgeon, Atlantic sturgeon, striped bass, bay anchovy, weakfish, etc.) these potential effects would presumably extend to EFH species as well. For all species examined, the assessment indicated that only a very small portion of the standing stock or population size would be subject to sound exposures resulting in the onset of physiological effects (187 dB re 1$\mu Pa^2 \cdot s$). A far smaller amount of fish would be exposed to levels causing injury or mortality.

For most of the pile driving scenarios modeled, including those in which the maximum number of simultaneous piles are being driven and/or for the largest piles, a substantial portion of the

Hudson River's width never reaches the SEL_{cum} criterion established for onset of physiological injury. Furthermore, even within a single day of operations (assuming up to a 12 hour day), there is likely to be no pile driving activity for a substantial amount of time, such as when piles are put in place, being welded, or when the pile driving machinery is relocated. Thus, fish in much of the river will not be exposed to pile driving sounds for significant periods, and the likelihood of accumulating sufficient energy (SEL_{cum}) to result in onset of physiological effects is low. Finally, fish are not likely to remain in an area at which noise (from pile driving or other source) would cause discomfort.

The expression SEL_{cum} represents the total energy at a particular location in the river for a discrete duration (typically the number of strikes) of a particular pile driving operation. Often, this represents the duration for the full driving of a single pile, or even for multiple piles if driven in a single day (if a pile is driven over two days, there is a "resetting" of the SEL_{cum} after 12 hours and accumulation starts again (Carlson et al., 2007; Stadler and Woodbury, 2009). It is important to note that it is highly unlikely that a fish would be exposed to the full SEL_{cum} of a pile driving operation since that could only occur if the fish stays in place and exhibits no swimming behaviors (including behavioral response to the pile driving sounds) for the duration of the pile driving operation. Thus, the scenario with fish receiving a full accumulated exposure to any pile driving is highly unlikely and conservative for most Hudson River species of concern including EFH species.

Thus, caution must be used when interpreting the model's results that present SEL_{cum} at different locations relative to the pile driving because the model does not take into consideration any behavioral responses of fish that would result in the fish not being exposed to SEL_{cum} levels that would result in onset of physiological effects. Furthermore, data from Halvorsen et al. (2011) document that SEL_{cum} has to be substantially above the minimum level that would result in onset of low levels of physiological effects to be potentially fatal. Thus, for example, Chinook salmon exhibit some minor effects at a SEL_{cum} at about 210 dB re $1\mu Pa^2 \cdot s$, but it is not until the levels reach 216 – 219 dB re $1\mu Pa^2 \cdot s$ that injuries become potentially fatal (Halvorsen et al. 2011). The study indicated there was recovery from injuries sustained at 210 dB re $1\mu Pa^2 \cdot s$ within several days of exposure, and that none of the injuries observed were of a kind that would lead to a loss of fitness.

Effects of Sound on Fish Behavior

Results of empirical studies of hearing of fishes, amphibians, birds, and mammals (including humans), in general, show that behavioral responses vary substantially, even with a single species, depending on a wide range of factors such as the motivation of an animal at a particular time, the nature of other activities that the animal is engaged in when it detects a new stimulus, the hearing capabilities of an animal or species, and numerous other factors (Brumm and Slabbekoorn 2005). Thus, it is difficult to assign a single criterion above which behavioral responses to noise would occur.

It is also critical to note that animals (and humans) generally do not respond to sounds that are minimally perceivable (whether there is background sound or not). Sounds generally have to be well above the minimal detectable level in order to elicit behavioral changes (Dooling et al. 2009). At the lowest sound levels the animal may just ignore the sound since it is deemed to be unimportant or too distant to be of immediate relevance. It is only at higher amplitudes where the animal becomes "aware" of the sound and may make a decision whether or not to behaviorally respond to the sound. In some cases, sounds may be "masked" by background noise of the same or similar frequencies (Bee and Swanson 2007). In this case, the masked sound could either be undetectable or less detectable than it would otherwise be under quieter conditions. In a natural setting, it is possible that the sound has to be sufficiently above the masked threshold of detection for the animal to be able to resolve the signal within the surrounding ambient noise and recognize the signal as being of biological relevance.

By way of example, in an experiment on responses of American shad to sounds produced by their predators (dolphins), it was found that if the predator sound is detectable, but not very loud, the shad will not respond (Plachta and Popper 2003). But, if the sound level is raised an additional 8 or 10 dB, the fish will turn and move away from the sound source. Finally, if the sound is made even louder, as if a predator were nearby, the American shad go into a frenzied series of motions that probably helps them avoid being caught. It was speculated by the researchers that the lowest sound levels were those recognized by the American shad as being from very distant predators, and thus, not worth a response. At somewhat higher levels the shad recognized that the predator was closer and then started to swim away. Finally, the loudest sound was thought to resemble a very near-by predator, eliciting maximum response to avoid predation.

At the same time, there is evidence from a recent study in Norway (Doksaeter et al. 2009) that fishes will only respond to sounds that are of biological relevance to them. Doksaeter et al. (2009) showed no responses by free-swimming herring (*Clupea* spp.) when exposed to sonars produced by naval vessels. Similarly, sounds at the same received level that had been produced by major predators of the herring (killer whales) elicited strong flight responses. Significantly, the sound levels at the fishes from the sonar in this experiment was from 197 dB to 209 dB re 1 µPa (rms) at 1,000 to 2,000Hz. The hearing threshold for herring that are most closely related to those used in the Doksaeter et al. (2009) study in this frequency range is about 125 to 135 dB re 1 µPa (also see Mann et al., 2005). This means that the fish showed no reactions to a sound that was up to 84 dB above the fish's hearing threshold (209 dB re 1 µPa sonar vs. 120 dB re 1 µPa threshold) but not biologically relevant to this species.

There is not an extensive body of literature on effects of anthropogenic sounds on fish behavior, and even fewer studies on effects of pile driving, and many of these were conducted under conditions that make the interpretation of the results for this project uncertain. Of the studies available, the most useful in assessing the potential effects on behavior of pile driving on fish are those that use seismic air guns since the air gun sound spectrum is reasonably similar to that of pile driving. The results of the studies summarized below suggest that there is a potential for underwater sound of certain levels and frequencies to affect behavior of fish but that it varies with fish species, the existing hydroacoustic environment, and the behavioral response may change over time as fish individuals habituate. The project will maintain a corridor where ensonification due to pile driving is below the 150 dB µPa rms SPL behavioral guidance level suggested by NMFS (see **Figures 30 through 33**). Therefore, the project would minimize the potential for the driving of piles with an impact hammer project to impede movement of fish in the Hudson River. Behavioral responses to other noise sources, such as noise associated with vessel traffic, and the results of noise deterrent studies are also summarized below.

Behavioral Studies Using Pile Driving (or Pile Driving-Like) Sounds

There have been very few studies that have examined behavioral effects of pile driving on fish. Most of these studies, as reviewed by Popper and Hastings (2009) were in small cages where behavior is severely constrained and so would not be considered a normal setting. In order for the results of an empirical study to be relevant to an assessment of the potential for pile driving, or other anthropogenic stimuli, to affect fish and other aquatic biota, it be done in free-swimming wild animals. While not done on free-swimming animals, Mueller-Blenke et al. (2010) evaluated response of Atlantic cod (*Gadus morhua*) and Dover sole (*Solea solea*) in large pens to playbacks of sounds recorded during pile driving during construction of wind farms. The investigators reported that a few representatives of both species exhibited some movement response, which they claim to have represented increased swimming speed or freezing to the pile-driving stimulus at peak sound pressure levels ranging from 144 to 156 dB re 1 µPa for sole and 140 to 161 dB re 1 µPa for cod. However, with the methodology used it was impossible to determine fish position more frequently than once every 80 seconds, and so, despite the suggestions of behavioral responses by the investigators, it was scientifically impossible to know if, and how, fish were moving or otherwise responding to the sound. Moreover, even in the few times that the investigators could glean information that suggested that fish moved from one place in the pen to another during sound presentation, this was only for very few fish, and it is not even clear that the authors interpretation of these results were correct since several alternative interpretations are possible from the very limited data. Finally, the statistical analysis of the results was very limited, and could not be used to document any behavioral responses by any animals.

Feist (1991) examined the responses of juvenile pink (*Oncorhynchus gorbuscha*) and chum (*O. keta*) salmon behavior during pile driving operations. Feist had observers watching fish schools in less than 1.5 m water depth and within 2 m of the shore over the course of a pile driving operation. The report (Feist's MS thesis) did not give pile size, other than to say that one was hollow steel and the other solid. While sound measurements were attempted, data were not available for this publication according to the author, thus none of the limited results can be correlated with sound levels from the pile driving operation. Feist did report that there were changes in distribution of schools at up to 300 m from the pile driving operation, but that of the 973 schools observed, only one showed any overt startle or escape reaction to the onset of a pile strike. Moreover, there was no statistical difference in the number of schools in the area on days with and without pile driving, although other behaviors changed somewhat. However, without data on sound levels, it is impossible to use the Feist data to help understand how fish would respond to pile driving and whether such sounds could result in avoidance or other behaviors. Indeed, one interesting observation, though in need of quantification and correlation with sound levels, is that the size of the stocks of salmon never changed, but appeared to be transient, suggesting that normal fish behavior of moving through the study area used was taking place no differently during pile driving operations and in quiet periods. These results, albeit very weak, suggest that at least these species of salmon are not avoiding pile driving operations.

Field Studies of Effects of Seismic Air Guns on Behavior

Aside from the few studies that have examined the effects of pile-driving noise on fishes, a number of additional studies have examined the effects of other anthropogenic impulsive sounds on fish with sound spectrums and rise time similar to those generated by pile driving, such as seismic air guns. The sound produced by seismic air guns is similar to that produced by a pile-driving strike in terms of the length of time to reach peak amplitude and the component of the sound most likely to elicit a startle response. Because the rise time of the signal for seismic air guns is even sharper for seismic air guns than for pile driving, noise generated by seismic air guns has the potential to be more behaviorally and physiologically disturbing to fish than pile driving.

In an evaluation of the behavior of free-swimming fishes to noise from seismic air guns, fish movement (e.g., swimming direction or speed) was observed in the Mackenzie River (Northwest Territories, Canada) using sonar. Fishes did not exhibit a noticeable response even when sound exposure levels (single discharge) were on the order of 175 dB re 1 µPa2–s and peak levels of over 200 dB re 1 µPa (Jorgenson and Gyselman, 2009).

Wardle et al. (2001) observed very minor behavioral responses to the air gun emissions (most often very brief startle responses) and no permanent changes in the behavior throughout the course of the study in response to peak sound levels of 210 dB re 1 µPa at 16 meters (52.5 feet) and 195 dB re 1 µPa at 109 meters (358 feet) from the source. Moreover, no animals appeared to leave the reef during noise production. Temporary changes in behavior in response to exposure to seismic air guns were reported in Engås et al. (1996), Engås and Løkkeborg (2002), Slotte et al. (2004), and Løkkeborg et al. (2012) although the level of sound received by fish was not reported. In other studies that looked at catch rate, Skalski et al. (1992) showed a 52 percent decrease in rockfish (*Sebastes* sp.) catch when the area of catch was exposed to a emissions of a seismic air gun at 186-191 dB re 1 µPa (mean peak level). The results also suggested that rockfish would show a startle response to sounds as low as 160 dB (re 1 µPa), but this sound level did not appear to elicit a decline in catch.

McCauley et al. (2000) examined the effects of seismic air guns on caged pink snapper (*Pagrus auratus* Forster). Fish were caged and exposed to hundreds of emissions from an air gun as it approached and moved over and beyond the cage for approximately 1.5 hours. Received SEL exceeded 180 dB re 1 μPa^2-s for several of the shots. Startle responses, when they occurred, were elicited by sound levels greater than 156-161 dB re 1 µPa. In addition to the startle response, some individuals moved from the bottom of the cage, possibly to areas of lower sound levels. Behavior of individuals that did respond to the seismic sounds returned to normal within 14 to 30 minutes of cessation of seismic exposure and those individuals exhibited no long-term physiological or behavioral effects. (McCauley et al. 2003). Fish were also reported to habituate to the seismic air gun (McCauley et al. 2000), which means that after some amount of exposure, fish will no longer pay attention to the sound and the sound will have no further effect on behavior.

In an evaluation of the effects of a seismic survey on wild and caged fish of various species inside of Scotts Reef Lagoon in Western Australia, McCauley et al. (2008) observed some startle responses and small levels of movement in fishes exposed to sound exposure levels (single sound) of about 145-155 dB re 1uPa2-s.

Behavioral Responses to Other Sound Sources

Noise from construction vessels used to conduct the project also have the potential to affect fish behavior. Using divers to observe behavioral responses of bluefin tuna (*Thunnus thynnus*) in large in-ocean cages (approximately 70 meters square opening and 30 meters deep) to passing boats, Sarà et al. (2007) documented changes in the depth, location and swimming patterns of the tuna school in the presence of sounds from approaching ferries and hydrofoils. However, the authors did not provide sound levels received by the fish.

Two recent studies suggest that fish will show behavioral responses to sounds far below 150 dB re 1 µPa (rms). However, both studies were conducted on fish within small tanks with the underwater sound source located close by, an experimental setup which would have exposed the test subjects to both sound pressure and particle motion components of the sound field, although only the sound pressure was measured. Since all of the fish in both studies are very likely to be most responsive to particle motion and not pressure, and since particle motion was not measured, it is impossible to know to which aspect of the signal the fish were responding. Indeed, due to tank acoustics it is very highly likely that there the fish were exposed to very large particle motion signals (Parvulescu, 1967), and any behavioral responses were associated with that component of the sound.

In one study, signals recorded from the operation of wind farms were found to temporarily alter the behavior of roach (*Rutilus rutilus*) and three-spined sticklebacks (*Gasterosteus aculeatus*) (Andersson et al. 2007). The reported sound pressure levels eliciting responses were from 80 to 120 dB re 1 µPa (rms), although, as indicated above, particle motion, the actual stimulus that the fish could detect, was not measured. Similarly, Purser and Radford (2011) also examined the behavioral response (e.g., startle response and foraging behavior) of three-spined sticklebacks to short (10-sec) and long (300-sec) sounds. Fish showed an increased level of startle response and poorer foraging behavior at sound levels of about 150 dB re 1 µPa. Again, however, particle motion, the likely stimulus for both species in this small tank, was not measured or reported.

A nine-month long study by Wysocki et al. (2007) demonstrated that continuous exposure to sounds at 150 dB re 1 µPa produced no behavioral responses in rainbow trout, and no indications whatsoever of effects on stress levels, growth, or feeding. Turnpenny et al. (1994), in an unpublished report, examined the behavior of three species of fish in a pool in response to different sounds and reported avoidance behavior at certain levels of pure-tone test frequencies. However, due to poor experimental design and substantial errors in acoustics, the results of this study are impossible to interpret because of lack of calibration of the sound field at different frequencies and depths of the tanks, and due to other problems with experimental design (see comments on this study by Popper and Hastings 2009).

Studies that examined the effectiveness of underwater sound to deter fish from entering an area (e.g., dam spillways, or irrigation ditches, power plant intakes) suggest that fish will not change movement or show avoidance when sound is used as a potential fish deterrence (reviewed in Van Der Walker 1967; Popper and Carlson 1998). The exception was a study by Maes et al. (2004), who used a sound deterrent system from 20 to 600 Hz to control the movement of some clupeid fishes (*Alosa* spp.) in an attempt to deter fish from the water intake of a nuclear power plant. Fishes without swim bladders, and others that are thought to have poor hearing (e.g., sticklebacks) were not deterred by the sound. In contrast, fish with presumably better hearing capabilities (clupeids) were deterred to some degree by the sound, although there are no data on received sound levels. Moreover, this work has not been replicated. In contrast, Ploskey et al. (2000), in a very well designed study, investigated the responses of a number of schools of different juvenile salmonid species near the Bonneville Dam on the Columbia River to sounds that ramped up and down in intensity from silent to 160 dB re 1 µPa every two seconds. Only one of over 100 schools of fish exhibited a short startle response, but no individuals were deterred from the vicinity of the dam or altered their behaviors in a way that differed from the control fish, thereby indicating no avoidance of the sound.

Hydroacoustic Modeling Results and Fish Behavior

Figures 30 through 33 present the modeled isopleths of areas in which 150 dB re 1 µPa would result from pile driving. These figures indicate that portions of the river would also be below the 150 dB RMS guidance for fish behavioral effect and the likelihood of a behavioral response, such as avoidance or startle, at 150 dB re 1 µPa is very low when one takes into consideration the data presented above regarding known behavioral responses of fish. In all cases, other than in the acoustically flawed studies by Peuser and Radford (2011) and Andersson et al. (2007), fish show no responses to sounds at 150 dB re 1 µPa rms. Other studies show small responses at substantially higher sound levels to which fish either habituate or from which they recover shortly after the end of exposure (e.g., McCauley et al. 2000, 2008; Wardle et al. 2001). In some cases, no response has been observed even at sound levels substantially higher than 150 dB re 1 µPa (e.g., Jorgensen and Gyselman (2009). Additionally, these sounds may not be detectable to fish if there is any masking from other ambient noises, such as those produced by the river, boats, and other non-project related sources (e.g., traffic on the current bridge, the railway along the shore of the Hudson River). As a consequence, even though the 150 dB re 1 µPa isopleth from driving a 10-ft pile (assuming a 10 dB reduction from noise attenuation measures) is considerable in the east-west direction, masking would mean that the sound is not perceived by the fish as being 150 dB re 1 µPa until the actual sound level (without the presence of a masker) is approximately 5-10 dB higher.

While the results of the behavioral studies to date suggest that there is not likely to be any adverse behavioral response from any fish species, at sound levels as low as 150 dB re 1 µPa, implementation of the EPC measures described previously for pile driving would minimize the potential for behavioral effects. Therefore, the project would minimize the potential for the project to impede movement of fish in the Hudson River. Moreover, and perhaps of even greater significance in ensuring a minimal or no behavioral impacts on fish is the fact that the duration of pile driving during bridge construction would be a very small percent of the total project duration. There is no pile-driving produced by impact hammering over approximately 93 percent of the project's construction. Combining this with the efforts to ensure a corridor where sounds will be below 150 dB re 1 µPa (rms) during pile driving, construction of the project would not result in adverse impacts to fish due to behavioral effects.

4.1.2.3.5. Impacts Associated with Increased Vessel Traffic

Several EFH species are known or documented to occur within the stretches of the river that included the project area; therefore, these species also may be directly impacted by increased vessel traffic in these areas.

Between 2000 and 2008, annual vessel traffic under the Tappan Zee Bridge ranged from 8,000 to 16,000 vessels per year (excluding small recreational boats, for which no data are available). **Table 12** provides a description of some of the larger vessels that travel along the Hudson River shipping channel, as reported by Hudson River Pilots, who operate many of these vessels. These data are based on vessel movements recorded between January 2005 and October 2006.

Materials shipped via the Hudson River vary from construction materials to oil. The majority of imports passing through the Port of Albany (approximately 95 percent) comprise oil. Cargo typically exported from Albany include grain, scrap metal, project cargo (e.g., industrial cargo from General Electric in Schenectady), heavy lift cargo, and cement. Several other marine terminals are located in the Hudson River Valley, including Newburgh, which supports marine terminals that accommodate oil barges; and Yonkers, in which Refined Sugars operates a marine terminal.

Table 12
Ship and Barge Movements on the Hudson River

Displacement (tons)	# of Ships	# of Barges*	Length Min/Max (feet)	Beam Min/Max (feet)	Draft Min/Max (feet)	Air Draft Min/Max (feet)
0-10,000	46		300/400	40/70	15/20	60/150
10,001-20,000	132	20	120/565	64/75	15/27	100/120
20,001-40,000	248	57	500/600	75/90	16/31	111/140
40,001-60,000	233		600/730	76/106	21/33	117/140
60,001-80,000	9		623/811	100/106	21/33	129/140
80,000+	8		735/805	106/137	27/33	129/140

Notes: *This table only reflects the number of vessels operated by Hudson River Pilots. Total barge movements are estimated to be approximately 2,800-3,000 per year.
Sources: Hudson River Pilots, Jan. 2005 – Oct. 2006

Construction of the new bridge and demolition of the existing bridge could affect marine traffic in the Hudson River due to increased use of the navigation channel and restrictions on navigation during construction of the main spans' substructure and superstructure, and demolition of the existing bridge. Delivery and installation of the segments would be coordinated with the U.S. Coast Guard to minimize the effect on shipping. It is anticipated that two hours would be required for the delivery of each section, with time included for the segment to reach the required clearance and be stabilized. For the Arch Option, bridge segments may also be delivered by barge, with a similar number of segments required. However, instead of construction in segments, there is the potential that the contractor may construct the Arch in one large full span lift—a method that would require closing of the main shipping channel for one or two days. To minimize any adverse effects on marine navigation, the NYSDOT and NYSTA would coordinate with the U.S. Coast Guard in conjunction with the Bridge Permit process to develop acceptable navigation windows and limit any channel closures to the minimum time necessary to provide a safe construction process.

Therefore, while the project would have a potential for increased vessel traffic for the delivery of materials, as well as dredge vessel traffic, the construction vessels would not occur within the navigation channel and at times, use of the navigation channel for the project would result in decreased vessel traffic due to restrictions that may be required for delivery and installation of certain bridge elements.

The potential direct effects associated with increases in vessel traffic within the dredged construction channel include potential collision with vessels and disturbance of foraging and migratory adults and juveniles associated with an increase in surface activity and noise. For the fish species for which EFH has been designated in the Hudson River, the effects of vessel strikes is likely a function of fish size and location within the water column; however, impacts to these (smaller) species from increased vessel traffic is more likely to occur in the form of propeller entrainment. While propeller entrainment has not been widely studied, Gutreuter et al. (2003) estimated the mortality rates of adult fish caused by entrainment through the propellers of commercial towboats operating in Mississippi and Illinois River channels. The method combined trawling behind towboats (to recover a fraction of the kills) and the use of a hydrodynamic model of diffusion (to estimate the fraction of the total kills). Estimates of entrainment mortality rates ranged from 0.13 fish/km of towboat travel (80 percent confidence interval, 0.00-0.41 fish/km) for skipjack herring (*Alosa chrysochloris*), 0.53 fish/km (0.00-1.33) for both shovelnose sturgeon (*Scaphirhynchus platorynchus*) and smallmouth buffalo (*Ictiobus bubalus*), up to 2.52 fish/km (1.00-6.09) for gizzard shad (*Dorosoma cepedianum*). In a related study of the same river reaches, Killgore et al. (2011) detected no effects of towboat operation variables (speed and engine revolutions per minute [RPM]) on entrainment rate (i.e., fish/km); however, the entrainment rate exhibited was closely related to hydraulic and geomorphic characteristics of the channel. Entrainment rate was low (<1 fish/km) in wide sections of the river, deep water, and swift current while entrainment in narrow sections with shallow, slow water was highly variable and reached relatively high levels (>30 fish/km). Although total entrainment rate was not related to engine RPM in this study, the authors reported that the probability of being struck by a propeller increased with fish length and engine RPM, with a presumed increase in mortality.

The increased surface activity and associated noise would have the potential to displace/disrupt adult and juvenile fish within the study area during foraging and migratory activities within the vicinity of in-water activities on a given day, which would minimize the potential for losses due to contact with vessels.

Another potential impact associated with increased vessel traffic is radiated noise. It is of considerable importance that fish transiting the navigable Hudson River will encounter an acoustic environment that is generally highly energetic under “normal” conditions. The sound levels lower in the estuary result from the high volume of commercial shipping traffic within the tidal Hudson and New York Harbor. While noise levels from shipping in the estuary are not known, it is possible to get a first approximation based upon sound levels from other locations. For example, a recent study in Hong Kong Harbor, one of the busiest ports in the world, demonstrated that there was a generally high noise level in the area (Würsig et al. 2002). The highest sound levels recorded in that study were associated with ship propellers (probably due to cavitation effects). Sound levels ranged from a high of about 148 dB re 1 µPa to a low of 110 dB re 1 µPa·m). While these recordings were made from within the frequency range of 10 – 20,000 Hz, the bulk of the acoustic energy was below 1,600 Hz. Even from these limited data, it is apparent that the sound from even a single vessel is above hearing thresholds of many fishes found in the Estuary. In other words, the sound level from a single ship could potentially be detectable to a fish within 50 or 100 meters of the propeller.

Other data also demonstrates that ships produce a great deal of noise. For example, a merchant ship traveling at 10-15 knots may produce 163 dB re 1 µPa·m at 50 Hz and 137 dB re 1 µPa·m at 300 Hz, while a large tanker (153 - 214 m long) at 15-18 knots may produce 176 dB re 1 µPa·m at 50 Hz and 149 dB re 1 µPa·m at 300 Hz (Mazzuca 2001). Although one overall ambient noise level due to marine traffic has been estimated to be around 75 dB re 1 µPa·m per Hz at 100 Hz, the source level associated with a large tanker can be as high as 186 dB re 1 µPa·m per Hz at a distance of 1 meter (Gisiner 1998). Richardson et al. (1995) suggest source levels and dominant frequencies ranging from 152 dB re 1 µPa·m at 6300 Hz for a five-meter boat with an outboard motor through 162 dB re 1 µPa·m for a tug and barge traveling at 18 km/hr, to a large tanker with a source level of 177 dB re 1 µPa·m in the 100 Hz band. Other authors cite shipping traffic at frequencies from 20 to 300 Hz, with smaller vessels producing the higher frequency sound peaking at around 300 Hz and larger cargo vessels producing lower frequency sounds (MMS 2001).

Because these representative values of radiated vessel noise are well below the peak SPL of 206 dB re 1 μPa established for pile driving, and because the Hudson River is subject to substantial commercial and recreational vessel noise under "normal" conditions, any incremental increase sound associated with vessel traffic related to bridge construction is not expected to affect fish, including EFH species.

4.1.2.3.6. Summary

The studies and analyses presented above indicate that pile driving and dredging would have minimal effects to anadromous fish migratory activities, as there would always be large portions of the river width that will not be ensonified due to driving piles with an impact hammer. There would be an acoustic corridor of at least 5000 feet at all times below the West Coast threshold for onset of physiological effects to fish, would presumably also include EFH species. The acoustic corridor shall be continuous to the maximum extent possible but at no point shall any contributing section be smaller than 1500 feet. Driving of 8- or 10-foot diameter piles with an impact hammer in the vicinity of the navigation channel (i.e. Zone C) would be restricted to 5 hours per day from April 1 to August 1, and dredging to be conducted in 3 of the 5 construction years would be limited to three month windows (August 1 to November 1). Dredging of 165 to 175 acres for access channels would create an area of reduced foraging opportunities for fish due to loss of benthic habitat. However, upon completion of in-water activities in a given area, estuarine depositional processes would, over time, allow the benthic habitat to return to its pre-construction state. Additionally, benthic organisms that prefer gravel substrates that would be introduced as a result of armoring would be expected to colonize the dredged construction channel. Gravel substrate is available nearby within and near the navigation channel that would serve as a source of these organisms. The temporary loss of the access channel area would represent a minor fraction of similar habitat in the Tappan Zee portion of the Hudson River. Incidental vessel strikes would be insignificant. Therefore, construction of the Replacement Bridge Alternative would not result in adverse impacts to populations of fish species in the Hudson River, including those designated as having EFH within the study area.

4.2 GENERAL DISCUSSION OF POTENTIAL AQUATIC IMPACTS FROM THE OPERATION OF THE PROPOSED PROJECT

4.2.1 WATER QUALITY

The principal potential impact to water quality of the Hudson River from the operation of the Replacement Bridge Alternative is the discharge of stormwater runoff from the decks of the replacement bridge. NYSDEC General Permit GP-0-010-01 regulates the discharge of stormwater runoff from construction activities associated with soil disturbance, including both water quality and quantity controls. NYSDEC requires treatment of stormwater runoff from areas of soil disturbance to improve water quality, as well as a reduction of peak flows of stormwater runoff providing channel protection, overbank flood protection and flood control. The technical standards and design criteria for stormwater management facilities are presented in NYSDEC's New York State SWMDM (NYSDEC 2010b).

The stormwater quality management goals stated in the SWMDM are to achieve an 80 percent reduction in total suspended solids (TSS) and a 40 percent reduction in total phosphorus (TP).

Most water quality treatment practices accomplish this goal by collecting the stormwater runoff and detaining it for some length of time, infiltrating it into the ground or filtering it. These practices, commonly referred to as “standard practices,” are assumed to meet the required removal efficiencies if designed according to the requirements presented in the SWMDM. Other treatment systems, or proprietary practices, such as hydrodynamic separators and grit chambers, can also be employed for water quality treatment. Typically proprietary practices are used when there are certain site specific conditions that prohibit the implementation of “standard practices.”

Stormwater runoff discharges from the Replacement Bridge Alternative would be ultimately discharged into the Hudson River, a tidal water body. The Hudson River is not on the State’s Section 303(d) list of waterbodies impaired by stormwater runoff or within a watershed improvement strategy area. Therefore, stormwater quantity or the channel protection volume, overbank flood protection or flood control sizing criteria would not be required. However, post-construction stormwater quality treatment practices would be required for runoff discharging to the Hudson River from the bridge landing portions of Interstate 87/287 in both Rockland and Westchester Counties. Stormwater runoff from the approaches and main span of the Replacement Bridge Alternative would be discharged directly to the Hudson River without treatment, as occurs for the existing bridge. With the implementation of post-stormwater quality treatment controls at the bridge landings, the net concentration of pollutants to the Hudson River from the Replacement Bridge Alternative (landings, approach spans, and main spans) would be expected to decrease for TSS and increase by only 3.4 pounds per year for TP. This increase in TP loadings from the Replacement Bridge Alternative would not result in adverse impacts to water quality of the Hudson River, or result in a failure to meet the Class SB water quality standards. When comparing just pollutant loadings within the landings under the existing and Replacement Bridge Alternative, pollutant loadings would decrease for TP and TSS. Given the overall decrease between the existing bridge and the proposed bridge in terms of both TSS and the minimal projected increase in TP, the water quality resulting from the operation of the project would not adversely affect EFH, or striped bass or marine turtles and mammals.

4.2.2 AQUATIC BIOTA

With respect to effects on EFH species potentially present in the project area, or other species of concern, the operation of the replacement bridge is not expected to result in any incremental increase in the effects of the existing bridge (to be removed). As discussed under *Water Quality*, the operation of the project would not result in adverse impacts to water quality of the Hudson River. Given that the Tappan Zee region of the Hudson River is not a migratory pathway for any species for which the Hudson has been designated as EFH, the effects of under-bridge lighting is not expected to result in any impediment to fish migration. Coupled with the generally highly turbid waters of the river, the fact that many species that regularly occur in the project area inhabit the deepest water available, and the presence of other anthropogenic lights along both shorelines of the River and associated with other river crossings, the operation of the project would not result in adverse effects to fish or EFH due to under-bridge lighting.

It has been maintained that shading of estuarine habitats can result in decreased light levels and reduced benthic and water-column primary production, both of which may adversely affect invertebrates and fishes that use these areas, particularly with respect to use as refuge and foraging habitat (Able et al. 1998, and Struck et al. 2004). The amount of area shaded by overwater structures will be affected by the height and width of the structure, construction materials and orientation of the structure relative to the arc of the sun (Burdick and Short 1995, Fresh et al. 1995 and 2000, Olson 1996, 1997 in Nightingale and Simenstad 2001) and piling density. Shading due to bridges has been found to affect plant communities such as tidal marshes and SAV, as well as benthic invertebrate communities within tidal marshes (Struck et al. 2004, and Broome et al., 2005 in CZR 2009). However, adverse effects on marsh vegetation and benthic macroinvertebrates have been found to be minimal when the bridge height-to-width ratio is greater than 0.7 (Struck et al, 2004, Broome et al. 2005 in CZR 2009). Significantly fewer oligochaete worms, which are common in the Hudson River, were found under bridges with a height-to-width ratio less than 0.7 when compared to marshes not affected by shading (Struck et al. 2004). Struck et al. (2004) found that bridges with height-to-width ratios greater than 1.5 had the lowest light attenuation beneath the bridge.

Because the elevations of the existing Tappan Zee Bridge and the Replacement Bridge Alternative are not consistent over the length of the structure (see **Figure 4**), the height-to-width ratio of the bridge varies along its length. **Table 13** compares the ratio of the existing bridge and the Short and Long Span Options for the Replacement Bridge Alternative at the stations indicated in **Figure 2**. The two spans of the Replacement Bridge Alternative would be separated by a gap of up to 70 feet. While impacts to vegetated wetlands or SAV would not be expected to be affected by the construction of the Replacement Bridge Alternative, the height-to-width ratios presented below provide an indication of the potential for the existing and Replacement Bridge Alternative to result in shading impacts. As indicated below, the height-to-width ratio for the portion of the existing bridge within the causeway (the western approach to the main span comprising Stations 845+00 to approximately 905+00) is low, ranging from 0.2198 to 0.2857). The ratio for these same stations for the Replacement Bridge Alternative, Short and Long Span Options, are much higher, ranging from 0.35 near the shoreline to 1.20, with the ratios for the Long Span Option being slightly greater because the height for this approach option is higher. The portion of the western approach just prior to the main span (Stations 920+00 to 935+00) has a ratio that ranges from 0.54 to 1.05 for the existing bridge. Again, the ratios of these stations for the Replacement Bridge Alternative are much greater, ranging from 1.23 to 1.82. The ratios for the main span of the existing bridge range from 1.51 to 1.52 and for the Replacement Bridge Alternative 1.49 to 1.82, while the ratios for the eastern approach are fairly similar for the existing and Replacement Bridge Alternative, ranging from 0.89 to 1.31 with the Long Span Option for the Replacement Bridge Alternative having the higher ratios.

The ratios in **Table 13** consider the height-to-width ratio separately for the two spans of the Replacement Bridge Alternative, assuming that the separation between the decks of the two spans (i.e., 70 feet at the main span and then decreasing toward the shorelines) allows light to penetrate between the two structures. This represents the best case analysis. Under this case, the Replacement Bridge Alternative would clearly result in a lower potential for shading of aquatic habitat compared to the existing bridge, particularly along the causeway (western approach to the main span). Even under the worst case, which assumes no separation between the spans of the Replacement Bridge Alternative and which would conservatively result in a halving of the height-to-width ratios presented in **Table 13**, the Replacement Bridge Alternative would still result in greater ratios (i.e., less shading) than the existing bridge for the western approach, but may result in more shading than the existing bridge for the eastern approach. Overall, the height-to-width ratios imply that even if the Replacement Bridge Alternative were treated as a single structure, with no separation between the spans, there would be a decrease in the potential for shading impacts to aquatic resources.

Table 13
Height-to-Width Ratios for the Existing Bridge and Short and Long Span Options for the Replacement Bridge Alternative at Various Stations Across the Length of the Bridge

Location	Existing	Short Span		Long Span	
	91 ft-wide deck	96ft-wide	87ft-wide	96ft-wide	87ft-wide
845+00	0.29	0.34	0.38	0.44	0.48
860+00	0.22	0.52	0.57	0.60	0.67
875+00	0.22	0.70	0.78	0.78	0.86
890+00	0.22	0.91	1.00	0.96	1.06
905+00	0.22	1.08	1.20	1.13	1.24
920+00	0.54	1.23	1.36	1.24	1.37
935+00	1.05	1.46	1.61	1.46	1.61
950+00	1.52	1.65	1.82	1.65	1.82
965+00	1.51	1.49	1.64	1.49	1.64
980+00	1.01	1.19	1.31	1.19	1.31
995+00	1.07	0.99	1.09	0.89	0.98

4.3 ASSESSMENT OF EFH SPECIES WITHIN THE HUDSON RIVER BRIDGE CONSTRUCTION STUDY AREA

An analysis of EFH for each fish species and life stage listed in **Table 9**—including the likelihood that the species would occupy the project area on the basis of physical site characteristics including salinity regime, water depth, and/or sediment type—is summarized below for each species. Table 14 summarizes the EFH species that were evaluated but determined not likely to occur within the Hudson River bridge construction study area on the basis of physical site characteristics (e.g., salinity, water depth, sediment). Of the 13 EFH species identified for the Hudson River estuary, the majority were found in highest abundance in the lower reaches of the estuary from the Battery to Yonkers (river miles 0-23). Only three of these species—Atlantic butterfish, bluefish and summer flounder—were captured during the 2007-2008 sampling program for the project. These marine species were captured in the warmer months of the year when higher water temperatures and salinities are present within the Hudson River bridge construction study area. Six EFH species were collected in the Utilities Long River Monitoring Program between 1998 and 2007, albeit relatively infrequently in the Tappan Zee region (RM 24-33) compared to collections in the lower reaches of the estuary. Among these species were winter flounder (egg, larvae, young of year and yearling or older), bluefish (young of year, yearling and older), Atlantic herring (larvae, young of year, yearling and older), windowpane flounder (eggs, larvae, young of year, yearling and older), summer flounder (larvae, young of year), and Atlantic butterfish (larvae, young of year, yearling and older). The Utilities Fall Shoals Program also collected winter and summer flounder, bluefish and Atlantic butterfish, but in relatively few of the samples taken between 1998 and 2007. Atlantic mackerel, Spanish mackerel and scup were each collected in fewer than 3 of over 1,800 samples taken in the Tappan Zee region (RM 24-33) over the ten year period.

Table 14
Essential Fish Habitat Species Not Likely to Occur Within the Hudson River Bridge Construction Study Area On the Basis of Physical Site Characteristics

Species	Reason
Atlantic Mackerel	Juveniles and adults are most common at salinities ≥25 ppt[1]
Black Sea Bass	Juveniles and adults can be found at salinities from 8 - 38 ppt but are most common at salinities >20 ppt[1]
Cobia	Juveniles and adults are most common at salinities ≥25 ppt[1]
King Mackerel	Juveniles and adults are most common at salinities >32 ppt[1] and depths >59 ft[3]. Eggs and larvae are common at salinities >30 ppt[1].
Red Hake	Larvae are found at depths >33 ft[3]. Juveniles and adults are most common at salinities > 20 ppt[1]. Adults are most common at depths >82 ft[3].
Scup	All life stages are most common at salinities >15 ppt[1] and are designated as using habitats with salinities ≥25 ppt[2]
Spanish Mackerel	Eggs and larvae are most common at depths >39 ft[3]. Juveniles are most common at salinities >12 ppt[1]. Adults are most common at salinities >32 ppt[1].
Clearnose Skate	Juveniles and adults are most common at salinities >20 ppt[1].
Little Skate	Juveniles and adults are most common at salinities >20 ppt[1].
Winter Skate	Juveniles and adults are most common at salinities >20 ppt[1].

[1]Salinities in the Tappan Zee region range from 0 - 12 ppt over the course of the year (AECOM Hudson River Ecology chapter).

[2]NMFS Essential Fish Habitat designation of "S" Seawater salinity zone.

[3]Depths greater than 30 ft are limited to the navigation channel, which is approximately 15% of the river width in the Tappan Zee region. Maximum depths do not exceed 60 ft.

4.3.1 ATLANTIC BUTTERFISH (*PEPRILUS TRIACANTHUS*)

Butterfish occur from Newfoundland to Florida and are most abundant between southern New England and Cape Hatteras. It has been suggested that two populations of butterfish exist. One population appears largely restricted to shoals (less than 20 m [66 ft]) south of Cape Hatteras, and another mainly north of Hatteras that occurs in shoals and possibly some deeper waters along of the shelf. Throughout its range, butterfish are found over the entire shelf, inshore and offshore. According to Able and Fahay (1998), butterfish move inshore as water temperatures increase during the spring and migrate back offshore as inshore water temperatures decrease in the fall. Butterfish require 10°C (50ºF) for survival. This species spawns from June to August in inshore waters generally less than 30 m (98 ft) deep.

Peak egg production is in late June and early July off Long Island Sound. Very few butterfish eggs have been collected in the Hudson River estuary during utilities-sponsored fish surveys conducted between 1998 and 2007. Those that were collected were found in late June and July in the lower estuary from the Battery to near Yonkers at river mile 23. No butterfish eggs have been reported from the Tappan Zee region during these surveys. However, the Hudson River is within an area designated as EFH for larval, juvenile, and adult butterfish. Studies performed in the Hudson-Raritan Estuary noted that butterfish comprised less than 1 percent of total catches of fish (USACE 2000).

Newly hatched larvae are between 2 and 16 mm (0.1-0.6 in) in length. Larvae are found at the surface and often in the shelter of the tentacles of large jellyfish. The latter tend to be more nektonic (freely swimming) than planktonic (passively drifting with currents) when between 10 and 15 mm (0.4-0.6 in) long. Larvae are found at temperatures ranging from 7-26°C (45-79°F), although most abundant at 9-19°C (48-66°F), and at depths less than 120 m (394 ft) (Cross et al. 1999).

At 6 mm (0.24 in), larval body depth has increased substantially in proportion to length. At 15 mm (0.6 in), the fins are differentiated and the young fish takes on the general appearance of the adult. Adult butterfish can range from 120 to 305 mm (4.7-12 in) long. Both juveniles and adults have similar habitat characteristics. Both are eurythermal and euryhaline and are common often near the surface in sheltered bays and estuaries during the spring to autumn months. In the Hudson-Raritan trawl survey, juveniles and adults were found at depths from 3-23 m (10-75 ft), salinities from 19-32 parts per thousand (ppt), and dissolved oxygen from 3-10 mg/L. Juvenile and adult butterfish also often prefer sandy and muddy substrates, and temperatures from 3-28°C (37-82°F) (Cross et al. 1999).

Occasional adult and juvenile butterfish have the potential to occur within the study area. Spawning would not occur within the study area. Woodhead (1990) reports butterfish to be a common transient in the New York Harbor in the summer. Atlantic butterfish prefer sandy bottoms, but are not closely associated with the bottom when inshore during the summer. They may stay close to the bottom during the day and move into the water column at night (Smith 1985). They are found in the Hudson-Raritan estuary in greatest abundance during summer and based on the last available decade of Utilities data (1998-2007), butterfish are present in the lower Hudson River from the Battery to West Point (upriver from the study area) from July through October (sampling starts in July). They have not been caught upstream of West Point and are far more abundant in the first 23 river miles (Battery and Yonkers) compared to areas farther upstream. The highest densities of butterfish are in the channel and to some extent, the deep bottom habitats in waters greater than 20 feet deep. They are infrequently collected in the shallow shoal habitat (i.e., less than 20 feet deep).

Because the Tappan Zee region of the Hudson River is marginal habitat for butterfish in terms of normal salinity ranges and the Hudson River is not a migratory corridor for the species, individuals this species are not likely to occur in the project area in large numbers but would occur during periods of low freshwater flows when the salt front is pushed upriver. The habitat found within the Tappan Zee region of the Hudson River does not represent a significant portion of the EFH for this species. Atlantic butterfish were collected within the study area during the sampling conducted for the project and were collected during the Utilities Fall Shoals Program from 1998 to 2007, although in relatively few of the samples. The Mid-Atlantic butterfish stock is considered overfished (NOAA 2011).

Sounds from pile driving and other in-water construction activities will be temporary, and would not be expected to represent a barrier to movement of individuals within the Hudson River. Potential hydroacoustic impacts to fish using the deep water portions of the Hudson River due to pile driving with an impact hammer would only occur during the initial few months of in-water construction activities. Pile driving would not occur at night and would not be continuous during the day (i.e., when piles are being put in place or being welded, or when the pile driver is being relocated). For most of the pile driving scenarios modeled, including those in which the maximum number of simultaneous piles are being driven and/or for the largest piles, a substantial portion of the Hudson River's width would never reach the SEL_{cum} criterion established for onset of physiological injury, and portions of the river would also be below the 150 dB RMS guidance for behavioral effect. Fish would not be expected to remain in an area at which noise would cause discomfort. Therefore, the hydroacoustic environment resulting from pile driving with an impact hammer would result in a temporary loss of a small area of EFH for this species and would not be expected to affect movement of this species within the river. Water quality changes, including the resuspension of bottom sediments, during construction of the proposed project would be minimal and temporary, limited to the immediate area of the activity. Operation of the project would not result in adverse impacts to water quality of the Hudson River, or adversely affect aquatic habitat due to under-bridge lighting. Therefore, the project would not result in adverse impacts to the EFH for this species.

4.3.2 ATLANTIC MACKEREL (*SCOMBER SCOMBRUS*)

Atlantic mackerel is a pelagic marine species that occurs on both sides of the North Atlantic, and in the western North Atlantic from Labrador to North Carolina. It sustains fisheries from the Gulf of St. Lawrence and Nova Scotia to the Cape Hatteras area. There may be two populations: one occurring in the northern Atlantic and associated with the New England and Maritime Canadian coast, and another more southerly population that inhabits the mid-Atlantic coast. Both populations overwinter in the deep waters at the edge of the continental shelf, generally moving inshore (in a northeastern direction) during the spring, and reversing this migration in autumn. The southern population begins its spawning migration by moving inshore between the Delaware Bay and Cape Hatteras and then in a northeastern direction along the coast. The timing of the migration and spawn is driven by warming water temperatures. The peak spawn for the southern population occurs off New Jersey and Long Island Sound in April and May. Most spawning occurs in the shoreward half of the continental shelf and in waters from 7 to 14°C (45-57°F), with the peak being 10 to 12°C (50-54°F) (Studholme et al. 1999). Eggs of the Atlantic mackerel have been collected in low abundance from mid-April to June and primarily in the lower portion of the Hudson River estuary from the Battery up to river mile 23 near Yonkers, based on utilities-sponsored fish survey data. Larval Atlantic mackerel are also collected in low abundances during May and June in the same region. Very few eggs or larvae are collected in the project area near Tappan Zee. Only 1 juvenile Atlantic mackerel was collected during these surveys in the Yonkers region. By June, schools of juveniles can be found off Massachusetts, and they move into the Gulf of Maine by June and July. In the New York Harbor Estuary, juveniles may be present from April to December, but are most common from April through June and October through November. Adults are present from April through June and from September through December, most commonly from April to May and from October to November (USACE 2000). The Hudson River is within an area designated as EFH for juvenile and adult Atlantic mackerel.

Juvenile metamorphosis includes swimming and schooling behaviors starting at approximately 30-50 mm (1.2-2.0 in), and they closely resemble adults by about 1 year of age. In the New York Harbor Estuary, juveniles are present in the spring and summer months, preferring depths from 4.9-9.8 m (16-32 ft), salinity ranges from 26-28.9 ppt, dissolved oxygen from 7.3-8.0 mg/L and temperatures from 17.6-21.7°C (64-71°F) (Studholme et al. 1999).

Adult Atlantic mackerel can range from 26 cm (10 in) in their second year to about 40 cm (15.8 in) in their sixth year. NEFSC trawl survey data indicate that adults are found in the spring at temperature ranges from 5-13°C (41-55°F) dispersed from 0-380 m (1,250 ft) (most abundant at 160-170 m [525-558 ft]), and in the summer at temperatures ranging from 4-14°C (39-57°F) at depths of 10-180 m (33-591 ft) (abundant at 50-70 m [164-230 ft]). Adults also prefer salinities of 25 ppt or greater (Studholme et al. 1999).

Due to salinity requirements, adults are not likely to be present within the Hudson River, in the study area (**Table 14**), where salinity is less than 10 PSU over much of the year except for during periods of low freshwater flows when the salt front is pushed upriver Atlantic mackerel were rarely collected during trawls in the New York Harbor by USACE from October 1998 through November 1999 (USACE 1999). Most individuals were found in the Lower Harbor (Raritan Bay and Sandy Hook Bay) (Woodhead and McEnroe 1991 in USACE 1999).

The habitat found within the Tappan Zee region of the Hudson River does not represent a significant portion of the EFH for juvenile and adult Atlantic mackerel. This species would not be expected to occur within the study area except as rare transient individuals. Therefore, adverse impacts would not occur to the EFH for this species.

4.3.3 ATLANTIC HERRING (*CLUPEA HARENGUS*)

Atlantic herring is a planktivorous marine species that occurs in coastal waters throughout the Northwestern Atlantic waters from Greenland to North Carolina. They are most abundant north of Cape Cod and relatively scarce in waters south of New Jersey (USACE 2000). Adult Atlantic herring routinely move into estuaries, but are largely restricted to well-mixed waters at salinities greater than 24 ppt. Adults rarely move into fresh water (Smith 1985) and appear to limit their distribution based on the transition zone between well-mixed and stratified waters. Juvenile and adult herring undergo complex north-south migrations and inshore-offshore migration for feeding, spawning, and overwintering. They spawn once a year in late August through November in the coastal ocean waters of the Gulf of Maine and Georges Banks. This species never spawns in brackish water and eggs of this species have not been collected in the Hudson River during utilities-sponsored fish surveys between 1998 and 2007. Post-spawn, the adults migrate to the New York Bight to overwinter from December to April and are followed several weeks later by larval herring that are transported to estuaries and tidal rivers where they also overwinter. The autumn migration by adults to overwintering areas is done in tight schools while the spring migration to spawning areas is much more dispersed. The Hudson River is within an area designated as EFH for larval, juvenile, and adult Atlantic herring.

Larval herring are free-floating, and for autumn-spawned fish this stage can last 4 to 8 months until the spring metamorphosis into juveniles. A fraction of those hatched remain at the spawning site, while others may drift in ocean currents, reaching eastern Long Island Sound and entering the Hudson River estuary on flood tides. In the Gulf of Maine, larvae occur at temperatures ranging from 9 to 16°C (48-61°F), and a salinity of 32 ppt. During post-metamorphosis, which occurs through April and May, juveniles form large schools and move into shallow waters. In the Hudson River, larval Atlantic herring are typically collected during spring and early summer and primarily in the lower reaches of the River from the Battery to river mile 23 near Yonkers. Larval herring are also collected further upstream in the Tappan Zee and Croton-Haverstraw regions, but are sparse upstream of Indian Point and river mile 46. Large schools of juveniles have been collected during spring and early summer (late April through late

June) between the Battery and Indian Point and are at peak abundances during May in the Tappan Zee region, based on utilities-sponsored fish survey data collected from 1998-2007. As early juveniles, Atlantic herring are found in brackish waters, but as older juveniles, this species emigrates from the estuary during summer and fall to overwinter in higher salinity bays or near the bottom in offshore areas. Within Long Island Sound, springtime abundances have been reported as being highest at temperatures ranging from 9 to 10°C (48- 50°F), depths ranging from 10 to 30 m (33-98 ft), and salinity ranging from 25 to 28 ppt. Within the New York Harbor Estuary, catches of herring were highest at temperatures ranging from 3 to 6°C (37-43°F) and in the deeper portions of the estuary (USACE 2000). Juveniles in the NOAA Northeast Fisheries Science Center (NEFSC, http://www.nefsc.noaa.gov) bottom trawl surveys of the New York Harbor Estuary were found to prefer temperatures at 2-16°C (36-61°F) and 12-22°C (54-72°F), and were most abundant at 4-6°C (40-43°F) and 15-18°C (59-64°F). Juveniles are commonly found at depths ranging from 30-135 m (98-443 ft) which varied seasonally (depths increasing with the summer months) (Reid et al. 1999).

On average, males and females mature at about 25-27 cm (10-11 in). In the NEFSC bottom trawl surveys, adults collected were most abundant at 3-6°C (37-43°F) at depths ranging from 4.5 to 13.5 m (14 to 44 ft). Preferred salinities for the Atlantic herring are greater than 28 ppt (Reid et al. 1999). Juveniles and adults perform diel and semi-diel vertical migrations in response to daily photoperiods and variations in turbidity. Being sensitive to light intensity, activity is highest after sunrise and just before sunset, when the herring will avoid the surface during daylight to avoid predators (Reid et al. 1999).

In 1999 the NOAA Technical Memo for the species indicated that the U.S. stock complex has fully recovered from the effects of over-exploitation during the 1960s and 1970s (Reid et al. 1999). The Atlantic herring fishery is not overfished and is not approaching an overfished condition (NFMS 2011b). The NMFS has designated the Hudson River mixing and salinity zone as EFH for Atlantic sea herring larvae, juveniles, and adults.

Larvae, young of year, yearling and older Atlantic herring were observed in the Utilities Long River Monitoring Program collections between 1998 and 2007. However, abundances are highest in the lower portion of the estuary downstream of the project area. In the context of this species' habitat requirements, the Tappan Zee region of the Hudson River is marginal habitat for Atlantic herring based on low relative abundances of this species in the vicinity of the project area compared to abundances further downstream. Furthermore, salinities in the project area are near the low end of the species' normal salinity ranges, particularly for older juveniles and adults. Finally, the Hudson River is not a migratory corridor for the species. Because the habitat found within the Tappan Zee region of the Hudson River does not represent a significant portion of the EFH for this species and individuals of this species are not likely to occur in the project area in large numbers. The project is not likely to result in adverse impacts to EFH for this species.

4.3.4 BLACK SEA BASS (*CENTROPRISTIS STRIATA*)

Black sea bass is a marine species that occurs from Cape Cod, Massachusetts to Cape Canaveral, Florida. The fishery is divided into two populations: one major population north of Cape Hatteras, North Carolina, and one in southern waters. The northern population migrates seasonally: shoreward and north in the spring and offshore and south in the autumn. In the autumn, older fish move offshore sooner and overwinter in deeper waters (73 to 163 m [240-535 ft]) than young-of-the-year fish (56 to 110 m [184-361 ft]). Black sea bass can tolerate temperatures as low as 6°C (43°F) but are most abundant in off-shore waters warmer than 9°C (48°F) between 20 to 60 m (66-197 ft) deep (USACE 2000). During the spring migration, adults move to spawning grounds on the nearshore continental shelf and juveniles move inshore and into estuaries. For the northern population, spawning generally takes place in the summer, in water 18 to 45 m deep from the Chesapeake Bay to Montauk Point, New York. The Hudson River is within an area designated as EFH for juvenile and adult black sea bass.

Larvae develop for the most part in continental shelf waters and are most abundant in the southern portion of the Middle Atlantic Bight. Larvae quickly become bottom dwellers and may move into estuaries as late-stage larvae or early juveniles, although eggs and larvae are not typically found in estuaries (Able et al. 1995). While inhabiting the estuary, juvenile black sea bass are strongly structure-oriented and occupy bottom habitats consisting of shells, amphipod tubes and rubble, and have been observed on inshore jetties in late May to early June.

In the Hudson River, young-of-the-year have been captured in both open water and inter-pier areas. Juvenile sea bass occur in the saline portions of estuaries from Massachusetts to Florida starting with the initial spring migration until late autumn and are commonly found around jetties, piers, wrecks, and bottom areas with shells (USACE 2000). They appear to prefer hard bottom (Bigelow and Schroeder 1953).

Juveniles settle in estuaries and the inner continental shelf growing up to 19 cm (7.5 in). Young-of-the-year black sea bass inhabit estuarine areas in the Mid-Atlantic Bight at depths from 1-38 m (3-125 ft) from July to September. They prefer structured bottoms, shell patch substrates and often find shelter around manmade structures. Juveniles can be found in water temperatures ranging from 6-30°C (43-86°F) and salinities ranging from 8-38 ppt (but most preferring >20 ppt). The young-of-the-year are migratory during some portions of the first year. They migrate out of the estuaries and away from inner continental shelf nursery areas during the autumn as water temperatures drop (Steimle et al. 1999b). Adult black sea bass prefer similar habitat conditions as that of the juvenile and perform similar migratory patterns. Adults also tend to seek shelter around manmade structures (Steimle et al. 1999b) and are more common in nearshore coastal and offshore habitats than within estuaries

Black sea bass are bottom feeders, consuming crabs, shrimp, mollusks, small fish, and squid. Woodhead (1990) describes black sea bass as a common summer transient in the New York Harbor. Individuals have been collected in the New York Harbor and the Hackensack River (Smith 1985). Young-of-the-year black sea bass (i.e., juveniles) have been collected in the lower Hudson River off Manhattan from mid-July to September (Able et al. 1995) and are collected during utilities-sponsored fish surveys primarily in August downstream of the project area between the Battery and Yonkers in channel and bottom habitats at depths exceeding 20 feet. Eggs and larvae of this species have not been collected during utilities surveys in the Hudson River. Based on these observations, eggs and larvae are not expected to occur in the study area and there is a low probability that juvenile black sea bass will occur within the study area. For each of these life stages, it is unlikely that project activities would have an impact on this species.

The black sea bass fishery is not currently overfished or approaching an overfished condition (NOAA 2011). The NMFS has designated the Hudson River mixing and salinity zones as EFH for black sea bass juveniles and adults.

Due to salinity requirements (**Table 14**), adults and juveniles are not likely to be present in the study area except in the lower portion of the estuary downstream of the project area near Tappan Zee or during periods of low freshwater flows when the salt front is pushed upriver. The Hudson River is not a migratory corridor for this species and individuals are not likely to occur within the study area in large numbers as suggested by fish-survey data. The habitat found within the Tappan Zee region of the Hudson River does not represent a significant portion of the EFH for this species (i.e., poly- to euhaline nearshore and offshore structured habitat) and individuals would not be expected to occur within the study area except as rare transient individuals. Therefore, the project would not result in adverse impacts to the EFH for this species.

4.3.5 BLUEFISH (*POMATOMUS SALTATRIX*)

Bluefish is a carnivorous marine species that occurs in temperate and tropical waters on the continental shelf and in estuarine habitats around the world. In North America, bluefish live along most of the Atlantic coastal waters from Nova Scotia south, around the tip of Florida, and along the Gulf Coast to Mexico. Bluefish migrate between summering and wintering grounds, generally traveling in groups of fish of similar sizes and loosely aggregated with other groups. They generally migrate north in the spring and summer and south in the autumn and winter.

Along the North Atlantic, summering waters are centered in the New York Bight, southern New England and northern sections of the North Carolina coastline. Wintering grounds are found in the southeastern parts of the Florida coast. Juvenile and adult bluefish travel far up estuarine waters (where salinity may be less than 10 ppt), but are more often found at higher salinities in poly- and euhaline waters (>20ppt), while eggs and larvae are largely restricted to marine habitats as a result of the adults preferred spawning locations in nearshore and offshore waters (USACE 2000). The Hudson River is within an area designated as EFH for juvenile and adult bluefish.

There are two spawning stocks along the U.S. Atlantic coast—a south Atlantic spring spawn, and mid-Atlantic summer spawn. The fish spawning in the spring migrate to the Gulf Stream/coastal shelf interface between northern Florida and Cape Hatteras in April and May.

Post-spring spawn, smaller bluefish drift westward while the larger fish slowly migrate north along the shelf and west into mid-Atlantic bays and estuaries including the New York Harbor Estuary where they remain until autumn. Summer-spawning fish migrate to the mid-Atlantic from Cape Cod to Cape Hatteras in June through August. Summer post-spawn fish head towards the mid-Atlantic shores and are particularly abundant in Long Island Sound (USACE 2000, Fahay et al. 1999). Juveniles from the spring spawn drift north in the early summer and enter the important nursery habitats in estuaries and bays along the mid-Atlantic coast in June. Summer-spawned fish enter the estuaries in mid- to late-summer (Buckel et al. 1999). All spent fish and juveniles migrate to the wintering grounds in the autumn (USACE 2000).

Juveniles in the Mid-Atlantic Bight inhabit inshore estuaries from May to October, preferring temperatures between 15 and 30°C (59-86°F), and salinities between 23 and 33 ppt. Although juvenile and adult bluefish are moderately euryhaline, they occasionally will ascend well into estuaries where salinities may be less than 3 ppt. Juveniles use estuaries as nursery areas, and can be found over sand, mud, silt, or clay substrates.. Bluefish juveniles are sensitive to changes in temperature; thermal boundaries apparently serve as important cues to juvenile migration off shore in the winter season (Fahay et al. 1999) and may impede early migration into the estuary during the spring.

Adult bluefish are pelagic and highly migratory with a seasonal occurrence in Mid-Atlantic estuaries from April to October. They prefer temperatures from 14-16°C (57-61°F) but can tolerate temperatures from 11.8-30.4°C (35-87°F) and salinities greater than 25 ppt. Adult bluefish are not uncommon in bays and larger estuaries, as well as in coastal waters (Bigelow and Schroeder 1953, Olla and Studholme 1971 in Fahay et al. 1999).

Within the Hudson River Estuary, juvenile and adult bluefish may occur in the late spring through autumn. No spawning would occur within the study area and no bluefish eggs or larvae have been collected during utilities-sponsored fish surveys conducted from 1998 through 2007. Juvenile or older bluefish were captured during the 2007-2008 sampling program for the project during the warmer months of the year when higher salinities are present within the study area. Additionally, juvenile bluefish were observed in the Utilities Long River Monitoring and Fall Shoals Program collections (which are targeted to early life stages). Equally high abundances were recorded from the Battery to West Point near river mile 55, including within the project area. Very low abundances were found in the Hyde Park region and no juvenile bluefish were collected upstream of river mile 85. Peak juvenile abundances typically occur in late August and September and dwindle into late October as juveniles migrate offshore for the winter.

Historically, bluefish was categorized as overfished—the stock size was below the minimum threshold set for this species—and a rebuilding program has been implemented. However, recent estimates of fishing mortality suggest that the rebuilding program, state-by-state quota system, and recreational harvest limit have been successful (MAFMC 2002, NMFS 2003, 2004, 2005). The bluefish fishery is not currently overfished, nor considered to be approaching overfishing status (NOAA 2011).

Juvenile and adult bluefish occupy the saline portions of Hudson River estuary during summer and fall, but emigrate from the River in late fall to overwintering grounds on the continental shelf during the rest of the year. The habitat found within the Tappan Zee region of the Hudson River does not represent a significant portion of the EFH for this species. The Hudson River is not a migratory corridor for this species and individuals are not likely to occur within the study area in large numbers as suggested by fish-survey data.

Sounds from pile driving and other in-water construction activities will be temporary, and would not be expected to represent a barrier to movement of individuals within the Hudson River. Potential hydroacoustic impacts to fish using the deep-water portions of the Hudson River due to pile driving with an impact hammer would only occur during the initial few months of in-water construction activities. Pile driving would not occur at night and would not be continuous during the day (i.e., when piles are being put in place or being welded, or when the pile driver is being relocated). For most of the pile driving scenarios modeled, including those in which the maximum number of simultaneous piles are being driven and/or for the largest piles, a substantial portion of the Hudson River's width would never reach the SEL_{cum} criterion established for onset of physiological injury, and portions of the river would also be below the 150 dB re 1 µPa rms guidance for behavioral effect. Fish would not be expected to remain in an area at which noise would cause discomfort. Therefore, the hydroacoustic environment resulting from pile driving with an impact hammer would result in a temporary loss of a small area of EFH for this species and would not be expected to affect movement of this species within the river. Water quality changes, including the resuspension of bottom sediments, during construction of the proposed project would be minimal and temporary, limited to the immediate area of the activity. Operation of the project would not result in adverse impacts to water quality of the Hudson River, or adversely affect aquatic habitat due to under-bridge lighting. Therefore, the project would not result in adverse impacts to the EFH for this species.

4.3.6 COBIA (*RACHYCENTRON CANADUM*)

Cobia are large, migratory, coastal pelagic fish of the monotypic family Rachycentridae. In the western Atlantic Ocean, cobia occur from Massachusetts to Argentina, but are most common along the south Atlantic coast of the United States and in the northern Gulf of Mexico. In the eastern Gulf, cobia migrate from wintering grounds off south Florida into northeastern Gulf waters during early spring. They occur off their northwest Florida, Alabama, Mississippi, and southeast Louisiana wintering grounds in the fall. Some cobia overwinter in the northern Gulf at depths of 100 to 125 m (328 to 410 feet). The Hudson River is within an area designated as EFH for eggs, larval, juvenile and adult cobia. However, only one collection of cobia was made during utilities-sponsored fish surveys between 1998 and 2007, which was a juvenile collected in open-water channel habitat in the Yonkers region during late August. Eggs and larval cobia have not been reported from these surveys in the Hudson River.

Information on the life history of cobia from the Gulf and the Atlantic Coast of the United States is limited. Essential fish habitat for coastal migratory pelagic species such as cobia includes sandy shoals of capes and offshore bars, high profile rocky bottom and barrier island ocean-side waters, from the surf to the shelf break zone, but from the Gulf Stream shoreward, including areas inhabited by the brown alga, *Sargassum* spp. For cobia, essential fish habitat also includes high salinity bays, estuaries, and seagrass habitat. The Gulf Stream is an essential fish habitat because it provides a mechanism to disperse coastal migratory pelagic larvae. Preferred temperatures are greater than 20°C and salinities are greater than 25 ppt.

Cobia are likely to occur only as rare transient individuals within the study area due to its coastal migrations, pelagic nature, and salinity requirements (**Table 14**). Individuals would have the potential to occur during periods of low freshwater flows when the salt front is pushed upriver. The habitat found within the Tappan Zee Region of the Hudson River does not represent a significant portion of the EFH for this species and individuals would not be expected to occur within the study area except as rare transient individuals. Therefore, the project would not result in adverse impacts to the EFH for this species. The habitat found within the Tappan Zee Region of the Hudson River does not represent a significant portion of the EFH for this species. This species would not be expected to occur near the project site except as rare transient individuals. Therefore, the project would not result in adverse impacts to the EFH for this species.

4.3.7 KING MACKEREL (*SCOMBEROMORUS CAVALLA*)

King mackerel is a marine species that inhabits Atlantic coastal waters from the Gulf of Maine to Rio de Janeiro, Brazil, including the Gulf of Mexico. There may be two distinct populations of king mackerel. One group migrates from waters near Cape Canaveral, Florida south to the Gulf of Mexico, making it there by spring and continuing along the western Florida continental shelf throughout the summer. A second group migrates to waters off the coast of the Carolinas in the summer, after spending the spring in the waters of southern Florida, and continues on in the autumn to the northern extent of the range. The Hudson River is within an area designated as EFH for eggs, larval, juvenile, and adult king mackerel.

Overall, temperature appears to be the major factor governing the distribution of the species. The northern extent of its common range is near Block Island, Rhode Island, near the 20°C (68°F) isotherm and the 18-meter (59 ft) contour. King mackerel spawn in the northern Gulf of Mexico and southern Atlantic coast. Larvae have been collected from May to October, with a peak in September. In the south Atlantic, larvae have been collected at the surface with salinities ranging from 30 to 37 ppt and temperatures from 22 to 28°C (70-81°F). Adults are normally found in water with salinity ranging from 32 to 36 ppt (USACE 2000).

Due to salinity and water depth requirements (**Table 14**), king mackerel are not likely to be present within the Hudson River in the study area except during periods of low freshwater flows when the salt front is pushed upriver. This species has not been collected during utilities-sponsored fish monitoring in the Hudson River. The habitat found within the Tappan Zee Region of the Hudson River does not represent a significant portion of the EFH for this species. This species would not be expected to occur near the project site except as rare transient individuals. Therefore, the project would not result in adverse impacts to the EFH for this species.

4.3.8 RED HAKE (*UROPHYCIS CHUSS*)

Red Hake is a bottom-dwelling fish that lives on sand and mud bottoms along the continental shelf from southern Nova Scotia to North Carolina (concentrated from the southwestern part of the Georges Banks to New Jersey). Spawning adults and eggs are common in marine portions of most coastal bays between Rhode Island and Massachusetts. Spawning occurs from May to June in the New York Bight (Steimle et al 1999a). The Hudson River is within an area designated as EFH for larval, juvenile, and adult red hake.

Larval red hake are free floating and occur in the middle and outer continental shelf. They are most common in water temperatures from 11 to 19°C (52-66°F) and depths from 10 to 200 m (33-660 ft). Recently metamorphosed juveniles remain pelagic (i.e. in the water column) for approximately two months, during which time they achieve growth up to 25-30 mm (1.0-1.2 in) in total length. Shelter/structure is a critical habitat requirement for juvenile red hake. In the autumn, juveniles descend from the water column to the bottom and seek sheltering habitat in depressions in the sea floor. Juvenile settlement usually occurs in October and November. Older juveniles use scallop shells, mussel beds, moon snail egg collars, and other available structure until their second autumn when they move inshore to waters less than 55 m (180 ft) in depth. They typically remain inshore until the temperature reaches 4°C (39°F), at which point they migrate offshore to overwinter (USACE 2000, Steimle et al. 1999a).

Woodhead (1990) describes red hake as a common resident of the New York Harbor system. In the Harbor Estuary, the distribution of red hake is influenced by salinity, water temperature, and dissolved oxygen. Juvenile red hake were collected when salinity was greater than 22 ppt and at depths from 5 to 50 m (16-164 ft) deep. Collections tapered off when salinity reached greater than 28 ppt. Adult red hake prefer temperatures from 2 to 22°C (36-72°F), salinity ranging from 20 to 33 ppt and depths greater than 25 m (82 ft) deep. In Middle Atlantic Bight, red hake occur most often in coastal waters in the spring and autumn, moving offshore to avoid warm summer temperatures. Additionally, red hake have been reported to be sensitive to dissolved oxygen levels and within the Hudson River Estuary they preferred dissolved concentrations of 6 mg/L or more (Steimle et al. 1999a).

Within the study area, juvenile and adult red hake have the potential to occur in the deeper waters of the Hudson River, but may be limited by occasional low DO concentrations and low salinity. The study area represents a small portion of the EFH for this species. Eggs of this species have been reported at very low densities in early spring (March-April), but were limited primarily to the lower estuary from the Battery to Yonkers at river mile 23 based on utilities-sponsored fish surveys conducted between 1998 and 2007. Several collections of red hake eggs have also been reported from the Cornwall region (river miles 56-61) upstream of the project area, but no red hake eggs have been collected in the Tappan Zee region during these surveys. Larvae of this species have not been reported to occur in the River, however, juvenile red hake have been collected from the Battery in the lower Hudson River estuary in bottom habitat deeper than 20 feet. Juveniles typically occur in this region of the River during spring (April-May) and late fall (November-December), but have not been documented from the project area during these surveys.

In 1999, the NOAA Technical Memo for the species indicated that the red hake are managed as two U.S. stocks: a northern stock, from the Gulf of Maine to northern Georges Bank and a southern stock, from southern Georges Bank into the Middle Atlantic Bight (Steimle 1999a). The southern stock index was relatively stable from the mid-1960s until the 1980s when it declined with a short period of increase about 1990-1991. The southern stock (or overall stock) is not currently considered overfished and no management action is considered required (NMFS 2011b).

Because the Tappan Zee region of the Hudson River is marginal habitat for red hake in terms of normal salinity ranges and the Hudson River is not a migratory corridor for the species, this species is not likely to occur in the project area in large numbers. Sounds from pile driving and other in-water construction activities will be temporary, and would not be expected to represent a barrier to movement of individuals within the Hudson River. Potential hydroacoustic impacts to fish using the deep water portions of the Hudson River due to pile driving with an impact hammer would only occur during the initial few months of in-water construction activities. Pile driving would not occur at night and would not be continuous during the day (i.e., when piles are being put in place or being welded, or when the pile driver is being relocated). For most of the pile driving scenarios modeled, including those in which the maximum number of simultaneous piles are being driven and/or for the largest piles, a substantial portion of the Hudson River's width would never reach the SEL_{cum} criterion established for onset of physiological injury, and portions of the river would also be below the 150 dB re 1 µPa rms guidance for behavioral effect. Fish would not be expected to remain in an area at which noise would cause discomfort. Therefore, the hydroacoustic environment resulting from pile driving with an impact hammer would result in a temporary loss of a small area of EFH for this species and would not be expected to affect movement of this species within the river. Water quality changes, including the resuspension of bottom sediments, during construction of the proposed project would be minimal and temporary, limited to the immediate area of the activity. Operation of the project would not result in adverse impacts to water quality of the Hudson River, or adversely affect aquatic habitat due to under-bridge lighting. Therefore, the project would not result in adverse impacts to the EFH for this species.

4.3.9 SCUP (*STENOTOMUS CHRYSOPS*)

Scup is a marine fish that occurs primarily on the continental shelf from Cape Cod, Massachusetts to Cape Hatteras, North Carolina. It migrates extensively from inshore summer grounds to offshore winter grounds. Scup arrive in the waters off New Jersey and New York by early May. During the summer months, older fish (four years old or older) tend to stay in the inshore waters of the bays while the younger fish are found the more saline waters of estuaries such as the New York Harbor Estuary. Spawning occurs in May through August with a peak in June and occurs principally in the estuaries of New York and New Jersey. Juveniles grow quickly and migrate with the rest of the population to offshore wintering grounds starting in late October. They usually are absent from inshore waters by the end of November (USACE 2000). The Hudson River is within an area designated as EFH for eggs, larval, juvenile, and adult scup.

Scup eggs are buoyant and are rather small (0.8 to 1.0 mm [0.03-0.04 in]), hatching in about 2-3 days depending on temperature. Most were collected from May-August at depths less than 50 m (164 ft) and at temperatures ranging from 11-23°C (52-73°F) (Steimle et al. 1999c). Newly hatched larvae are pelagic and approximately 2 mm (0.08 in) long. In approximately three days following hatching, diagnostic characteristics of the species are evident. Shortly thereafter, the larvae abandon the pelagic phase and become bottom dwelling. They occur in water with temperatures ranging from 14-22°C (57-72°F) and occupy more saline (23-33 ppt) portions of estuaries. They are often found within the water column at depths less than 50 m (164 ft) (Steimle et al. 1999c).

Juveniles from 15-30 mm (0.6-1.2 in) and up to 10 cm (4 in) are common during November. By the end of their first year they can reach up to 16 cm (6.3 in). Juveniles inhabit estuarine areas at depths of 5-12 m (16-39 ft), particularly areas with sand and mud substrates or mussel and eelgrass beds. Juveniles prefer temperatures from about 9-27°C (48-81°F) and salinities greater than 15 ppt (Steimle et al. 1999c). Scup males and females reach sexual maturity at age two and reach about 15.5 cm (6 in).

In the New York Harbor Estuary, spawning occurs primarily in the Lower New York Bay and the Eastern Long Island Bay (USACE 2000) and would be unlikely to occur within the vicinity of the study area. However, eggs and larval scup were not collected in the project area or within the Hudson River estuary during utilities-sponsored fish surveys conducted between 1998 and 2007. Juveniles were observed in low abundance, primarily in the lower reaches of the River from the Battery to Yonkers near river mile 23, but were also collected as far upstream as Indian Point above the project area. Juvenile scup were present in the vicinity of the project area in bottom habitats in waters deeper than 20 feet from late July into August. Woodhead (1990) reports that scup is a common summer transient in the New York Harbor. Although overfishing of the scup stock is occurring (NMFS 2004), the rebuilding schedule and management measures implemented in 1996 have resulted in a dramatic increase in scup abundance. The scup fishery is not currently overfished or approaching an overfished condition (NOAA 2011).

Because the Tappan Zee region of the Hudson River is marginal habitat for scup in terms of normal salinity ranges (**Table 14**) and the Hudson River is not a migratory corridor for the species, this species is not likely to occur in the study area in large numbers. Adults and juveniles would have the potential to occur from July through November with freshwater flows are lower and the salinity is higher. Sounds from pile driving and other in-water construction activities will be temporary, and would not be expected to represent a barrier to movement of individuals within the Hudson River. Potential hydroacoustic impacts to fish using the deep water portions of the Hudson River due to pile driving with an impact hammer would only occur during the initial few months of in-water construction activities. Pile driving would not occur at night and would not be continuous during the day (i.e., when piles are being put in place or being welded, or when the pile driver is being relocated). For most of the pile driving scenarios modeled, including those in which the maximum number of simultaneous piles are being driven and/or for the largest piles, a substantial portion of the Hudson River's width would never reach the SEL_{cum} criterion established for onset of physiological injury, and portions of the river would also be below the 150 dB RMS guidance for behavioral effect. Fish would not be expected to remain in an area at which noise would cause discomfort. Therefore, the hydroacoustic environment resulting from pile driving with an impact hammer would result in a temporary loss of a small area of EFH for this species and would not be expected to affect movement of this species within the river. Water quality changes, including the resuspension of bottom sediments, during construction of the proposed project would be minimal and temporary, limited to the immediate area of the activity. Operation of the project would not result in adverse impacts to water quality of the Hudson River, or adversely affect aquatic habitat due to under-bridge lighting. Therefore, the project would not result in adverse impacts to the EFH for this species.

4.3.10 SPANISH MACKEREL (*SCOMBEROMORUS MACULATUS*)

Spanish mackerel is a marine species that can occur in the Atlantic Ocean from the Gulf of Maine to the Yucatan Peninsula. The Hudson River is within an area designated as EFH for eggs, larval, juvenile, and adult Spanish mackerel. This species occurs most commonly between the Chesapeake Bay and the northern Gulf of Mexico from spring through autumn, and then over-winters in the waters of south Florida. Spanish mackerel spawn in the northern extent of their range (along the northern Gulf Coast and along the Atlantic Coast). Spawning begins in mid-June in the Chesapeake Bay and in late September off Long Island, New York. Temperature is an important factor in the timing of spawning and few spawn in temperatures below 26°C (79°F). Spanish mackerel apparently spawn at night. Studies indicate that Spanish mackerel spawn over the Inner Continental Shelf in water 12-34 m (39-112 ft) deep.

Spanish mackerel eggs are pelagic and about 1 mm in diameter. Hatching takes place after about 25 hours at a temperature of 26°C. Most larvae have been collected in coastal waters of the Gulf of Mexico and the east coast of the United States and no eggs or larvae of this species have been collected in the Hudson River during utilities-sponsored fish surveys conducted between 1998 and 2007. Juvenile Spanish mackerel can use low salinity estuaries (~12.8 to 19.7 ppt) as nurseries and also tend to stay close inshore in open beach waters (USACE 2000). Only one juvenile Spanish mackerel was collected in the Hudson River within the Tappan Zee region. This individual was observed in the deep channel habitat during late September.

Overall, temperature and salinity are indicated as the major factors governing the distribution of this species. The northern extent of their common range is near Block Island, Rhode Island, near the 20°C (68°F) isotherm and the 18-meter (59-ft) contour. During warm years, they can be found as far north as Massachusetts. They prefer water from 21 to 27°C (70-81°F) and are rarely found in waters cooler than 18°C (64°F). Adult Spanish mackerel generally avoid freshwater or low salinity (less than 32 ppt) areas such as the mouths of rivers (USACE 2000).

Because this is a marine species that prefers higher salinity waters, Spanish mackerel are not likely to be present within the study area except during periods of low freshwater flows when the salt front is pushed upriver. The habitat found within the Tappan Zee Region of the Hudson River does not represent a significant portion of the EFH for this species (**Table 14**). This species would not be expected to occur near the project site except as rare transient individuals. Therefore, the project would not result in adverse impacts to EFH for this species.

4.3.11 SUMMER FLOUNDER (*PARALICHTHYS DENTATUS*)

Summer flounder prefer the estuarine and shelf waters of the Atlantic Ocean and are found between Nova Scotia and southeastern Florida. They are most abundant from Cape Cod, Massachusetts, to Cape Hatteras, North Carolina. Summer flounder usually appear in the inshore waters of the New York Bight in April, continuing inshore in May and June, and reach their peak abundance in July and August. Spawning takes place in the New York Bight in nearshore waters outside estuarine systems in September to October. Spawning occurs in surface water temperatures of 7-14°C (45-57°F), with peak activity occurring around 10-12°C (50-54°F) (Packer et al. 1999). The Hudson River is within an area designated as EFH for larval, juvenile, and adult summer flounder.

Larvae occur in water from 0 to 22°C (32-72°F) and are transported to estuarine nurseries by currents. Juvenile summer flounder are well adapted to the temperature and salinity ranges present in estuarine habitats. They are distributed throughout the estuary prior to late summer and are more concentrated in sea grass beds (as opposed to tidal marshes) in the late summer and early autumn (USACE 2000). Planktonic larvae (2-13 mm [0.08-0.5 in]) have been found in temperatures ranging from 0-23°C (32-73°F), but are most abundant between 9°C and 17°C (48-63°F). Salinity preference within the New York area for this species was found between 20-30 ppt. In the Mid -Atlantic Bight, larvae were found at depths from 10-70 m (33-230 ft). Greater densities of young fish were found in or near inlets (Packer et al. 1999).

Young summer flounder move into shallow estuaries (i.e. 0.5-5.0 m [1.6-16 ft] in depth) using these areas as nursery habitat in the autumn, summer, and spring months. Juvenile summer flounder are able to withstand a wider range of temperatures (greater than 11°C [52°F]) and salinities from 10-30 ppt than many species, and have evolved this tolerance to exploit estuarine nursery areas. Juveniles can be found on mud and sand substrates in flats, channels, salt marsh creeks, and eelgrass beds (Packer et al. 1999).

Adult summer flounder feed both in the shelf waters and estuaries and are more active in the daylight hours; they generally feed by sight (USACE 2000). Adults are found to grow to lengths ranging from 25-71 cm (10-28 in). They inhabit sand substrates at depths up to 25 m (82 ft), at temperatures ranging from 9-26°C (48-79°F) in the autumn, 4-13°C (39-55°F) in the winter, 2-20°C (36-72°F) in the spring, and 9-27°C (48-81°F) in the summer. Salinity is known to have a minor effect on distribution as compared to substrate preference (Packer et al. 1999).

In 2002, the stock was considered overfished and was in the 8th year of a 10-year rebuilding program (NMFS 2003, MAFMC 2002). The latest stock assessment for summer flounder indicates that management measures have been successful. The resource is no longer overfished although overfishing is currently occurring (NMFS 2005). The summer flounder fishery is not overfished and is currently rebuilding (NOAA 2011).

Summer flounder eggs have not been reported from utilities-sponsored fish surveys conducted in the Hudson River from 1998 to 2007. Larval summer flounder, however, are frequently collected during the spring (March-April) in the lower estuary near the Battery (river miles 0-11). Juvenile and adult summer flounder have the potential to occur in the Hudson River within the study area during the warmer months. Juveniles, in particular are often collected in bottom habitats at depths exceeding 20 feet from the Battery to Tappan Zee during the spring (March-April) and again in October. Additionally, summer flounder were captured during the 2007-

2008 sampling program for the project during the warmer months of the year when higher salinities are present within the study area.

Sounds from pile driving and other in-water construction activities will be temporary, and would not be expected to represent a barrier to movement of individuals within the Hudson River. Potential hydroacoustic impacts to fish using the deep water portions of the Hudson River due to pile driving with an impact hammer would only occur during the initial few months of in-water construction activities. Pile driving would not occur at night and would not be continuous during the day (i.e., when piles are being put in place or being welded, or when the pile driver is being relocated). For most of the pile driving scenarios modeled, including those in which the maximum number of simultaneous piles are being driven and/or for the largest piles, a substantial portion of the Hudson River's width would never reach the SEL_{cum} criterion established for onset of physiological injury, and portions of the river would also be below the 150 dB re 1 µPa rms guidance for behavioral effect. Fish would not be expected to remain in an area at which noise would cause discomfort. Furthermore, because summer flounder do not have a swim bladder, the likelihood of physical damage is far lower than for fish species with a swim bladder. Therefore, the hydroacoustic environment resulting from pile driving with an impact hammer would result in a temporary loss of a small area of EFH for this species and would not be expected to affect movement of this species within the river. Water quality changes, including the resuspension of bottom sediments, during construction of the proposed project would be minimal and temporary, limited to the immediate area of the activity. Loss of bottom habitat due to the placement of the piles and other structures (including armoring of the dredged channel) would be minimal and would not be expected to result in significant reductions in fish habitat or prey availability. Furthermore, the loss of these habitats will be fully or nearly fully offset by the removal of the existing bridge and associated piles to below the mud line. The small incremental increase in overwater shading resulting from the proposed project would also be offset by the removal of the existing bridge. Operation of the project would not result in adverse impacts to water quality of the Hudson River, or adversely affect aquatic habitat due to under-bridge lighting. Therefore, the project would not result in adverse impacts to the EFH for this species.

4.3.12 WINTER FLOUNDER (*PSEUDOPLEURONECTES AMERICANUS*)

Winter flounder typically are found from Labrador to North Carolina, but are most common in estuaries from the Gulf of St. Lawrence to the Chesapeake Bay (Bigelow and Schroeder 1953, Heimbuch et al. 1994, USACE 2000). This fairly small, thick flatfish is abundant in the Hudson River Estuary, where it is a resident, but may move upriver into fresh water (Heimbuch et al. 1994). It spawns during the winter and early spring, typically at night in shallow, inshore estuarine waters with sandy bottoms. Woodhead (1990) reports spawning to occur mostly in the Lower New York Bay and the New York Bight. The Hudson River is within an area designated as EFH for eggs, larval, juvenile, adult, and spawning adult winter flounder.

Winter flounder have negatively buoyant eggs that clump together and sink following fertilization (Heimbuch et al. 1994, USACE 2000). Optimal egg hatching occurs at 3°C (37°F) and in salinity ranging from 15 to 25 ppt. Winter flounder larvae develop to juveniles within the estuarine systems. In March, April and May, winter flounder larvae can be found in the Upper New York Bay near the bottom (Heimbuch et al. 1994).

For the first summer, young-of-year winter flounder remain in the shallow waters (0.1-10 m [0.2-33 ft] in depth) of bays and estuaries where temperatures are generally less than 28°C

(82°F) and salinities range from 5-33 ppt. Juveniles often occupy areas with sand and/or mud substrates where they feed on a variety of worms and small crustaceans, switching to mostly mollusks as they grow. Juveniles beyond their first year have also been found to overwinter in estuaries at temperatures less than 25°C (77°F), salinities from 10-30 ppt, and depths from 1-5 m (3-16 ft) (Pereira et al. 1999). However, in some studies, wintertime juvenile catches generally increased outside of the estuary while at the same time decreasing within the estuary, suggesting that juveniles migrate out of the estuary in the winter (Pearcy 1962, Warfel and Merriman 1944, and Richards 1963 in Pereira et al. 1999).

Adult winter flounder prefer depths of 20 to 48 m (66-158 ft) and are commonly associated with mud, sand, pebble, or gravel bottoms (USACE 2000), feeding on small invertebrates and fishes. Because they are sight feeders, increased turbidity can interfere with feeding success (USACE 2000).. Adults generally leave the Hudson River Estuary in the summer as water temperatures increase, returning in the autumn (Woodhead 1990). Winter flounder will live close to shore, swimming in shallow water to feed. Adults tend to move to deeper water when water temperatures increase in the summer or decrease in the autumn and winter (Heimbuch et al. 1994). NMFS Northeast Fisheries Science Center (NEFSC) trawls within the New York Harbor Estuary found adult winter flounder at temperatures between 4°C and 12°C (39-54°F) and salinities as low as 15 ppt, although most were found at salinities greater than 22 ppt. The bulk of the adult catch occurred in water depths of 25 m (82 ft) or less in the spring (during and just after spawning) and 25 m or deeper in the autumn (prior to spawning) (Pereira et al. 1999).

All stages of this demersal fish have the potential to occur within the Hudson River in the study area. Winter flounder eggs have been reported in the lower estuary from the Battery to Yonkers near river mile 23 during spring (March and April) , but have not been collected in the Tappan Zee region based on utilities-sponsored fish monitoring data. However, larvae are distributed throughout the River and are commonly observed in most habitats between March and June with peak abundances in the project area during mid-April.

Within the Hudson River, young-of-the-year are most abundant from the mouth of the River at the Battery upriver to Indian Point (river mile 46). Juvenile winter flounder may occur from early April through December, although they are most abundant in the River between April and July, with peak densities in the Tappan Zee region during May and June, based on utilities-sponsored fish surveys conducted from 1998 to 2007. While in the estuary, juvenile winter flounder are most commonly collected in the deeper channel habitats at depths exceeding 20 feet. Catches of winter flounder in the Hudson River Estuary off Manhattan have been reported to be highest from May through June (Woodhead 1990). Older winter flounder have been found in the Harbor Estuary from late May to September (Heimbuch et al. 1994).

While winter flounder are found throughout the Hudson River Estuary, this species is currently experiencing high fishing rates that are in excess of natural production (annual exploitation rates from 55 to 70 percent). The Southern New England/Mid-Atlantic stock unit (which includes the New York population), is subject to overfishing and is considered overfished with reduced harvest currently needed for the fishery to rebuild (NOAA 2011).

Sounds from pile driving and other in-water construction activities will be temporary, and would not be expected to represent a barrier to movement of individuals within the Hudson River. Potential hydroacoustic impacts to fish using the deep water portions of the Hudson River due to pile driving with an impact hammer would only occur during the initial few months of in-water construction activities. Pile driving would not occur at night and would not be continuous during the day (i.e., when piles are being put in place or being welded, or when the pile driver is being relocated). For most of the pile driving scenarios modeled, including those in which the maximum number of simultaneous piles are being driven and/or for the largest piles, a substantial portion of the Hudson River's width would never reach the SEL_{cum} criterion established for onset of physiological injury, and portions of the river would also be below the 150 dB re 1 µPa rms guidance for behavioral effect. Furthermore, because winter flounder do not have a swim bladder, the likelihood of physical damage is far lower than for fish species with a swim bladder. Fish would not be expected to remain in an area at which noise would cause discomfort. Therefore, the hydroacoustic environment resulting from pile driving with an impact hammer would result in a temporary loss of a small area of EFH for this species and would not be expected to affect movement of this species within the river. Water quality changes, including the resuspension of bottom sediments, during construction of the proposed project would be minimal and temporary, limited to the immediate area of the activity. Loss of bottom habitat due to the placement of the piles and other structures (including armoring of the dredged channel) would be minimal and would not be expected to result in significant reductions in fish habitat or prey availability. Furthermore, the loss of these habitats will be fully or nearly fully offset by the removal of the existing bridge and associated piles to below the mud line. The small incremental increase in overwater shading resulting from the proposed project would also be offset by the removal of the existing bridge. Operation of the project would not result in adverse impacts to water quality of the Hudson River, or adversely affect aquatic habitat due to under-bridge lighting. Therefore, the project would not result in adverse impacts to the EFH for this species.

4.3.13 WINDOWPANE (*SCOPHTHALMUS AQUOSUS*)

Windowpane, also called sand flounder, is found from the Gulf of St. Lawrence to South Carolina and maximally abundant in the New York Bight. Windowpanes are generally found offshore on sandy bottoms in water between 80 m deep (262 ft) and close inshore in estuaries just below the mean low water mark. They migrate inshore into shallow shoal waters in the summer and early autumn as water temperatures increase, and migrate offshore during the winter and early spring months when temperatures decrease. Windowpanes spawn within the mid-Atlantic Bight from April to December in bottom waters, with temperatures ranging from 8.5 to 13.5°C (47-56°F). Spawning peaks occur in May and then again in the autumn in the southern portion of the Bight (USACE 2000). The Hudson River is within an area designated as EFH for eggs, larval, juvenile, adult, and spawning adult windowpane.

The eggs and larvae are found predominately in the estuaries and coastal shelf water for the spring spawning period and in the coastal shelf waters alone for those eggs spawned in the autumn. Windowpane eggs are buoyant, and can be found in the water column at temperatures of 5-20°C (41-68°F), specifically at 4-16°C (39-61°F) in spring (March through May), 10-16°C (50-61°F) in summer (June through August), and 14-20°C (57-68ºF) in autumn (September through November), and within depths less than 70 m (230 ft) (Chang et al. 1999). Larvae are free swimming, and typically are found in the areas of the estuaries where salinity ranges from 18 to 30 ppt in the spring and on the continental shelf in the autumn. Juvenile windowpanes were found year-round in both the shelf waters and inshore during a recent study of the New York Harbor Estuary (Chang et al. 1999). In this study, juvenile fish were fairly evenly distributed but seemed to prefer the deeper channels in the winter and summer. They were most abundant where bottom water temperatures ranged from 5 to 23°C (41-73°F), depths ranged from 7 to 17 m (23-56 ft), salinities ranged from 22 to 30 ppt, and dissolved oxygen concentrations ranged from 7 to 11 mg/L. Similarly, adults were fairly evenly distributed year-round, preferring deeper channels in the summer months. Adults were collected in bottom waters where temperatures ranged from 0 to 23°C (32-73°F), depths were less than 25 m (82 ft), salinity ranged from 15 to 33 ppt, and dissolved oxygen ranged from 2 to 13 mg/L (USACE 2000).

All life stages of windowpane have the potential to occur within the vicinity of the study area in the Hudson River. Eggs have been reported from the lower estuary from the Battery to Yonkers near river mile 23 during much of the year (March to October), Some windowpane eggs have been collected in the vicinity of the project area near Tappan Zee, primarily in May and June, but abundances there are lower than those observed near the mouth of the River. Larval and juvenile windowpane have been frequently collected during utilities-sponsored fish surveys in the River, where highest abundances were typically reported in the lower estuary near the Battery (river mile 0-11). Relatively high abundances were also observed in the Yonkers and Tappan Zee regions, with less abundances further upstream to West Point near river mile 55. Larval windowpanes recruit to channel and bottom habitats in the deeper portion of the River (>20 feet deep) during May and June. Juveniles are most abundant in the project area in the Tappan Zee region during June. The southern New England/Middle Atlantic windowpane stock is currently considered to be subject to overfishing but no longer overfished and the Southern New England/Mid-Atlantic stock is rebuilding (NOAA 2011). As with winter flounder, this species is widely distributed throughout the Harbor Estuary.

Sounds from pile driving and other in-water construction activities will be temporary, and would not be expected to represent a barrier to movement of individuals within the Hudson River. Potential hydroacoustic impacts to fish using the deep water portions of the Hudson River due to pile driving with an impact hammer would only occur during the initial few months of in-water construction activities. Pile driving would not occur at night and would not be continuous during the day (i.e., when piles are being put in place or being welded, or when the pile driver is being relocated). For most of the pile driving scenarios modeled, including those in which the maximum number of simultaneous piles are being driven and/or for the largest piles, a substantial portion of the Hudson River's width would never reach the SEL_{cum} criterion established for onset of physiological injury, and portions of the river would also be below the 150 dB RMS guidance for behavioral effect. Fish would not be expected to remain in an area at which noise would cause discomfort. Furthermore, because windowpane do not have a swim bladder, the likelihood of physical damage is far lower than for fish species with a swim bladder. Therefore, the hydroacoustic environment resulting from pile driving with an impact hammer would result in a temporary loss of a small area of EFH for this species and would not be expected to affect movement of this species within the river. Water quality changes, including the resuspension of bottom sediments, during construction of the proposed project would be minimal and temporary, limited to the immediate area of the activity. Loss of bottom habitat due to the placement of the piles and other structures (including armoring of the dredged channel) would be minimal and would not be expected to result in significant reductions in fish habitat or prey availability. Furthermore, the loss of these habitats will be fully or nearly fully offset by the removal of the existing bridge and associated piles to below the mud line. The small incremental increase in overwater shading resulting from the proposed project would also be offset by the removal of the existing bridge. Operation of the project would not result in adverse impacts to water quality of the Hudson River, or adversely affect aquatic habitat due to under-bridge lighting. Therefore, the project would not result in adverse impacts to the EFH for this species.

4.3.14 CLEARNOSE SKATE (*RAJA EGLANTERIA*)

Clearnose skates are a marine species that occur in the Atlantic Ocean from the Gulf of Maine to northern Florida and in the northern Gulf of Mexico. The Hudson River is within an area designated as EFH for all life stages of the clearnose skate. In the Hudson/Raritan estuary, this species occurs most commonly in the summer, but moves offshore during the cooler months.

Spawning takes place in spring and summer north of Cape Hatteras. Clearnose skates produce a pair of eggs during each of the multiple reproductive events each season and may produce up to 35 pairs of eggs in a year. Eggs are deposited and attached to submerged vegetation or structure and incubate for approximately 90 days, at which time a fully formed juvenile clearnose skate hatches from the egg case.

The center of distribution for juvenile and adult clearnose skates is in coastal waters from Delaware Bay south to Cape Hatteras, with fewer individuals collected in the Hudson/Raritan estuary and Long Island Sound. Those individuals that have been collected near the Hudson River were found near deeper channel habitats. Juveniles and adults are most common at depths ranging from 16 – 26 ft and over soft sediments at salinities > 20 ppt.

Because this is a marine species that prefers higher salinity waters, clearnose skates are not likely to be present within the study area (**Table 14**) except during periods of low freshwater flows when the salt front is pushed upriver. The habitat found within the Tappan Zee Region of the Hudson River does not represent a significant portion of the EFH for this species (**Table 14**). This species would not be expected to occur near the project site except as rare transient individuals. Therefore, the project would not result in adverse impacts to EFH for this species.

4.3.15 LITTLE SKATE (*LEUCORAJA ERINACEA*)

Little skates are a marine species that occur in the Atlantic Ocean from Nova Scotia to Cape Hatteras. The Hudson River is within an area designated as EFH for all life stages of the little skate. In the Hudson/Raritan estuary, juveniles of this species occur most commonly during winter and spring, but makes short migrations to deeper waters during the summer months. Adults were uncommon in the estuary.

Spawning takes place year-round but is most frequent during winter and summer. Little skates produce a pair of eggs during each of the multiple reproductive events each season and may produce up to 30 pairs of eggs in a year. Eggs are deposited and attached to submerged vegetation or structure and incubate for approximately 180 days, at which time a fully formed juvenile little skate hatches from the egg case.

Juveniles in the Hudson/Raritan estuary are most common at depths ranging from 20 – 26 ft and over coarse, sandy and gravel sediments at salinities between 15 and 33 ppt, with the majority found at salinities > 25 ppt. Fewer adults are found in the estuary, but those that do occur are most common at depths > 23 ft and salinities > 20 ppt.

Because this is a marine species that prefers higher salinity waters, little skates are not likely to be present within the study area (**Table 14**) except during periods of low freshwater flows when the salt front is pushed upriver. The habitat found within the Tappan Zee Region of the Hudson River does not represent a significant portion of the EFH for this species (**Table 14**). This species would not be expected to occur near the project site except as rare transient individuals. Therefore, the project would not result in adverse impacts to EFH for this species.

4.3.16 WINTER SKATE (*LEUCORAJA OCELLATA*)

Winter skates are a marine species that occur in the Atlantic Ocean from Newfoundland to Cape Hatteras. The center of their distribution is on Georges Bank and the northern portion of the Mid-Atlantic Bight. The Hudson River is within an area designated as EFH for all life stages of the winter skate. In the Hudson/Raritan estuary, this species occurs most commonly from fall through spring, but moves offshore or into deep channel habitats during the summer months.

Spawning takes place from summer to early winter. Like other skates, winter skates produce pairs of egg cases which are deposited and attached to submerged vegetation or structure and incubate until hatching, at which time a fully formed juvenile winter skate emerges from the egg case.

In the Hudson/Raritan estuary, juvenile winter skates are most common at depths ranging from 16 – 26 ft and over sandy and gravel sediments at salinities > 20 ppt. Very few adults are found in this estuary.

Because this is a marine species that prefers higher salinity waters, winter skates are not likely to be present within the study area (**Table 14**) except during periods of low freshwater flows when the salt front is pushed upriver. The habitat found within the Tappan Zee Region of the Hudson River does not represent a significant portion of the EFH for this species (**Table 14**). This species would not be expected to occur near the project site except as rare transient individuals. Therefore, the project would not result in adverse impacts to EFH for this species.

Chapter 5: Potential Impacts to Marine Turtles Within the Hudson River Bridge Construction Study Area

Four species of marine turtles, all state and federally listed, occur in coastal areas around the mouth of the Hudson River. Juvenile Kemp's ridley (*Lepidochelys kempii*) and large loggerhead (*Caretta caretta*) turtles are most common and regularly enter the New York Harbor and bays in the summer and fall. The other two species, green sea turtle (*Chelonia mydas*) and leatherback sea turtle (*Dermochelys coriacea*), are usually restricted to the high salinity areas of New York Harbor (USFWS 1997) and do not routinely move into the Hudson River as far upstream as the Tappan Zee region. These turtle species primarily inhabit Long Island Sound and Peconic and Southern Bays. They neither nest in the Hudson River Estuary, nor do they reside there year-round (Morreale and Standora 1995). It is unlikely that individuals of these four turtle species would occur in the study area (NMFS 2011b). Therefore, the project would not result in adverse impacts to marine turtles within the Hudson River bridge construction study area.

Chapter 6: Potential Impacts on Striped Bass Within the Hudson River Bridge Construction Study Area

Striped bass (*Morone saxatilis*) are anadromous, spending most of their life cycle in the marine environment but returning to fresh water to reproduce. They are native to North America and range along the Atlantic coast from the St. Lawrence River in Canada to the St. Johns River in northern Florida and from western Florida to Louisiana along the coast of the Gulf of Mexico. The Hudson River supports one of several principal spawning populations, which also include Delaware Bay, Chesapeake Bay, the Roanoke and Chowan rivers and Albemarle Sound, North Carolina, the Santee River in South Carolina and the St. Johns River in northern Florida.

Adult striped bass on the Atlantic coast feed in nearshore waters from summer through late winter. Northward migration of Hudson River fish extends as far north as the Bay of Fundy, Nova Scotia, with older fish tending to travel further north (Waldman et al. 1990). Over the winter, adult striped bass (ages 4 and older) aggregate near the mouths of their natal rivers and begin moving upstream to spawn as water temperatures increase in the spring. Spawning begins in the spring when water temperatures reach about 57°F. Peak spawning typically occurs at about 60 to 65°F in freshwater areas of estuaries where currents are moderate to swift (CHGE et al. 1999). In the Hudson River, spawning occurs primarily between mid-May and mid-June in the middle portion of the Hudson River Estuary from Indian Point (RM 42) upstream to Saugerties (RM 106) (CHGE et al. 1999; ASA 2010). Depending on their age and size, females produce up to several million pelagic eggs. Based on utilities fish surveys from 1998 to 2007, striped bass eggs are collected in May and June and primarily upstream of Indian Point at river mile 46, with peak densities near Cornwall (river mile 56-61) and very low densities in the Tappan Zee region. Yolk-sac larvae (YSL) hatch from the eggs in 25 to 109 hrs, depending on temperature. Typically 0.125-inches long at hatching, the YSL initially drift with the current. Older YSL are mobile and exhibit positive phototaxis, or movement toward light (CHGE et al. 1999).

Larval striped bass recruit to the River during summer (May-July) and are abundant throughout the Hudson River but occur in higher numbers from Tappan Zee to Hyde Park than in the lower estuary. The higher numbers of striped bass larvae in the upstream reaches of the Hudson River are a result of spawning in the Croton-Haverstraw reach and further north.

As juveniles, striped bass begin move out of the middle estuary into the broader, shallower nursery habitat of the lower estuary (Tappan Zee through Croton-Haverstraw Bays, RM 24 through RM 38) to feed on copepods and amphipods. Larger juveniles feed on insect larvae, worms, opossum shrimps, crabs and small fish (Gardinier and Hoff 1982). Juvenile abundances are typically highest during late summer (July and August) and upstream Hyde Park in deeper (>20-ft) bottom habitats. In the Tappan Zee region, juvenile striped bass are frequently collected in shallow shoal and deeper bottom habitat, as well.

By the end of their first summer, many juvenile striped bass have moved downstream to the lower estuary and into New York Harbor, western Long Island Sound and along the south shore of Long Island (CHGE et al. 1999; Dunning et al. 2009). Juvenile striped bass overwinter in the lower Hudson River estuary, where they feed primarily on benthic invertebrates, such as gammarid amphipods (Dunning et al. 2009). During their second year, striped bass become largely piscivorous (Walter et al 2003; Dunning et al. 2009) consuming American shad, alewife, blueback herring, white perch, Atlantic tomcod and bay anchovy (Walter et al 2003; Dunning et al 1997; Heimbuch 2008). Juvenile striped bass are also prey for some marine and estuarine predator species.

At Age 2 or 3, striped bass leave Atlantic coast estuaries and begin the typical seasonal coastal migration, northward during the spring and summer and southward during the fall. Dispersal of Age 2+ striped bass out of the Hudson River is density-dependent and possibly to reduce intra-specific competition for food (Dunning et al. 2006). Striped bass in the Hudson River exhibit multiple life history strategies. Some individuals are thought to mature and remain year round in the upper freshwater portion of the estuary, while others adopt an anadromous life style and, once sexually mature, spend most of their time in coastal saltwater habitats but enter freshwater and brackish habitats in the spring to spawn (Zlokovitz et al. 2003).

Adult striped bass are top predators and are prey to few other animals. Adult striped bass in the Lower Hudson-Raritan Estuary prey upon at least 20 different taxa, dominated by a variety of small-bodied and juvenile fishes and crustaceans (Steimle et al. 2000; Dunning et al. 2009). Striped bass predation can impact juvenile abundances of prey species, including alewife and blueback herring, Atlantic tomcod, white perch, and bay anchovy (Heimbuch 2008; Schultz et al. 2006). Intraspecific predation (i.e., cannibalism) may also reduce the survival of striped bass from PYSL to juveniles (Heimbuch 2008). Since striped bass rarely move more than 10 miles offshore, they are available to sport and commercial fishermen throughout their migration route, often resulting in significant sport and commercial harvest (ASMFC 2009c). The most recent stock assessment for striped bass found that the coastal stock is healthy, with spawning stock biomass well above the target level specified in the Interstate Fisheries Management Plan (ASMFC 2009c) and stocks at historically high levels (NYSDEC 2010c).

The project would not result in adverse impacts to striped bass. Adult striped bass enter the Hudson River to spawn during spring and summer but spend most of their time in coastal waters, not within the study area for the project. Spawning occurs in freshwaters far upstream of the study area and would not be adversely affected by the construction or operation of the Replacement Bridge Alternative. Because striped bass spawning occurs far upriver, the majority of the larval striped bass are also located upstream of the study area. Some larvae would also drift with the prevailing current downstream and into the study area where they are very abundant during the summer. Juvenile striped bass are found in the Tappan Zee region within the study area as well. However, the highest abundances of juvenile striped bass are upstream of the study area, in the Hyde Park region. Because striped bass larvae and juveniles are widely distributed throughout the Hudson River, losses of individuals resulting from the construction of the project would not result in adverse impacts to striped bass populations of the Hudson River.

The analysis performed in the DEIS indicated that for the Short Span Option, the number of striped bass encounters within the boundaries of a SEL_{cum} level of 187 dB re $1\mu Pa^2$-s (onset of physiological effects would range from 0.08% (lower bound) to 0.7% (upper bound) of their standing stock. For the Long Span Option the number of fish encounters within the 187 dB re $1\mu Pa^2$-s ispoleth would range from approximately 0.06 percent to 0.7 percent of the striped bass standing stock. There would be far fewer striped bass that would be exposed to sound levels that would bring on the onset of injury (197 dB re $1\mu Pa^2$-s) or mortality (207 dB re $1\mu Pa^2$-s).

Chapter 7: Summary of Effects on EFH and Designated Species Within the Hudson River Bridge Construction StudyArea

7.1 POTENTIAL DIRECT IMPACTS

Direct effects are considered to be any adverse effects arising from project activities that could result in immediate impacts on individual fish. The primary potential direct impact to EFH species from the project is the physical disturbance to adults and juveniles as a result of pile driving, increased vessel traffic, and dredging. In the winter, few, if any, of the EFH species are likely to be in the project area because the salinity of the Hudson River within the study area would be far below the preferred salinity range. However, in the warmer months of the year several EFH species do frequent the Tappan Zee Region. Sounds from pile driving and other in-water construction activities will be temporary, and would not be expected to represent a barrier to movement of individuals within the Hudson River. Potential hydroacoustic impacts to fish using the deep water portions of the Hudson River due to pile driving with an impact hammer would only occur during the initial few months of in-water construction activities, and from April 1 to August 1 would be restricted to 5 hours per day for the 8- or 10-foot diameter piles in the vicinity of the navigation channel (i.e., Zone C— waters18 feet or deeper at MLLW). Pile driving would not occur at night and would not be continuous during the day (i.e., when piles are being put in place or being welded, or when the pile driver is being relocated). For most of the pile driving scenarios modeled, including those in which the maximum number of simultaneous piles are being driven and/or for the largest piles, a substantial portion of the Hudson River's width would never reach the SEL_{cum} criterion established for onset of physiological injury, and portions of the river would also be below the 150 dB re 1 µPa rms guidance for behavioral effect. Fish would not be expected to remain in an area at which noise would cause discomfort. Therefore, the hydroacoustic environment resulting from pile driving with an impact hammer would result in a temporary loss of a small area of EFH and would not be expected to affect movement of EFH species within the river. The species identified as having EFH within the study area are common throughout the waters of the Lower Hudson Estuary and it is anticipated that only a small percentage of the fish stock in the region would be exposed to potential impact. None of the EFH species utilize the project area or the Tappan Zee Region as their sole spawning grounds and/or critical habitat. Therefore, pile driving with an impact hammer would not be expected to result in adverse impacts to EFH or the species identified as having EFH within the study area.

The potential direct effects associated with increases in vessel traffic within the dredged construction channel include potential collision with vessels and disturbance of foraging and migratory adults and juveniles associated with an increase in surface activity and noise. For the fish species for which EFH has been designated in the Hudson River, the effects of vessel strikes is likely a function of fish size and location within the water column; however, impacts to these (smaller) species from increased vessel traffic is more likely to occur in the form of propeller damage. However, the increased surface activity and associated noise would have the potential to displace/disrupt adults and juveniles during foraging and migratory activities within the vicinity of the in-water activities on a given day, which would minimize the potential for losses due to contact with vessels.

The frequency of dredging or disturbance of an area affects the invertebrate community and its ability to recover following each dredging event. For EFH species that feed on benthos dredging would result in a sizable loss of bottom habitat and temporary alteration of this habitat that could affect foraging opportunities. However, benthic communities found in environments with a great deal of variability such as estuaries generally have high rates of recovery from disturbance, because they are adapted to disturbance. Recovery of the benthic macroinvertebrate community within the dredged and armored areas is expected to start upon cessation of bottom disturbing construction activities in a particular portion of the dredged construction channel. Therefore, while the dredging would result in the loss of individual macroinvertebrates, it is not expected to result in adverse impacts of these species at the population level within the Hudson River Estuary. The majority of the bottom habitat and associated benthic macroinvertebrates within the area impacted is the soft sediment community which dominates the Upper New York Harbor and Hudson River. Deposition of sediment into the dredged channel is projected to occur at a rate of one foot per year. Recolonization by benthic organisms adapted to softer sediments could be expected to begin within a few months after completion of in-water activities in any given area. Prior to the deposition of sufficient sediment to support a soft substrate benthic invertebrate community, some recolonization of the gravel armor material would be expected occur.

7.2 POTENTIAL INDIRECT IMPACTS

Indirect effects are defined as any effects that are caused by or will result from the proposed action later in time that do not directly affect individuals but may affect them by changes in habitat. The primary potential indirect impact to EFH species at the bridge-construction site is the physical disturbance as a result of loss of habitat, changes in interpier water velocities, total suspended solids (TSS), re-deposition of sediments from dredging activities, and operational impacts on water quality. Loss of bottom habitat due to the placement of the piles and other structures (including armoring of the dredged channel) would be minimal and would not be expected to result in significant reductions in fish habitat or prey availability. Furthermore, the loss of these habitats will be fully or nearly fully offset by the removal of the existing bridge and associated piles to below the mud line. Therefore, habitat changes resulting from the project would not adversely affect EFH.

Water quality changes resulting from resuspension of bottom sediment during dredging and other sediment disturbing construction activities would be minimal and temporary, limited to the immediate area of the activity, and within the range of suspended sediment concentration reported for this portion of the Hudson River. Therefore increases in suspended sediment resulting from dredging and other sediment disturbing construction activities would not adversely affect EFH.

Upon completion of construction, the operational impacts of either option would be largely positive. The wider spacing of piers for both options would reduce benthic scour and allow for more sunlight to enter the water column; thereby, reducing the conditions currently experienced along the western cause way of the existing bridge. The Long Span Option would have wider spaced piers which would thereby further reduce interpier velocity and scour than the Short Span Option configuration. The Replacement Bridge Alternative would result in a decrease in the potential for shading impacts to aquatic resources and the overwater shading resulting from the proposed project would also be offset by the removal of the existing bridge. Operation of the project would not result in adverse impacts to water quality of the Hudson River, or adversely affect aquatic habitat due to under-bridge lighting. Therefore, the project would not result in adverse impacts to the EFH.

7.3 POTENTIAL CUMULATIVE IMPACTS

The assessment of cumulative effects addresses the potential impacts from the project and other projects proposed within, or in the vicinity of, the Hudson River bridge construction study area that may affect EFH, striped bass, and marine turtles. Within the Hudson River, the proposed Champlain Hudson Power Express Inc. cable project and the American Sugar Refining, Inc. maintenance dredging project are the projects identified for evaluation of cumulative effects with the Tappan Zee Replacement Bridge Alternative because they are reasonably foreseeable during construction and may use the same project area. At the present time, US Gypsum, located upriver within Haverstraw Bay, is not expected to dredge its Stony Point facility and is not, therefore, evaluated with respect to cumulative impacts for the Replacement Bridge Alternative.

Champlain Hudson Power Express Inc. filed an application for a Certificate of Environmental Compatibility and Public Need Pursuant to Article VII of the Public Service Law of New York State. The Applicant is proposing to construct and operate a 1,000 MW submarine, underground, high-voltage, direct current, cable transmission system which will transport power from Canada and upstate New York to load centers in the New York City metropolitan area. The proposal calls for burying cables within two separate trenches 6 feet apart along a 118-mile stretch of the Hudson River that includes the study area for the Tappan Zee Replacement Bridge Alternative. Within the study area, the cables would be buried through the use of water jetting, where possible, and by hydroplow or dredging where water jetting is not feasible (i.e., within Haverstraw Bay).

Depending upon the proposed timing of the submarine cable installation, there is a potential for conflict between the competing activities of the cable and Replacement Bridge Alternative that would need to be resolved for the portion of the cable that would be traversing the study area. Water jet embedment as a technique for underwater cable installation, is considered to have temporary and minimal impacts to aquatic resources compared to dredging. This is because the trench (four feet deep and two feet wide) created by the jetting device for each cable and its installation would only result in a temporary disturbance of the river bottom (ESS 2011). The associated increase in suspended sediments would also be expected to be short-term and localized because much of the resuspended sediments would be contained within the limits of the trench wall, with only a minor percentage of the re-suspended sediments leaving the trench. Any re-suspended sediments leaving the trench would be expected to settle out within proximity of the trench depending on sediment grain size, composition, water currents and the hydraulic jetting forces imposed on the sediment column (HDR/DTA, April 2010, *Champlain Hudson Power Express HVDC Transmission Project, Least Environmentally Damaging Practical Alternative Evaluation*, Prepared for Champlain Hudson Power Express, Inc., Toronto, Ontario, http://www.chpexpress.com/docs/regulatory/USACE/CHPE_USACE_Application_Apendices.pdf). Water jetting would potentially result in the loss of some benthic organisms unable to move from within the footprint of the trench, due to direct contact with the water jet or an inability to tolerate burial. The benthic community within the disturbed area would be expected to recover following completion of the trenching process (Ocean Surveys, Inc. 2005 in HDR/DTA 2010). Finfish would be expected to avoid areas of temporarily increased suspended sediment (HDR/DTA 2010).

American Sugar Refining, Inc. received authorization from the NYSDEC and the USACE to conduct maintenance dredging (approximately 80,000 cubic yards) within an approximately 5-acre berth area (approximately 650- to 850-feet long and extending into the river from the shoreline for about 300 feet) located about 14 miles downriver from the study area. The NYSDEC permit expires on October 31, 2016. It restricts dredging to the period of July 1 to October 31 and requires that anti-sedimentation curtains (floating boom with attached silt curtain with a minimum 3-ft depth) be deployed around the spoil-receiving barge and the mechanical dredge during dredging to minimize dispersal of dredged material. Dredge material was determined to meet the requirements for disposal at the HARS and would be transported to the HARS in bottom-opening barges.

Maintenance dredging by American Sugar Refining, should it occur concurrently with dredging for the project, would be at least 14 miles down-river. This distance is far beyond the 1,000 to 2,000 feet over which the incremental increase in suspended sediment of 10 mg/L due to the Replacement Bridge Alternative has been projected by the hydrodynamic modeling and beyond the 5 mg/L incremental increase in projected suspended sediment. Furthermore, compliance with the permit conditions would minimize the potential for the maintenance dredging to adversely affect water quality due to increased suspended sediment.

Cumulative adverse impacts to EFH, striped bass, and marine turtles would not be expected to occur as a result of the cable project and maintenance dredging activities with the Replacement Bridge Alternative. Collectively, these projects would not have the potential to affect spawning habitat within the study area for the species evaluated because the majority of the EFH spawn in the coastal and offshore waters of the Atlantic Ocean. No eggs were collected in the Tappan Zee region (RM 24-33) for 11 of the 13 EFH species. Striped bass spawn in the freshwater reaches of the Hudson River well upstream of the Tappan Zee region (RM 24-33) based on peak egg densities in the Cornwall region (RM 56-61). Eggs of Atlantic mackerel have also been reported in the Tappan Zee region, but only rarely and in very low densities, based on utilities fish surveys. The primary spawning habitat for this species is located over the continental shelf within the Mid-Atlantic Bight, with very little evidence for spawning in tidal rivers or estuaries. The primary spawning habitat for windowpane flounder is located in the nearshore coastal waters of the Mid-Atlantic Bight; however, spawning is also known to occur in the saline portions of the lower Hudson River at salinities greater than 25 ppt. Windowpane flounder eggs have been collected in low relative abundance during utilities fish surveys in the Tappan Zee region. The majority of windowpane flounder eggs are reported from the lower 23 miles between the Battery and Yonkers. On the basis of the range of preferred spawning salinities for windowpane flounder and the relatively low abundance of eggs in the Tappan Zee region, it is likely that eggs spawned downstream of the Tappan Zee study area are transported upstream on flood tides, rather than being spawned in the study area. Low densities of striped bass eggs have been reported by the utilities fish surveys from the Tappan Zee region suggesting that some spawning may occur just upstream of, or within, the study area. Based on considerably higher egg densities upstream of the project area, the low densities of striped bass eggs collected in the Tappan Zee region do not represent a significant proportion of the population's reproductive output.

The limited duration and area of disturbance resulting from cable installation within the study area would not be expected to result in changes in water quality (i.e., increases in suspended sediment) or result in long-term changes to aquatic habitat. Furthermore, the cumulative activities of these projects are not expected to adversely affect foraging or migration through the study area for EFH or striped bass. Should dredging be required for the installation of the cable in Haverstraw Bay, the distance between the study area and Haverstraw Bay is greater than 5 miles and outside the projected area of incremental increase in suspended sediment due to the project and would not result in cumulative adverse impacts to water quality within the study area. Therefore, cumulative adverse effects to water quality would not be expected to occur from these three projects.

The area of maintenance dredging for American Sugar Refining extends only 300 feet into the river from the east bank and does not extend into the navigation channel. Therefore, the three projects would not be expected to result in cumulative adverse impacts to migration of EFH or other anadromous fish species.

In summary, no cumulative adverse impacts to EFH, striped bass, and marine turtles would be expected to occur from the Replacement Bridge Alternative at the bridge-construction site near Tappan Zee in the Hudson River.

Chapter 8: EFH Assessment for Placement of Project Dredged Material at the HARS

8.1 INTRODUCTION

As discussed in Section 2.4.3.3, "Transport and Disposal of Dredged Material," the disposition of the dredged material would be left to the discretion of the contractor. However, transport by ocean scow and placement in the HARS in the New York Bight would offer a number of benefits to the project including cost, schedule, logistics and the avoidance of impacts to the surrounding residential communities on the Rockland and/or Westchester shorelines. Should this option be pursued by the contractor, the dredged materials would be transported to the HARS. This chapter:

- identifies the environmental reviews and consultations that have been undertaken for remediation of HARS, including the programmatic EFH for Placement of Category I Dredged Material at the Historic Area Remediation Site in the New York Bight Apex;
- summarizes the findings from the "*Programmatic Essential Fish Habitat Assessment for Placement of Category I Dredged Material at the Historic Area Remediation Site in the New York Bight Apex* (USACE 2002), the measures incorporated in the Site Management and Monitoring Plan for the Historic Area Remediation Site (USACE and USEPA 2009) to manage the operational aspects of dredging, HARS remediation activities and HARS monitoring;
- identifies the volume and characteristics of dredged material from the project that would be placed at the HARS as Remediation Material;
- evaluates potential adverse impacts to aquatic biota and EFH from offshore dredged material disposal at the HARS;
- provides profiles for the EFH species currently identified as having EFH in the vicinity of the HARS that were not evaluated in the programmatic EFH for HARS (i.e., clearnose skate, little skate, smooth dogfish, thresher shark and winter skate) and describes the applicability of the Programmatic EFH assessment for HARS to the project; and
- evaluates potential direct, indirect and cumulative impacts to EFH due to placement of dredged material from the project at the HARS.

8.2 AGENCY CONSULTATIONS

8.2.1 NEPA AND SECTION 7 CONSULTATION

Pursuant to the National Environmental Policy Act (NEPA) the USEPA Region 2 prepared a Supplement to the Environmental Impact for the HARS (USEPA 1997). Consultations pursuant to Section 7 of the Endangered Species Act (ESA) have taken place for the area of the HARS during preparation of the SEIS. The USEPA prepared a biological assessment that concluded that the closure of the Mud Dump Site and designation of the HARS would not be likely to adversely affect loggerhead and kemps ridley sea turtles, and humpback and fin whales (USEPA

1997). Special conditions are included in USACE Section 103 permits for placement of Remediation Material at HARS that requires the presence of NMFS approved Endangered Species Observer(s) on disposal scows during their trips to the HARS. The role of these observers is to prevent adverse impacts to endangered or threatened species transiting the area between the proposed dredge site and the HARS. With the implementation of these conditions placement of Remediation Material at the HARS would not result in adverse impacts to listed endangered or threatened species.

8.2.2 PROGRAMMATIC EFH FOR PLACEMENT OF CATEGORY I DREDGED MATERIAL AT THE HARS

Disposal of dredged material offshore such as the placement of Remediation Material at the HARS has the potential to result in the following impacts:

- burial/disturbance of benthic habitat;
- conversion of substrate/habitat and changes in sediment composition;
- increased in suspended sediment and turbidity;
- release of contaminants in the water column;
- changes in bottom topography, altered hydrological regimes and altered current patterns; and
- release of nutrients/eutrophication (NMFS 2008).

The USACE prepared a programmatic EFH for placement of Category 1 Dredged material at the HARS (SACE 2002), which was reviewed by NMFS. On the basis of the programmatic EFH and information provided by the USACE and USEPA during the site designation process the NMFS determined that the agency had no conservation recommendations to offer provided that the HARS is operated in accordance with the SMMP and that no further consultation pursuant to Section 305(b) of the Magnuson Stevens Act would be necessary. The Programmatic EFH for the HARS, attached to this EFH as Attachment 1, assessed the potential effects of the placement of Category I dredged material on the managed fish species identified as having EFH within the HARS. Table 15 presented below indicates the managed species currently identified as having EFH in the vicinity of the HARS and identifies those species and or life stages that were not evaluated in the programmatic EFH for the HARS. These species include clearnose skate, little skate, smooth dogfish, thresher shark and winter skate.

Direct impacts evaluated in the programmatic EFH included the burial of the benthic community with Remediation Material and temporary increases in suspended sediment. This loss of prey species for EFH dependent on benthic invertebrates would be minimized spatially and temporally through use of a grid system for the placement of Remediation Material. The USACE determined that direct burial of EFH species is possible yet improbably and, therefore, would have minimal impact on target species of their EFH. Although the placement of Remediation Material would have the potential to result in increased turbidity and contaminant concentrations, these effects are typically short-lived (less than one hour) and would cause no more than minimal impact on EFH. Furthermore, recolonization of a healthier benthic community would occur by those benthic invertebrate individuals able to unbury themselves and recolonization by individuals from nearby similar habitats. The placement of Remediation Material would result indirect impacts through minor changes in bathymetry that would not be expected to create noticeable changes in the physical oceanography and would not be sufficient to alter the relationship of the benthic community with the photic zone. The cumulative impacts resulting from placement of Remediation Material at the HARS would be beneficial because the "remediation of the HARS will result in an improved benthic community, and ultimately, improvement of the fishing and shellfishing resources of the New York Bight" (USACE 2002).

The programmatic EFH for the HARS states that "The remediation of the HARS with Category I sediments is the most expeditious means of eliminating the potential risk associated with contaminated sediments of the Priority Remediation Area. Decreased contaminant toxicity and bioavailability to fish and shellfish resources will greatly reduce the risk to biota of the New York Bight. The planned remediation will also prevent dispersion of degraded sediments from the seafloor as a result of resuspension due to high-energy events." Placement of Category I dredged material at the HARS was determined to result in "no more than minimal impact to Essential Fish Habitats" for the species evaluated and that "remediation efforts at the HARS should be conducted without the need for seasonal restrictions or mitigation measures to protect habitat or individual species" (USACE 2002).

8.3 POTENTIAL IMPACTS FROM THE PLACEMENT OF DREDGED MATERIAL FROM THE PROPOSED PROJECT AT THE HARS

Remediation Material has been placed at the HARS since at least 1998. Permit and contract specifications require placement at pre-determined locations within the HARS. Since development and installation of the Automated Disposal Surveillance System (ADISS) monitoring/positioning systems aboard scows and tugs, discrete placement grids have been used for organized placement at the HARS. ADISS allows placement at designated latitude-longitude coordinates. Specific grid coordinates and instructions/requirements are contained in the Department of the Army permits issued by the USACE. Placement of Remediation Material within the nine PRAs (approximately 1 square nautical mile) is managed in priority order, beginning with PRA-1 and ending with Area 9. Use of a particular PRA may be discontinued upon completion of remedial activities and demonstration that at least a 1 meter cap of Remediation Material has been placed over the entire area. Placement is occurring in several phases within each area to allow consolidation of sediments and assessment of coverage. The USACE, using the STFate numerical model, determine the distance from the HARS border where material can be placed such that water quality standards are not exceeded. Most maintenance dredging projects, which are predominantly composed of silt and clay, have been used to remediate the central and eastern portions of HARS PRAs 1, 2, and 3 and the northern portion of PRA 4. Remediation Material that is mostly sand and dredged rock has been used to remediate areas closer to the outer edges of PRAs 1 through 3 (USACE and USEPA 2009).

The grid area designated for placement is proportional to the estimated volume of material for remediation associated with each project with higher volume projects using larger area grids. Grid cells are typically 250 feet by 500 feet, with cells of 100 to 150 feet by 100 to 200 feet used for coarse material. The goal is to provide 0.5 to 3 feet of coverage within a grid during each dredging project. If an area has been used for placement of maintenance mud, usually the area is not used for additional placement for a year to allow compaction and dewatering of the mud. Grids for concurrent projects are spaced far enough apart, at least 3280 feet if one grid is due north of the other, to avoid vessel interference during placement (USACE and USEPA 2009).

As presented in Table 5 of this EFH, dredging would be conducted in three stages, each stage conducted during a separate dredging season occurring within a three-month period from August 1 to November 1. For the Long Span Option, the option with the higher dredging quantities, approximately 1.12 MCY would be dredged during Stage 1, 0.43 MCY during Stage 2, and 0.19 MCY during Stage 3, for a total of 1.74 MCY. This volume is about 5 percent of the volume of Remediation Material placed at the HARS in PRAs 1 through 4 as of December 2008.

Section 2.3.4, "Sediment Characteristics," provides a detailed discussion of the sediments within the study area that would be dredged as a result of the project. As discussed in that section, Hudson River bottom sediments in the study area comprise primarily clayey silt, similar to much of the sediment within the HARS and already evaluated by the USEPA and the USACE with respect to water quality effects during placement. Additionally, the dredged material from the project would only be placed at HARS as Remediation Material if it is determined to meet the Category I sediment criteria, and therefore, would not cause significant undesirable effects to aquatic biota, including through bioaccumulation. The dredged material would be placed at the location and in accordance with the placement protocols that would be specified in conditions issued by the USACE in the permit for the project. Therefore, increases in suspended sediment and concentrations of contaminants that may be released due to placement of the dredged material from the project within the HARS would be expected to dissipate rapidly and would not result in adverse impacts to water quality or result in adverse effects to fish and other aquatic biota due to changes in water quality. Similarly, the location for placement selected by the USACE, would be determined on the basis of the sediment characteristics developed on the basis of sediment sampling that would be conducted as part of the Section 103 permit application, and would not be expected to adversely affect water quality outside the mixing zone established for the HARS.

As evaluated in the programmatic EFH, direct impacts to fish during placement of the dredged material at the HARS would be expected to be minimal due to the small contact footprint of the fluidized sediments as they leave the barge (typically 50 foot by 100 foot), Remediation Material is placed sequentially in a predetermined grid, resulting in continuous remediation in one zone rather than random placement increasing the chance of escape by fish using the area, and noise from vessels repetitively working in one area would further increase the likelihoods that fish would leave the area receiving placement of material.

Fish species that feed on benthic or pelagic fishes or squid (e.g., bluefish, summer flounder, scup) are present at the HARS. Individuals of these species would be expected to leave the area receiving dredged material during a placement event. Because there would be sufficient similar habitat available nearby with similar benthic invertebrates, adverse impacts due to loss of prey species would not be expected to occur to these species. Fish that feed on pelagic and planktonic invertebrates and larvae (e.g., Atlantic sea herring, red hake, and Atlantic butterfish) would have minimum disruption to their feeding. It is anticipated that these species would avoid the Remediation Material and plume, and simply relocate to neighboring waters.

Because the characteristics of the sediment from the project would be similar to those in and around the HARS, benthic invertebrates would be expected to quickly recolonize the cells used for the placement of this material.

8.4 EFH SPECIES

Table 15 presents the fish species and life stages identified as having EFH within the HARS. The five species not evaluated in the programmatic EFH, clearnose skate, little skate, smooth dogfish, thresher shark and winter skate, are profiled below.

8.4.1 CLEARNOSE SKATE (*RAJA EGLANTERIA*)

The clearnose skate occurs along the Atlantic coast from the Nova Scotian Shelf to northeastern Florida and in the northern Gulf of Mexico from Texas to Florida. It is considered a southern species that is rare in the northern part of its range (Packer et al. 2003a). The New York Bight is within an area designated as EFH for juvenile and adult clearnose skates. North of Cape Hatteras, clearnose skates move inshore and northward along the continental shelf during the spring and early summer and offshore and southward during autumn and early winter. This species occurs off of New Jersey and New York from late April through May and October through November (Packer et al. 2003a).

In winter, juveniles are concentrated from the Delmarva Peninsula south to Cape Hatteras out to the 200 m contour. In spring they concentrate inshore from the Delmarva south to Cape Hatteras. In summer they occur inshore from the New Jersey coast to around Cape Hatteras with a limited presence off Cape Cod. In Hudson-Raritan Estuary bottom trawls, the largest numbers were found in the summer, particularly in and near channels and south of Coney Island. Small numbers were collected in the spring and autumn, with very few collected in the winter. The distribution of adults in Hudson-Raritan Estuary trawls was similar to that of the juveniles (Packer et al. 2003a).

This skate is found on soft bottoms along the continental shelf but also occur on rocky or gravelly bottoms. It is most abundant at depths less than 364 feet. The Hudson-Raritan trawls found juveniles most abundant at depths of 16 to 23 feet and temperatures 55 to 75°F. Adults were most abundant at depths of 16 to 26 feet and temperatures 48 to 75°F. In this survey, clearnose skates were found at salinities ranging from 22 to 32 ppt (Packer et al. 2003a).

Clearnose skates juveniles and adults would have the potential to occur at the HARS during the period that dredged material from the project would be placed at the HARS, late summer through late fall, although the larger population of this southern species is concentrated around the Delmarva Peninsula and further south. The northeastern stocks of clearnose skate are not overfished and nor is overfishing occurring (NMFS 2011). Because the placement of the Remediation Material from the project would not result in adverse impacts to water quality, sufficient bottom habitat would still be available for foraging for benthic invertebrates within the vicinity of the area receiving placement, and a small percentage of the population for this species would be expected to occur within the HARS, the placement of dredged material from the project at HARS would not result in adverse impacts to EFH for this species.

Table 15
Essential Fish Habitat Designations by Life Stage Within the Historical Area Remediation Site

Species		Life Stage			
Common name	**Scientific name**	**Eggs**	**Larvae/YOY**	**Juvenile**	**Adult**
Atlantic bluefin tuna	*Thunnus thynnus*			X	(1)
Atlantic cod	*Gadus morhua*				X
Atlantic herring	*Clupea harengus*		X	X	X
Atlantic skipjack tuna	*Katsuwonus pelamis*				X
Blue shark	*Prionace glauca*	n/a*	(1)	X (2)	X
Clearnose skate	*Raja eglanteria*		n/a*		X (2)
Dusky shark	*Carcharhinus obscurus*	n/a*	X	X	X (2)
Little skate	*Leucoraja erinacea*		n/a*	X (2)	
Monkfish	*Lophius americanus*	X	X	X	X
Ocean pout	*Macrozoarces americanus*	X	X	X	X
Red hake	*Urophycis chuss*	X	X	X	X
Sand tiger shark	*Carcharias taurus*	n/a*	X		
Sandbar shark	*Carcharhinus plumbeus*	n/a*	(1)	X	X
Shortfin mako shark	*Isurus oxyrinchus*	n/a*	X	X	X (2)
Silver hake (whiting)	*Merluccius bilinearis*	X	X	X	X
Smooth dogfish	*Mustelus canis*	n/a*	X (2)	X (2)	X (2)
Thresher shark	*Alopias vulpinus*	n/a*	X (2)	X (2)	X (2)
Tiger shark	*Galeocerdo cuvier*	n/a*	(1)	X (2)	X (2)
White shark	*Carcharodon carcharias*	n/a*	X (2)	X	X (2)
Windowpane flounder	*Scophthalmus aquosus*	X	X	X	X
Winter flounder	*Pseudopleuronectes americanus*	X	X	X	X
Winter skate	*Leucoraja ocellata*		n/a*	X (2)	
Witch flounder	*Glyptocephalus cynoglossus*	X	X		
Yellowtail flounder	*Limanda ferruginea*	X	X	X	X

Notes:
(1) Species was present in Programmatic EFH for the HARS
(2) Species was not present in Programmatic EFH for the HARS
* Life stage does not exist for this species
Sources:
NOAA's EFH Mapper (http://sharpfin.nmfs.noaa.gov/website/EFH_Mapper/map.aspx)
USACE. Undated. Programmatic Essential Fish Habitat Assessment for Placement of Category I Dredged Material at the Historic Area Remediation Site in the New York Bight Apex.

8.4.2 LITTLE SKATE (*LEUCORAJA ERINACEA*)

Little skates occur from Nova Scotia to Cape Hatteras and are one of the most dominant demersal (bottom-dwelling) species in the northwest Atlantic. The center of abundance is in the northern portion of the Mid-Atlantic Bight and on George's Bank, where it is found year-round. Little skates do not make extensive migrations but do move onshore and offshore with the seasons, generally to shallow waters in the spring and deeper waters in winter (Packer et al. 2003b). The New York Bight is within an area designated as EFH for juvenile and adult little skates.

Little skates are generally found on sandy or gravelly bottoms but can also be found on muddy bottoms. This species are generally found in the Hudson-Raritan Estuary when temperatures are less than about 61 to 64°F. Juvenile little skates are generally absent from the Hudson-Raritan Estuary and the New York Bight apex during summer months and well distributed throughout in the spring, autumn, and winter. Those that were collected in the estuary in the summer during trawl surveys were generally found in the deeper, warmer waters of channels. Juveniles were generally found at depths between 13 to 79 feet and salinities between 17 and 35 ppt (but most at ≥ 25 ppt).

Few adults were collected during the Hudson-Raritan Estuary surveys (conducted 1992-1997), and only two adults were collected during summer surveys. Temperatures where this species was collected ranged from 34 to 63°F, depths from 5 to 16 m (16 to 52 feet), and salinities from 18 to 32 ppt (but most at ≥ 25 ppt). Based on NEFSC trawls, juvenile little skates have the potential to occur in the Hudson-Raritan Estuary and in the New York Bight apex in the autumn through the spring, although the adults would be less common, and would therefore, have the potential to be present during the period when dredged material from the project would be placed at HARS. The northeastern stocks of little skate are not currently overfished nor is overfishing occurring (NMFS 2011). Because the placement of the Remediation Material from the project would not result in adverse impacts to water quality, sufficient bottom habitat would still be available for foraging for benthic invertebrates within the vicinity of the area receiving placement, and a small percentage of the population for this species would be expected to occur within the HARS, the placement of dredged material from the project at HARS would not result in adverse impacts to EFH for this species.

8.4.3 WINTER SKATE (*LEUCORAJA OCELLATA*)

The winter skate occurs from the south coast of Newfoundland and the southern Gulf of St. Lawrence to Cape Hatteras. Its center of abundance is on Georges Bank and in the northern portion of the Mid-Atlantic Bight. It is often second in abundance to the little skate (Leucoraja erinacea) and immature winter skates are often confused with immature little skates (Packer et al. 2003c). The New York Bight is within an area designated as EFH for juvenile and adult winter skates.

This skate is found most often on sandy or gravelly bottoms but can also be found on muddy bottoms. It is most abundant at depths less than 364 feet. During surveys of the Hudson-Raritan Estuary, juvenile winter skates were generally absent during the summer and well distributed in winter, spring, and autumn. This species was most abundant in winter. Those individuals present in the summer were generally found in deeper channel waters. Juveniles are found in warmer waters during the spring and autumn (most at 6 to 9°C and 5 to 17°C, respectively) than winter (mostly in 0 to 7°C), and remain mostly around depths of 16 to 26 feet during those seasons.

Salinities ranged from 15 to 34 ppt, but most were found between 23 and 32 ppt. Very few adults were collected in these surveys (conducted 1992-1997). Too few were found to determine their habitat preferences.

Juvenile and adult winter skates have the potential to occur within the vicinity of the New York Bight and the HARS. The center of distribution for winter skate stocks in the Northeast region is over Georges Bank, north of the HARS, although this species does occur in lesser abundance in the northern Mid-Atlantic Bight and within the New York Bight (Packer et al. 2003c). Seasonally, winter skate juveniles and adults are more common in the vicinity of the HARS during winter and spring and less abundant during the summer and fall months. Therefore, individuals would have the potential to occur at HARS during the late summer to late fall period when dredged material from the project would be placed at the HARS, but in low numbers. In the 2008 Report to Congress, the Southern New England and Georges Bank stocks were declared overfished (NMFS 2009). However, as of the most recent 2010 Report to Congress, the northeastern stocks of winter skate are not currently overfished, and overfishing is not occurring (NMFS 2011). Because the placement of the Remediation Material from the project would not result in adverse impacts to water quality, sufficient bottom habitat would still be available for foraging for benthic invertebrates within the vicinity of the area receiving placement, and a small percentage of the population for this species would be expected to occur within the HARS, the placement of dredged material from the project at HARS would not result in adverse impacts to EFH for this species.

8.4.4 SMOOTH DOGFISH (*MUSTELUS CANIS*)

This species is not managed in federal waters, but is included in the Atlantic States Marine Fisheries Commission's Interstate Fishery Management Plan. As of 2009, there was no assessment of smooth dogfish stocks on the Atlantic coast (ASMFC 2009).

Smooth dogfish are demersal sharks found along the Atlantic coast as far north as Massachusetts. They occupy continental shelves and inshore waters as deep as 200 meters and primarily feed on large crustaceans (particularly crabs and American lobsters). They also feed on small bony fish, gastropods, bivalves, and marine annelid worms (Compagno 1984). During winter, smooth dogfish are primarily found between southern North Carolina and the Chesapeake Bay. In spring, they migrate along the coast when bottom waters reach 43°F. When temperatures drop again, they migrate offshore to their overwintering areas (Compagno 1984). Smooth dogfish have been collected during sampling programs in the Hudson-Raritan Estuary (USACE 2004; NOAA 2000).

Smooth dogfish would have the potential to occur within the HARS during the period that dredged material from the project would be placed there as Remediation Material. However, because the placement of the Remediation Material from the project would not result in adverse impacts to water quality, sufficient bottom habitat would still be available for foraging for benthic invertebrates within the vicinity of the area receiving placement, and a small percentage of the population for this species would be expected to occur within the HARS, the placement of dredged material from the project at HARS would not result in adverse impacts to EFH for this species.

8.4.5 THRESHER SHARK (*ALOPIAS VULPINUS*)

EFH for the thresher shark has been designated in waters offshore from Long Island, New York in pelagic waters deeper than 164 feet (NMFS 2012). Thresher sharks are large, active, and strong-swimming sharks widely distributed in warm and temperate waters in the Atlantic Ocean. They are found in both coastal and oceanic waters, but usually occur within 40 to 75 miles of land over continental and insular shelves and slopes (Strasburg 1958, Holts 1988, Litvinov 1990 as cited in Smith et al. 2008). Juveniles tend to remain over the continental shelf in shallow water, while adults are most common in deeper water. Both juveniles and adults are often associated with highly productive water in regions of upwelling or intense mixing.

In the warm season (April to August), the thresher shark undertakes inshore and northerly coastal migrations. They are known to travel in schools segregated by sex and size, and catches of adults are skewed at certain times and locations in the Atlantic. Female-dominated schools move shoreward in spring, presumably towards inshore nursery areas. Near the end of spring, inshore schools are made up of predominantly neonates and pregnant females, to the exclusion of adult males (Moreno et al. 1989; Smith et al. 2008).

The HARS site is located outside the longitude given for thresher shark EFH and is shallower (approximately 46 to 138 feet) than the thresher shark EFH (USACE 2002); therefore, thresher shark EFH is not located within the HARS site and placement of dredged material from the project at HARS would not result in adverse impacts to EFH for this species.

8.5 SUMMARY OF EFFECTS ON EFH FROM PLACEMENT OF DREDGED MATERIAL FROM THE PROJECT AT THE HARS

8.5.1 POTENTIAL DIRECT IMPACTS

As described in the programmatic EFH for the HARS, direct impacts to EFH resulting from the placement of dredged material from the project at the HARS as Remediation Material would be the burial of benthic invertebrates within the cells receiving the material. While the loss of benthic invertebrates within the placement cells would be immediate, there would be sufficient foraging area available outside each approximately 250 foot by 500 foot cell such that fish species that forage on benthic invertebrates would not be adversely affected. Individual EFH would be expected to leave the area of the cells receiving dredged material from the project and would not be directly impacted due to the placement of the material due to burial or contact with the barge. Water quality impacts resulting from placement of the dredged material such as increased turbidity and contaminant concentrations would be expected to be temporary (less than an hour) and would not result in adverse impacts to EFH. Because the dredged material placed at the HARS from the project would be similar to the existing sediment at the HARS recolonization of the cell(s) receiving this material would be expected to occur rapidly.

8.5.2 POTENTIAL INDIRECT IMPACTS

Benthic invertebrates contained in the dredged material from the project would have the potential to provide additional prey for EFH species using the habitats in the vicinity of the cells receiving placement of the Remediation Material. While minor changes to bathymetry may occur as a result in the placement, it would never be more than approximately 3 feet, which would not be expected to adversely affect the suitability of the sediment for benthic invertebrates on the basis of depth or light penetration.

8.5.3 POTENTIAL CUMULATIVE IMPACTS

The primary cumulative impact from the placement of the dredged material from the project at the HARS would be the eventual remediation of the HARS which would result in an improved benthic community and improved habitat for fish and shellfish. The placement of the dredged material from the project at the HARS in three stages would minimize the area of disturbance within the cells designated for the project by the USACE during each dredging season for the project. Because changes to water quality during placement of Remediation Material would be expected to be limited temporally and spatially, placement of the dredged material with material from other projects would not be expected to result in adverse impacts to water quality or EFH. Given the large area of the HARS yet to be remediated in RPAs 5 through 9, and much of PRA 1 and 2 has been remediated, placement of the dredged material from the project concurrent with placement of material from other projects, sufficient EFH would still be available within the HARS that placement of the dredged material concurrent with placement of Remediation Material from other projects would not be expected to result in adverse impacts to EFH.

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FIGURES

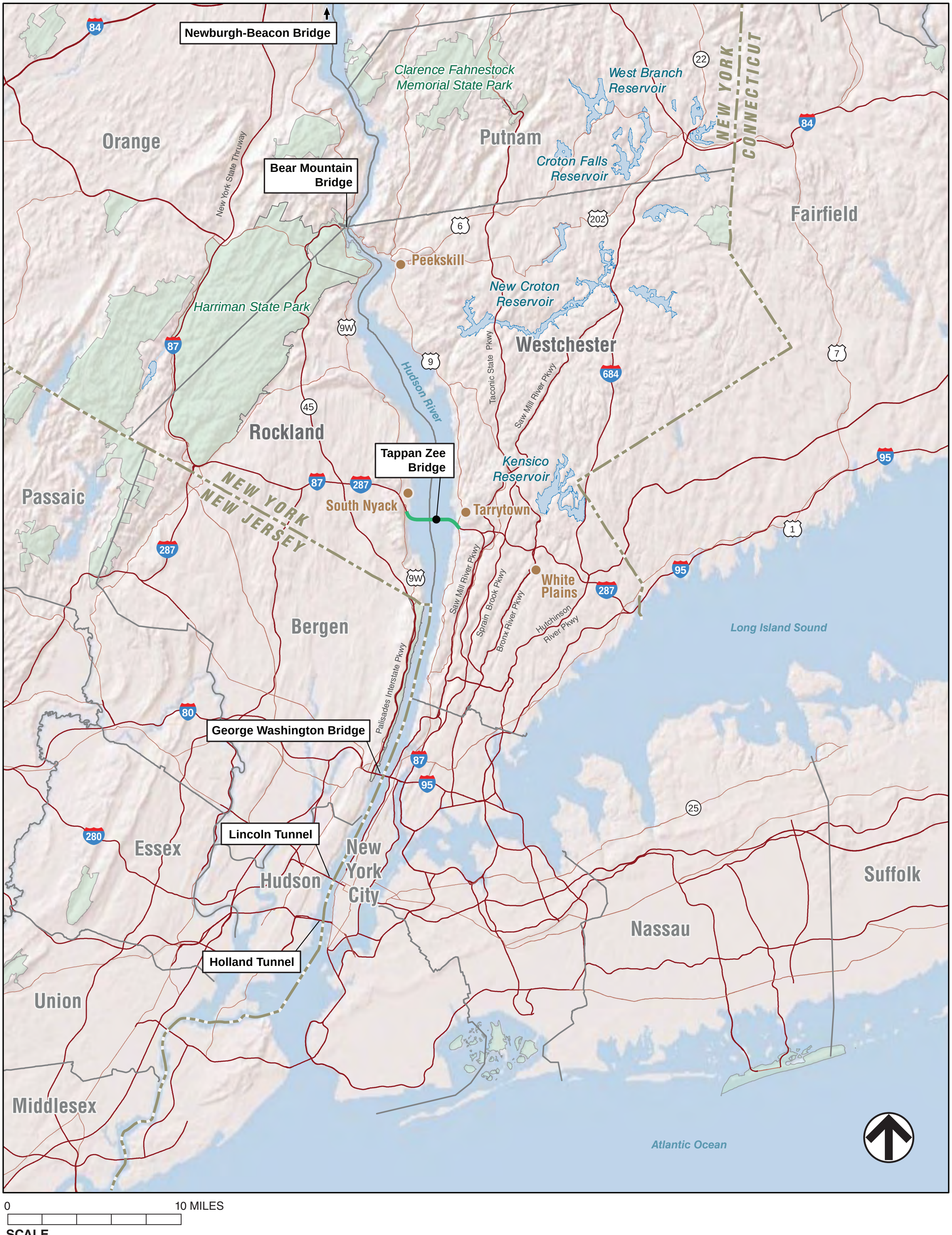
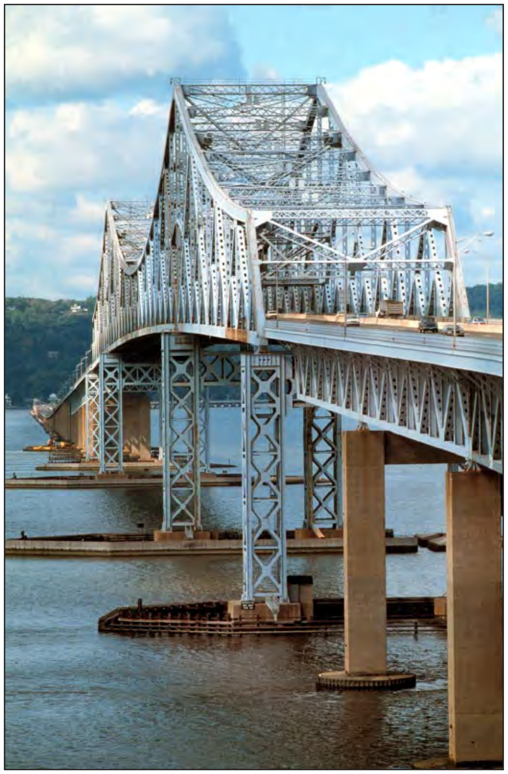
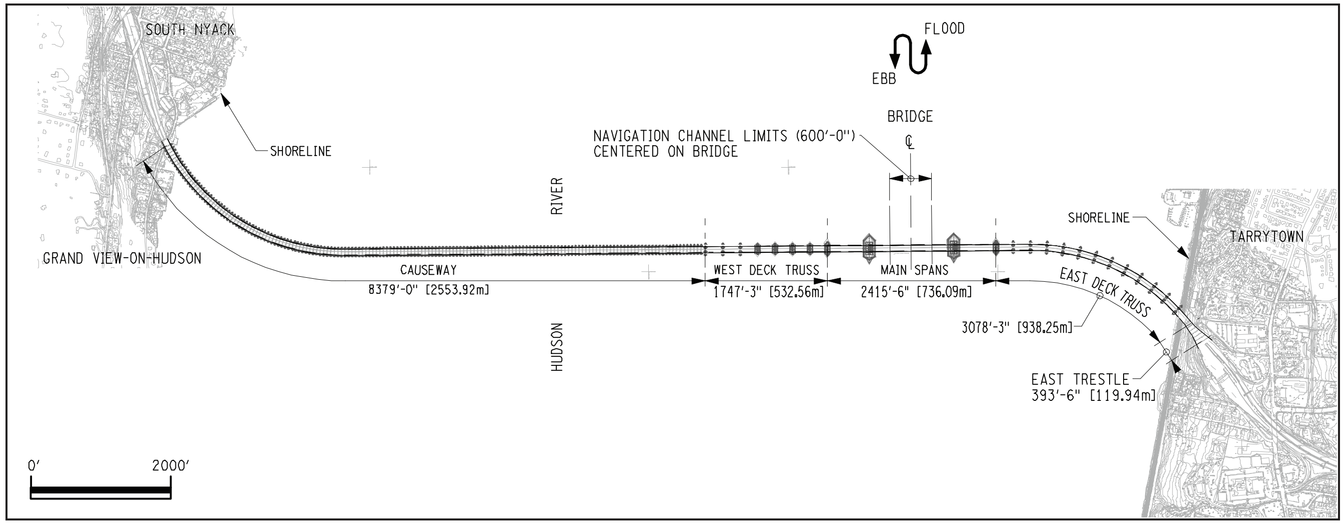
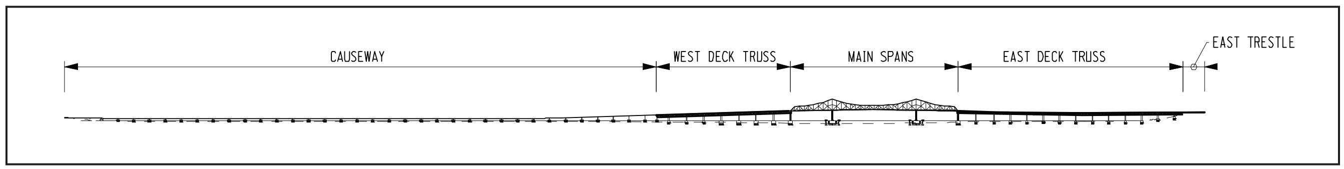


Figure 1
Project Location and Regional Roadway Network

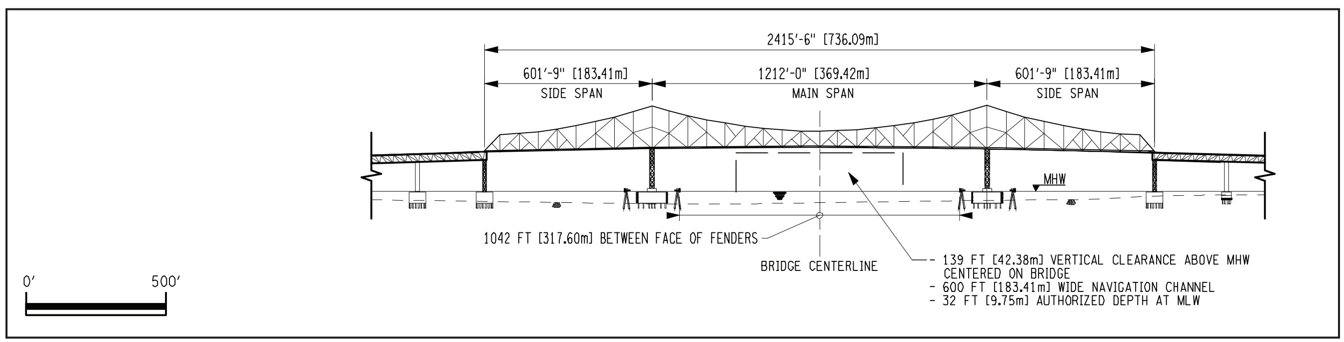




PLAN



PROFILE



MAIN SPANS

Figure 2
Existing Bridge Plan, Profile, and Photographs

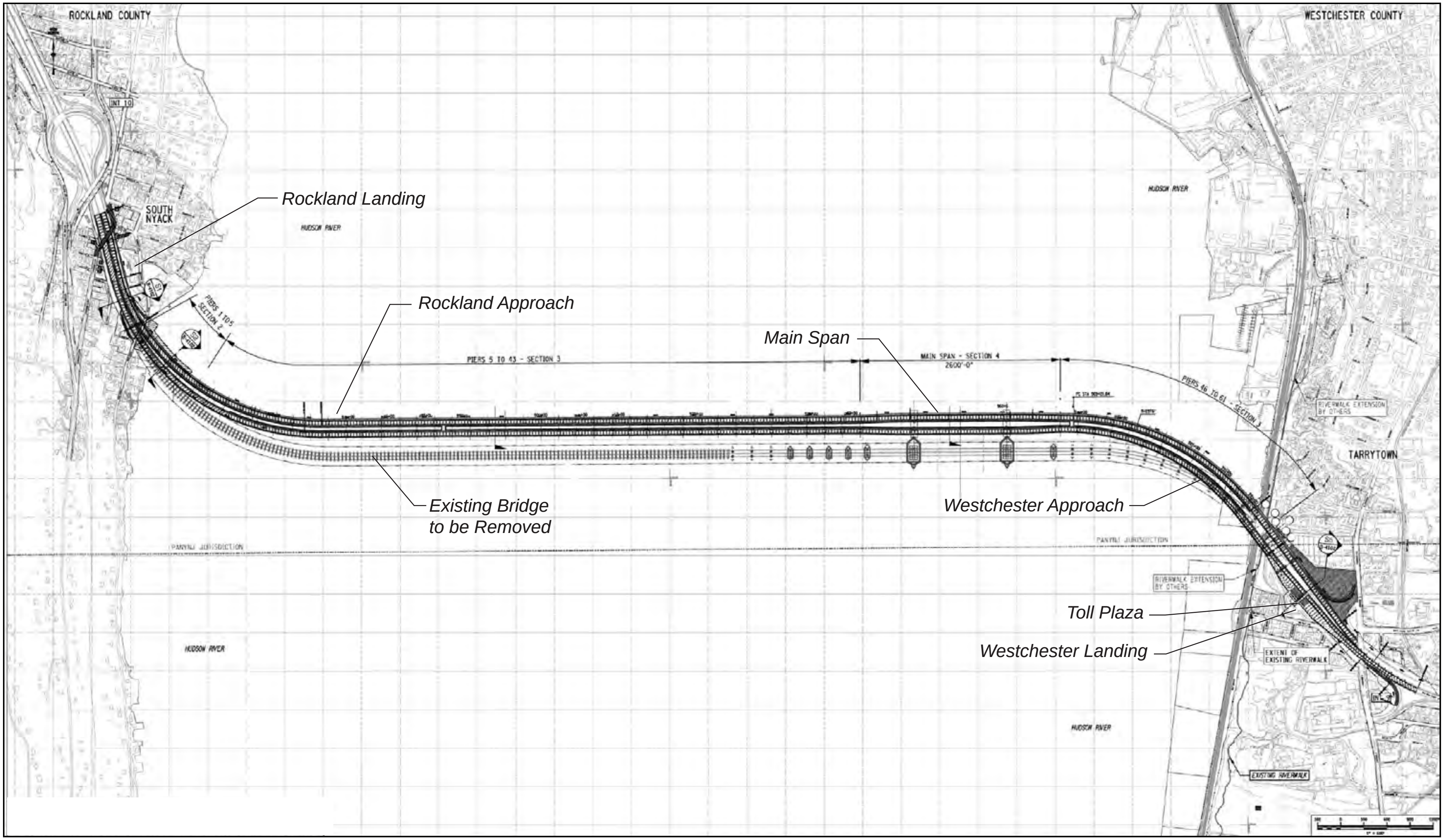
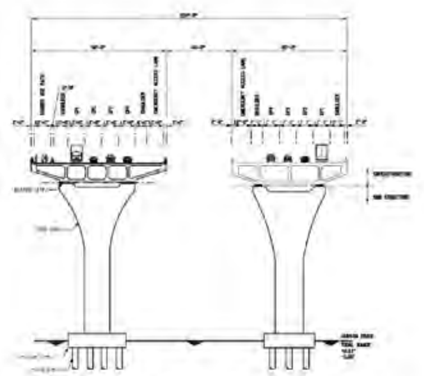


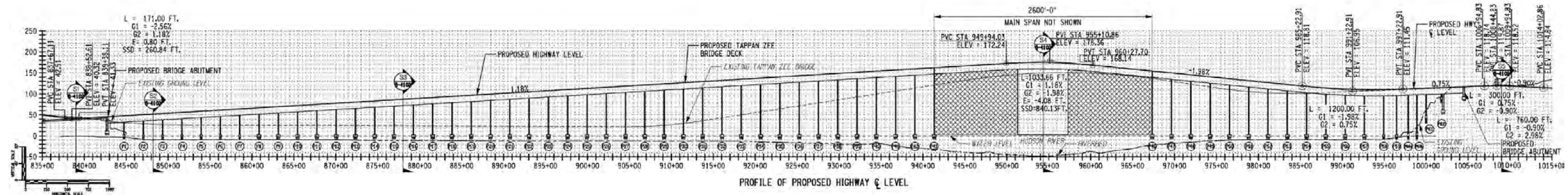
Figure 3
Replacement Bridge Alternative

1.4.12

Short Span Option

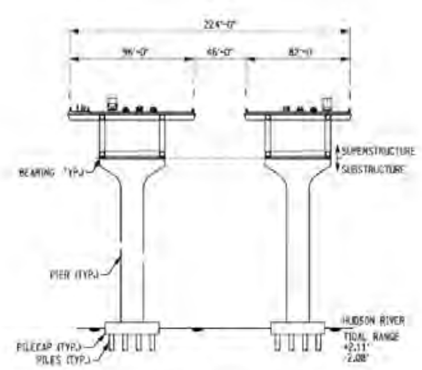


Short Span Cross-Section

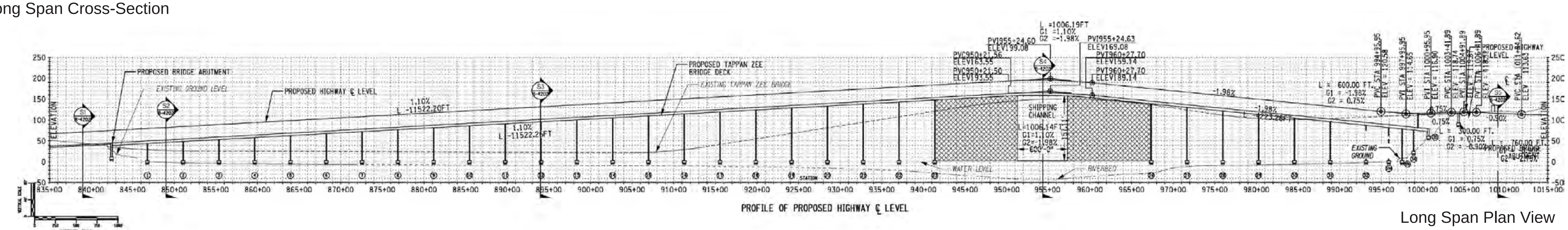


Short Span Plan View

Long Span Option



Long Span Cross-Section



Long Span Plan View

Figure 4
Approach Spans Options

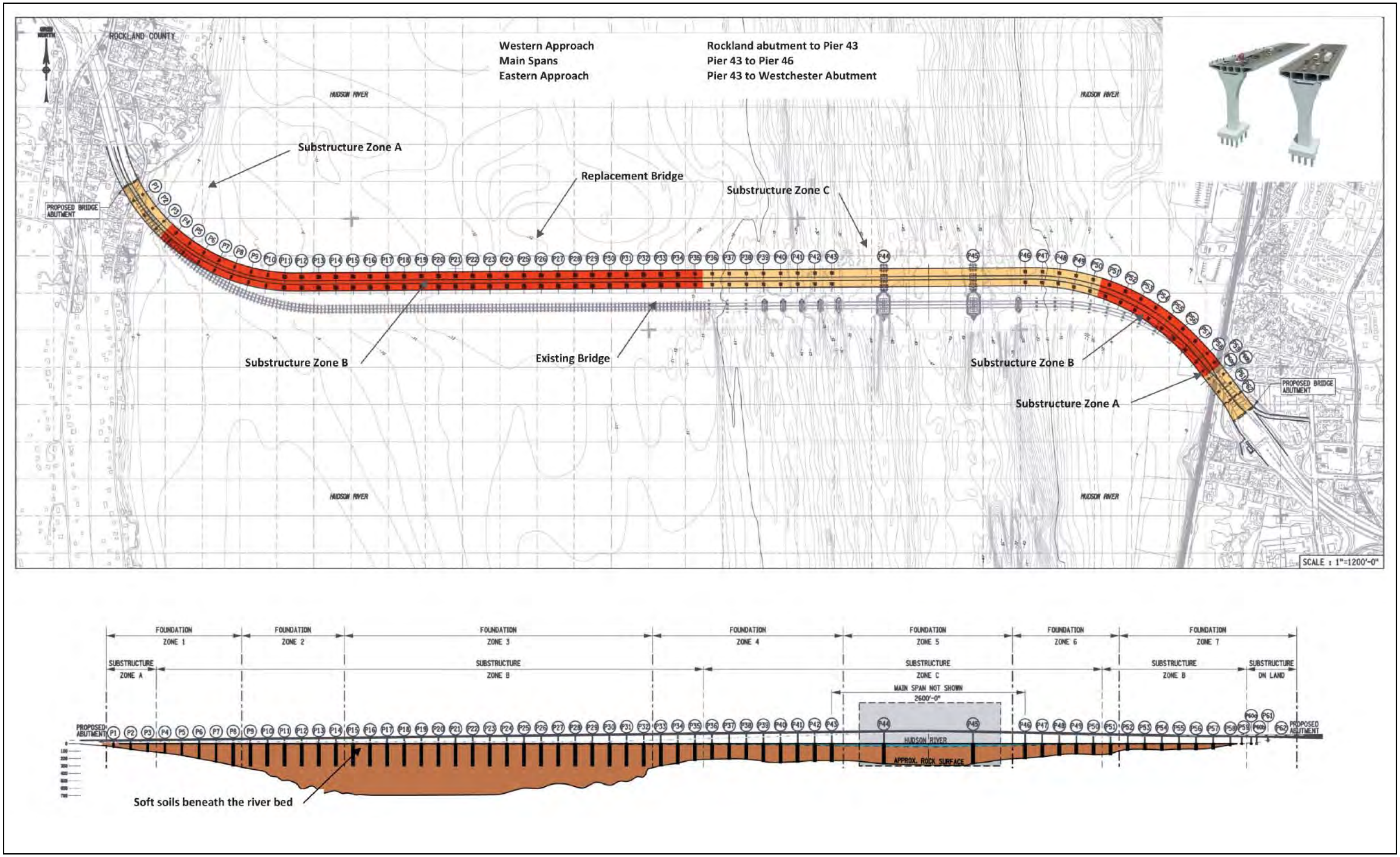


Figure 5
Construction Zones for Short Span Bridge Option

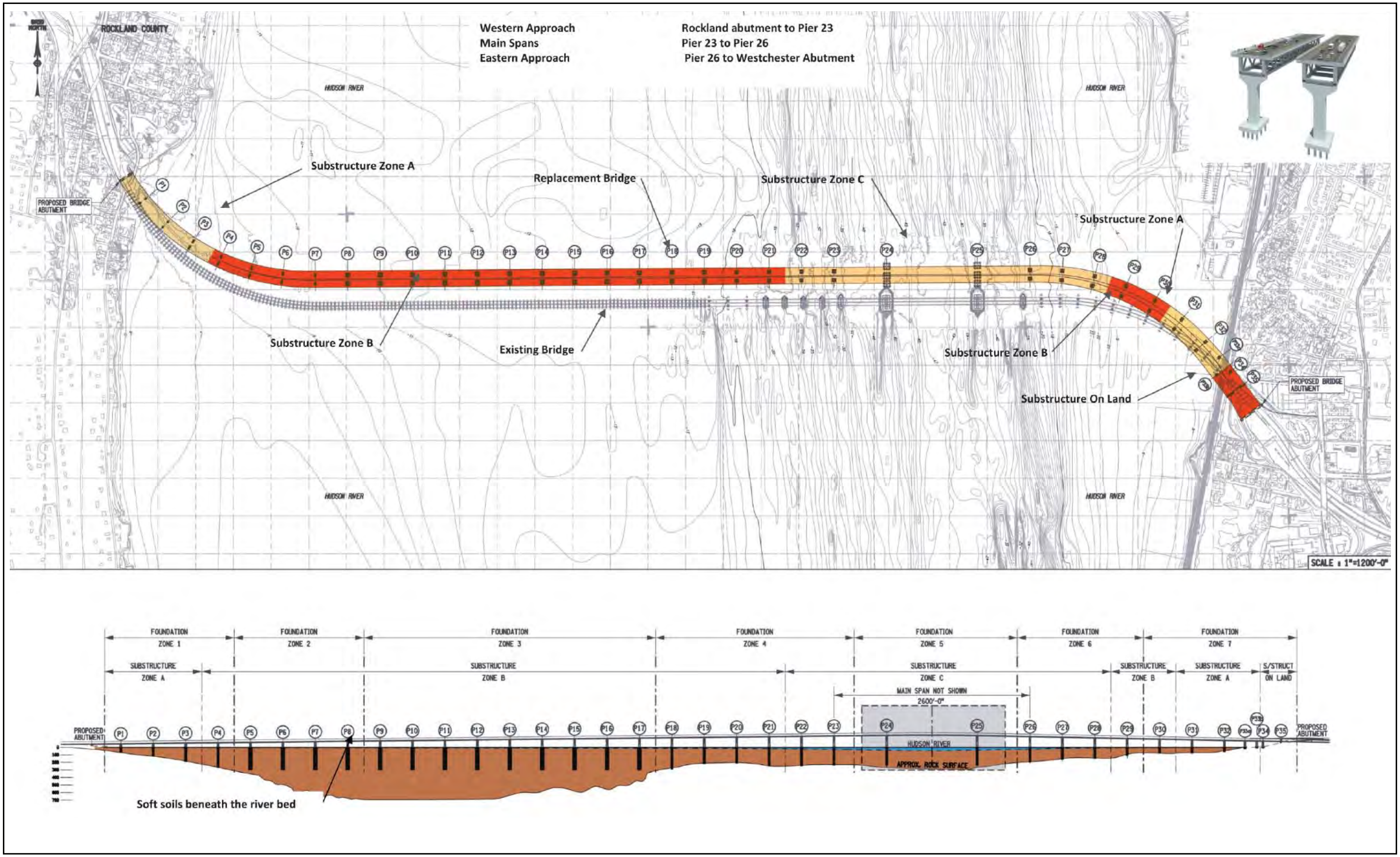
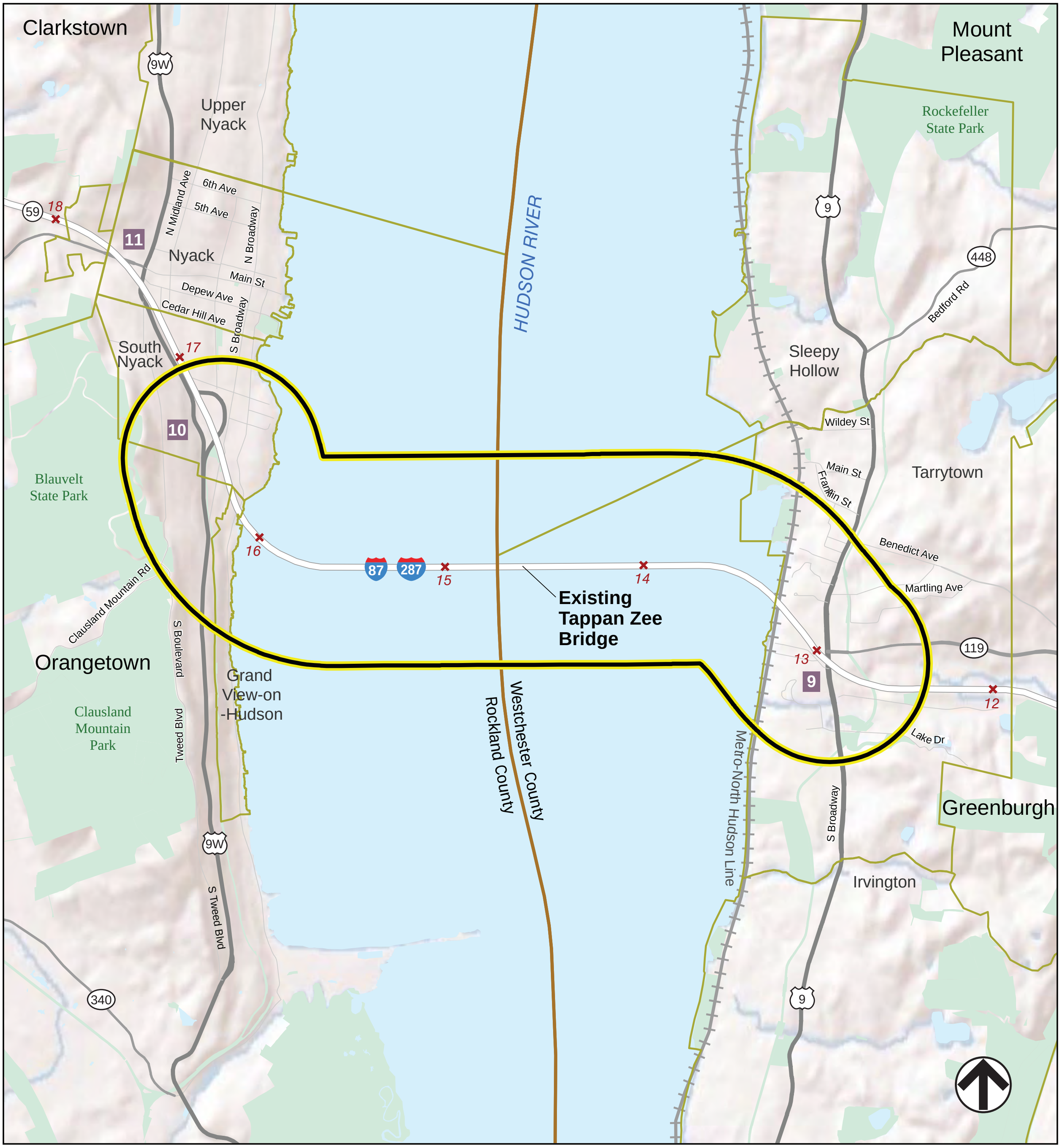


Figure 6
Construction Zones for Long Span Option

1.4.12

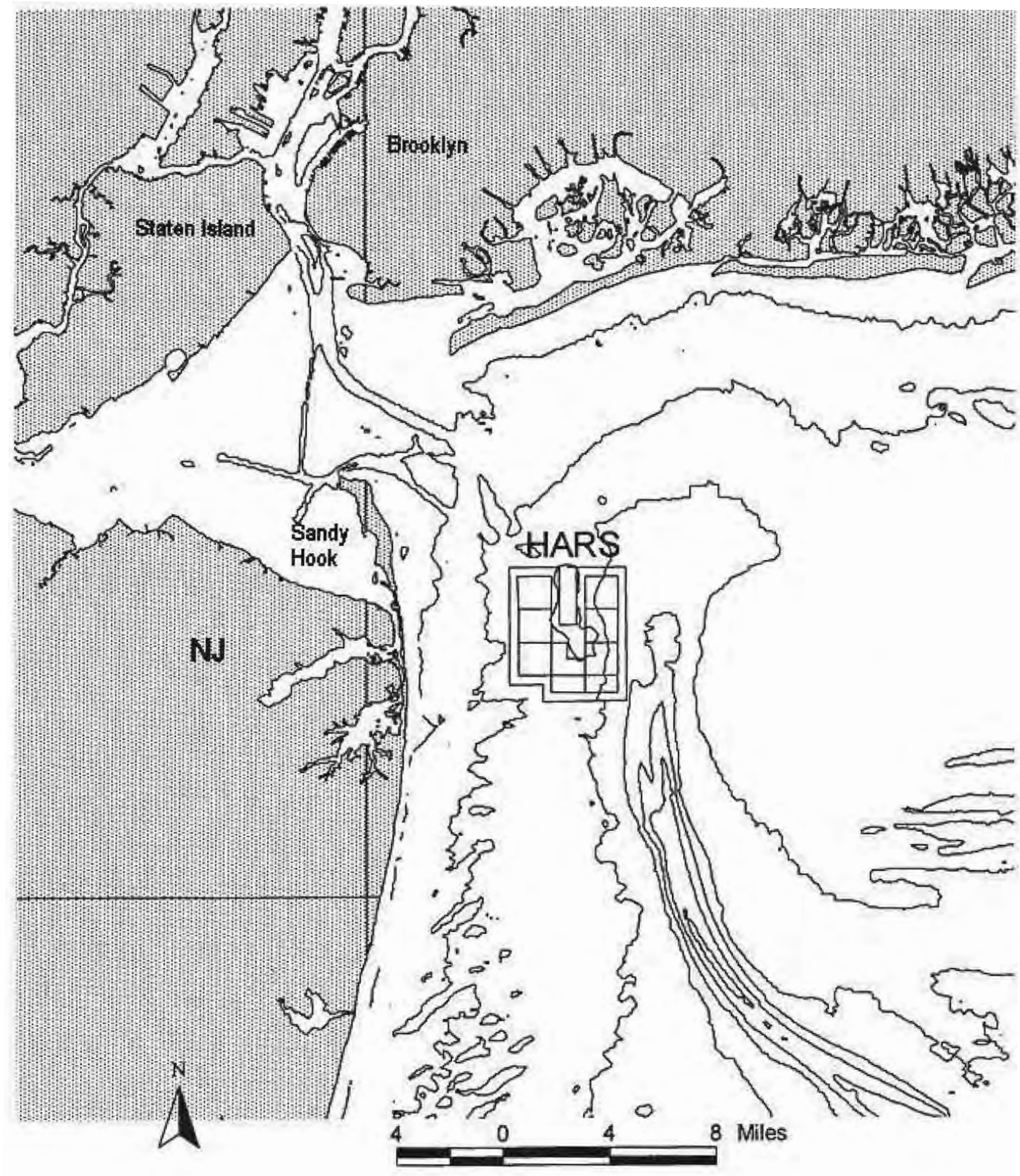


Study Area	Interstate Highway
15 Mile Post	U.S. Highway
Municipal Boundary	State Highway
County Boundary	Other Major Road
Railroad	
14 Interchange Number	

0 1/2 1 MILE
SCALE

TAPPAN ZEE HUDSON RIVER CROSSING
Essential Fish Habitat

Figure 7
Hudson River Bridge Construction Study Area



SOURCE: USACE and USEPA 2009

Figure 8
Location of HARS

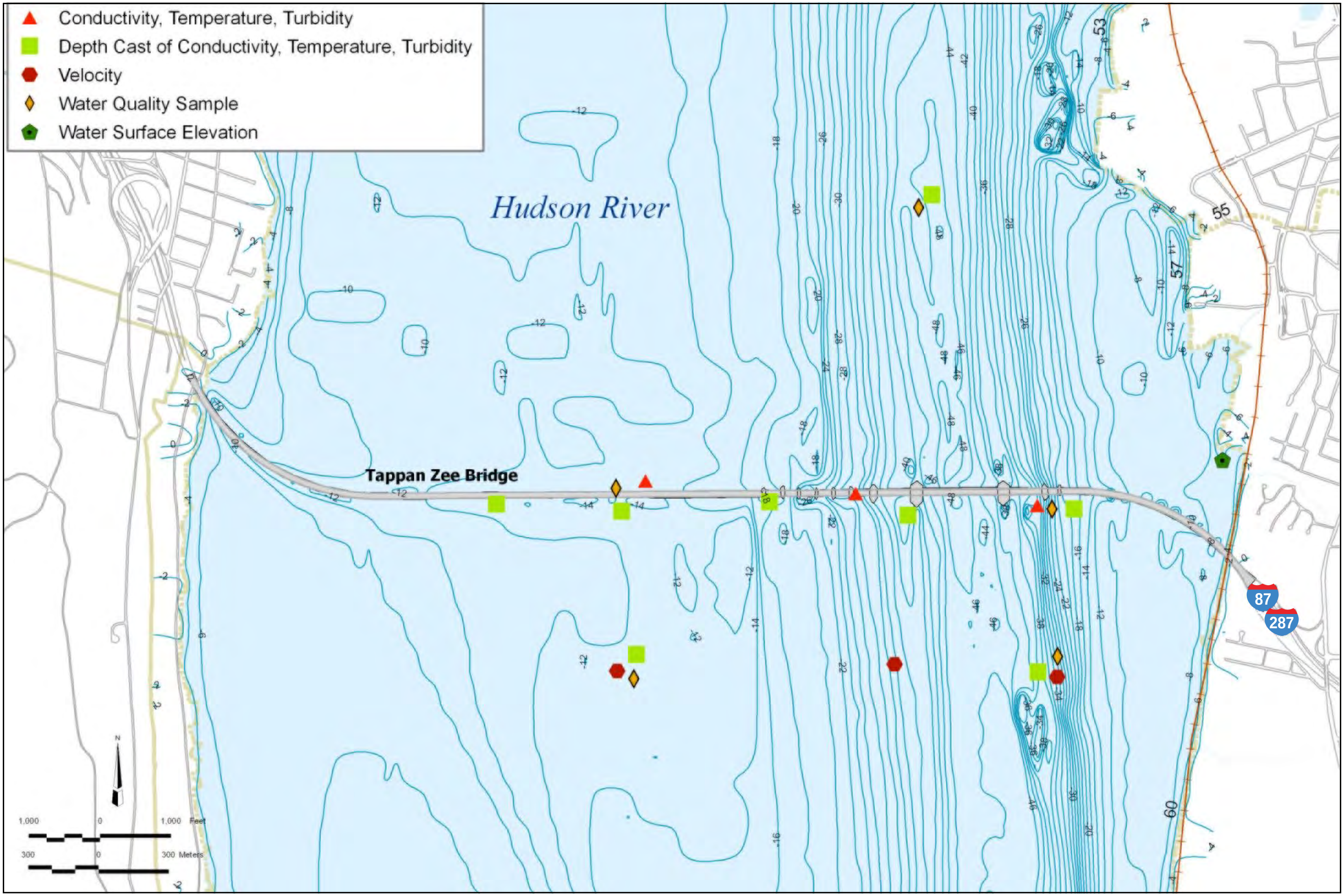


Figure 9
Bathymetry

Figure 10
Average Salinity Concentration at Hastings-on-Hudson

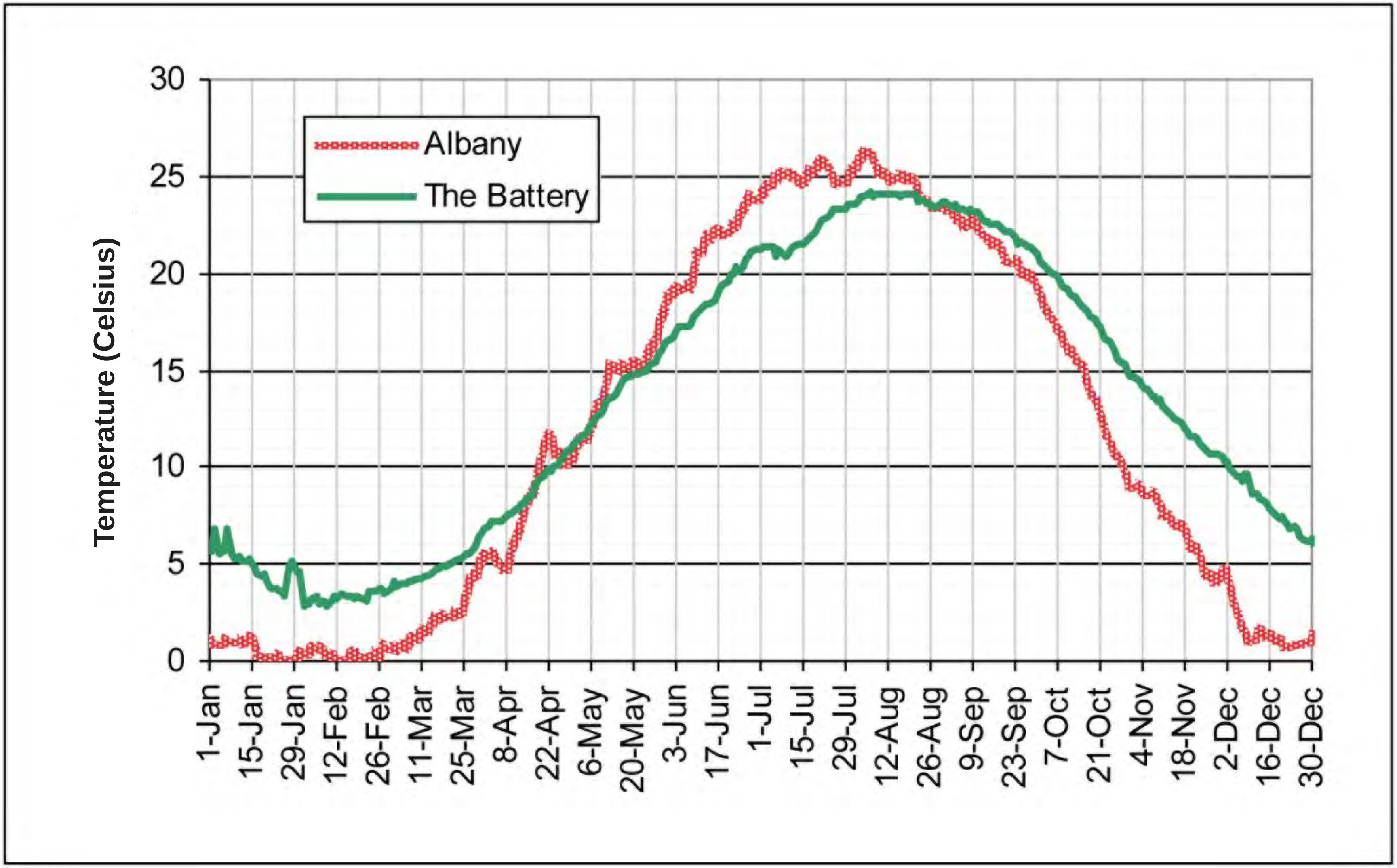


Figure 11
Average Water Temperature at Albany and the Battery

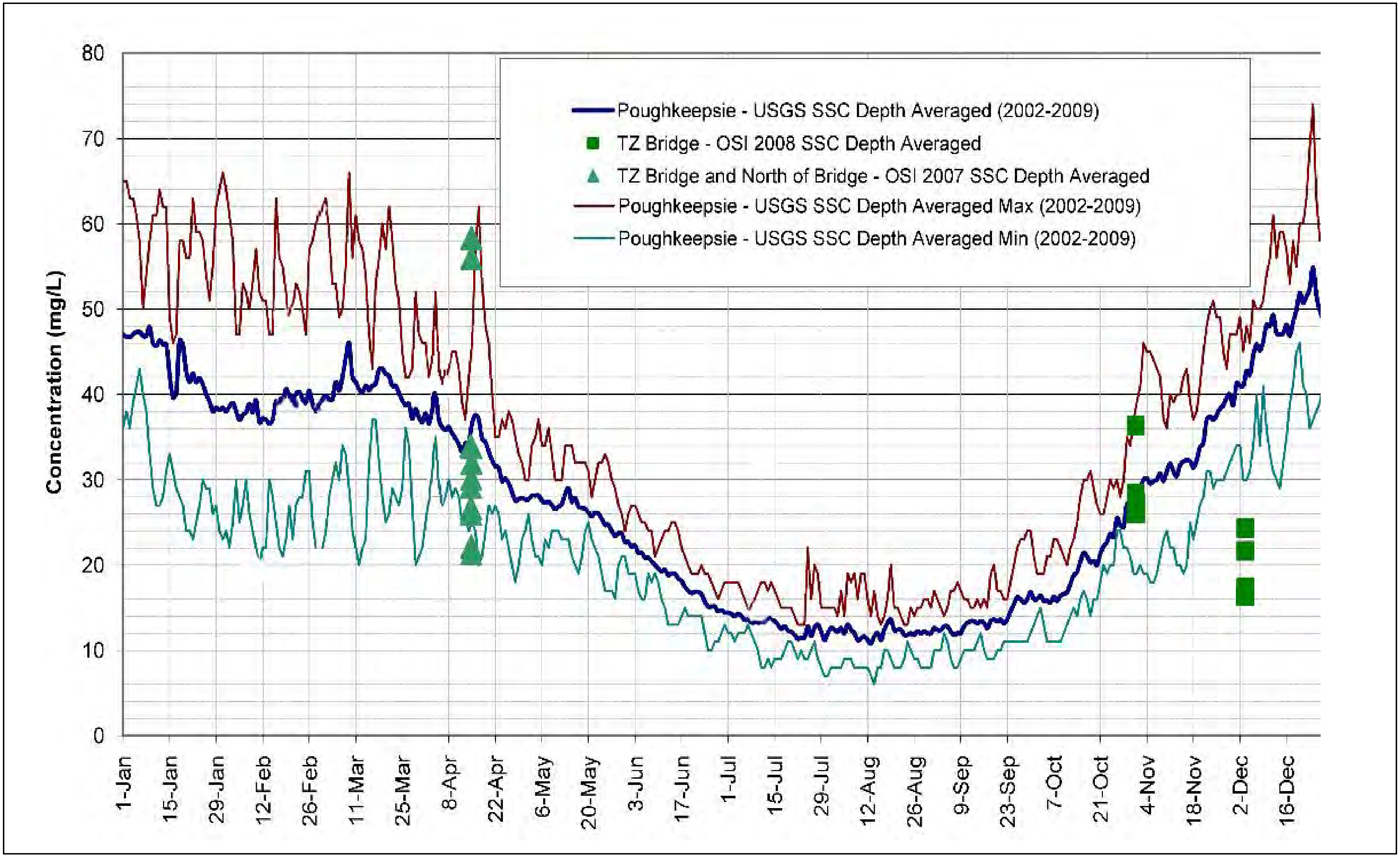


Figure 12
SSC Data

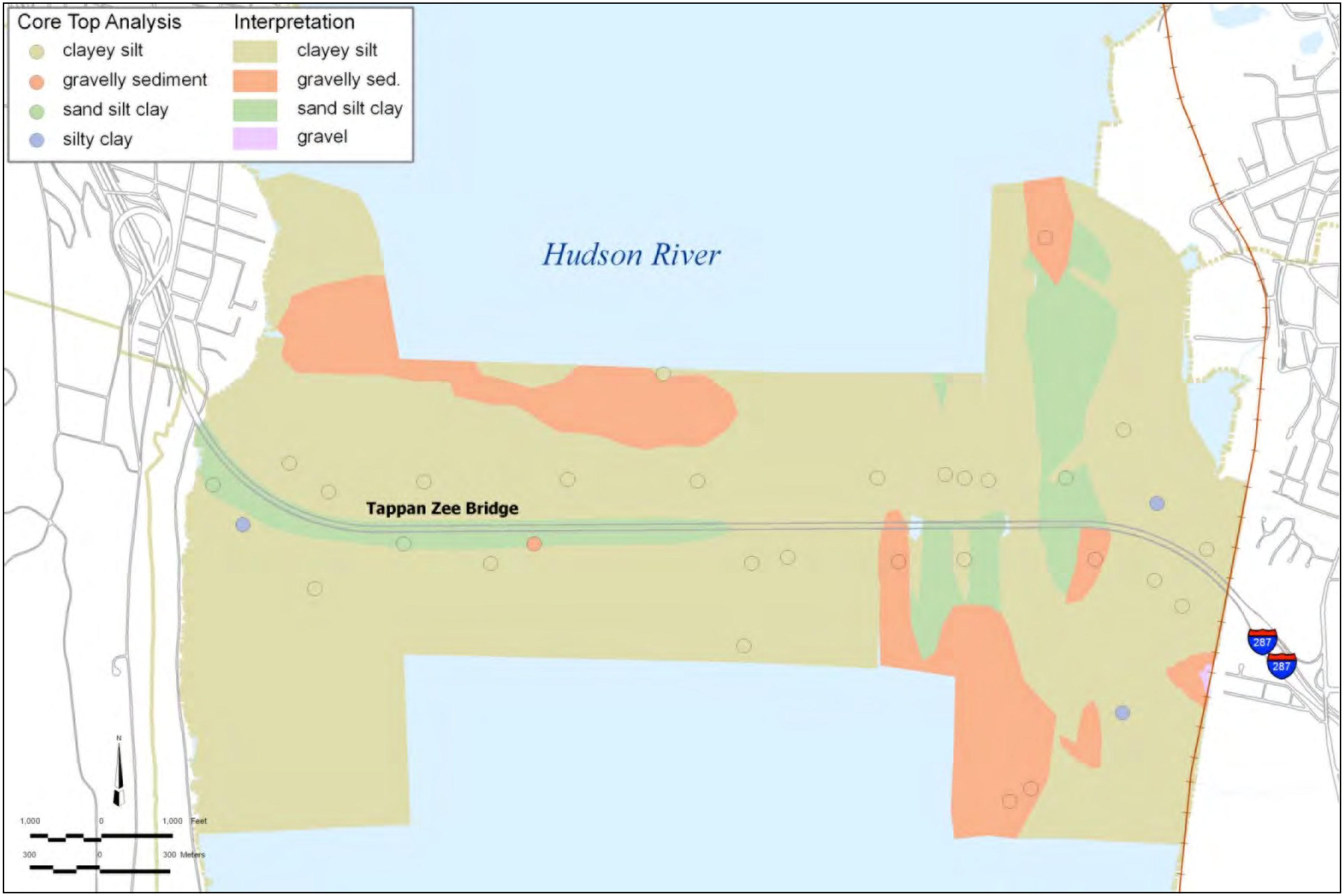


Figure 13
Sediment Texture

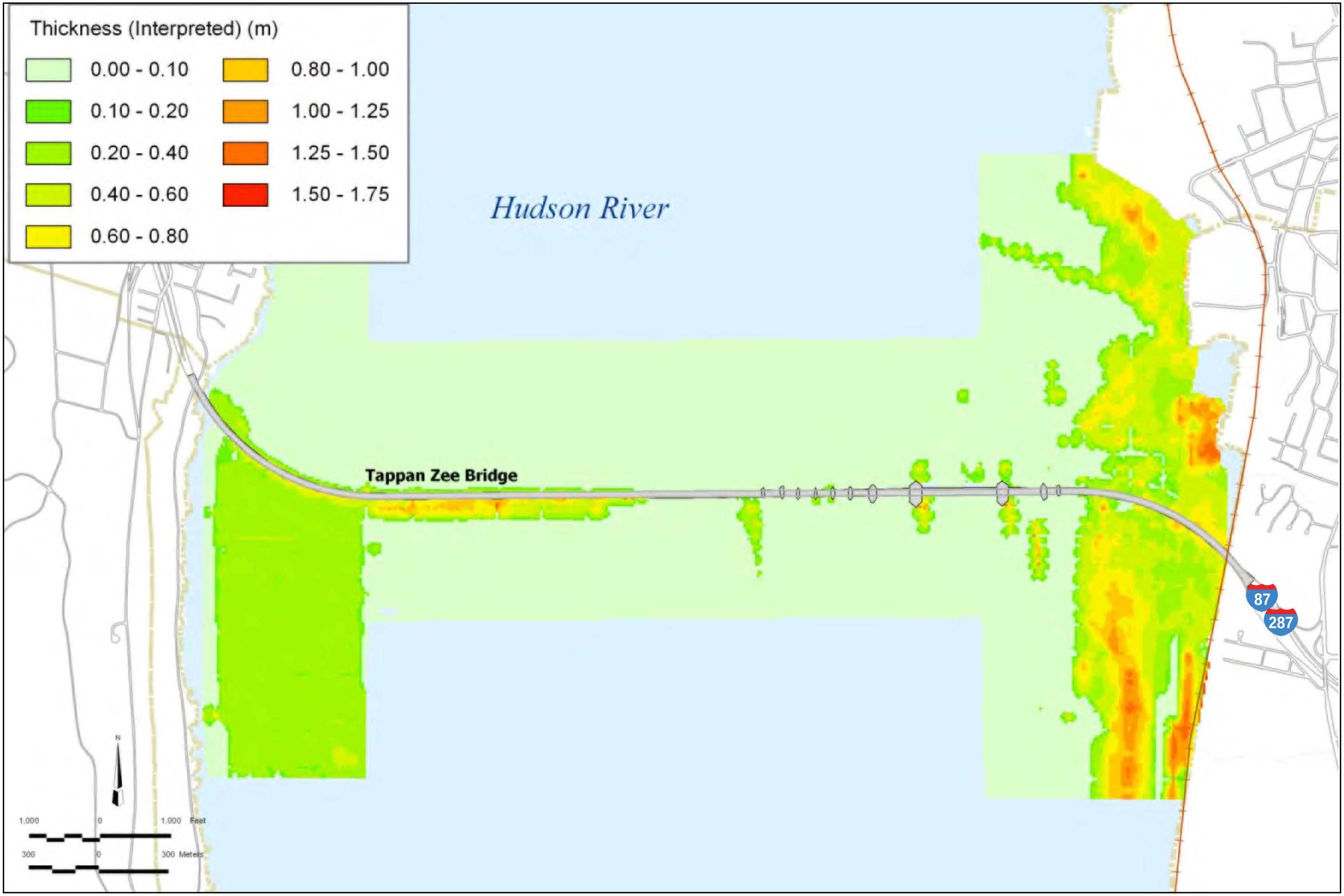


Figure 14
Recent Sediment Deposit Thickness

1.4.12

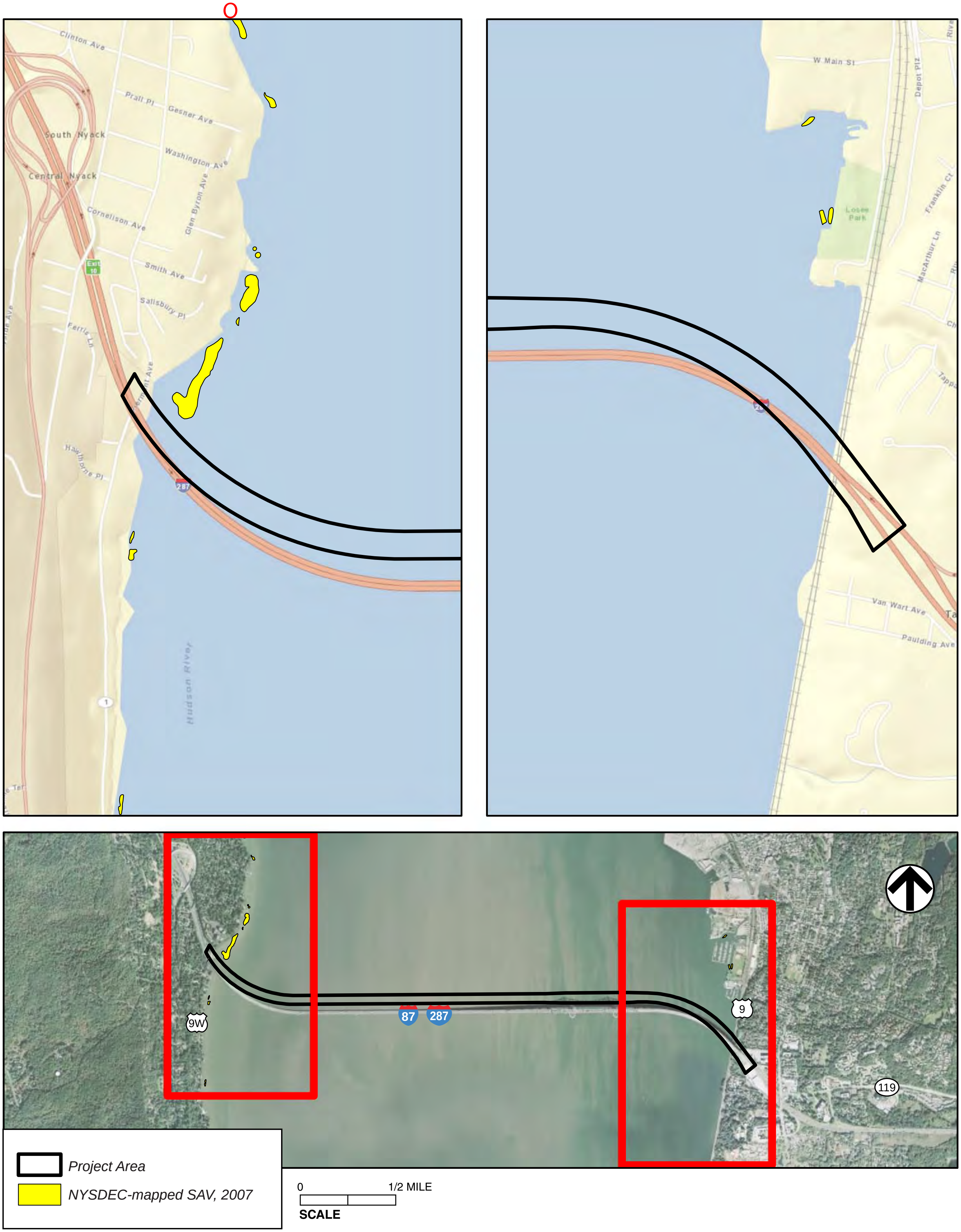


Figure 15
Submerged Aquatic Vegetation (SAV)

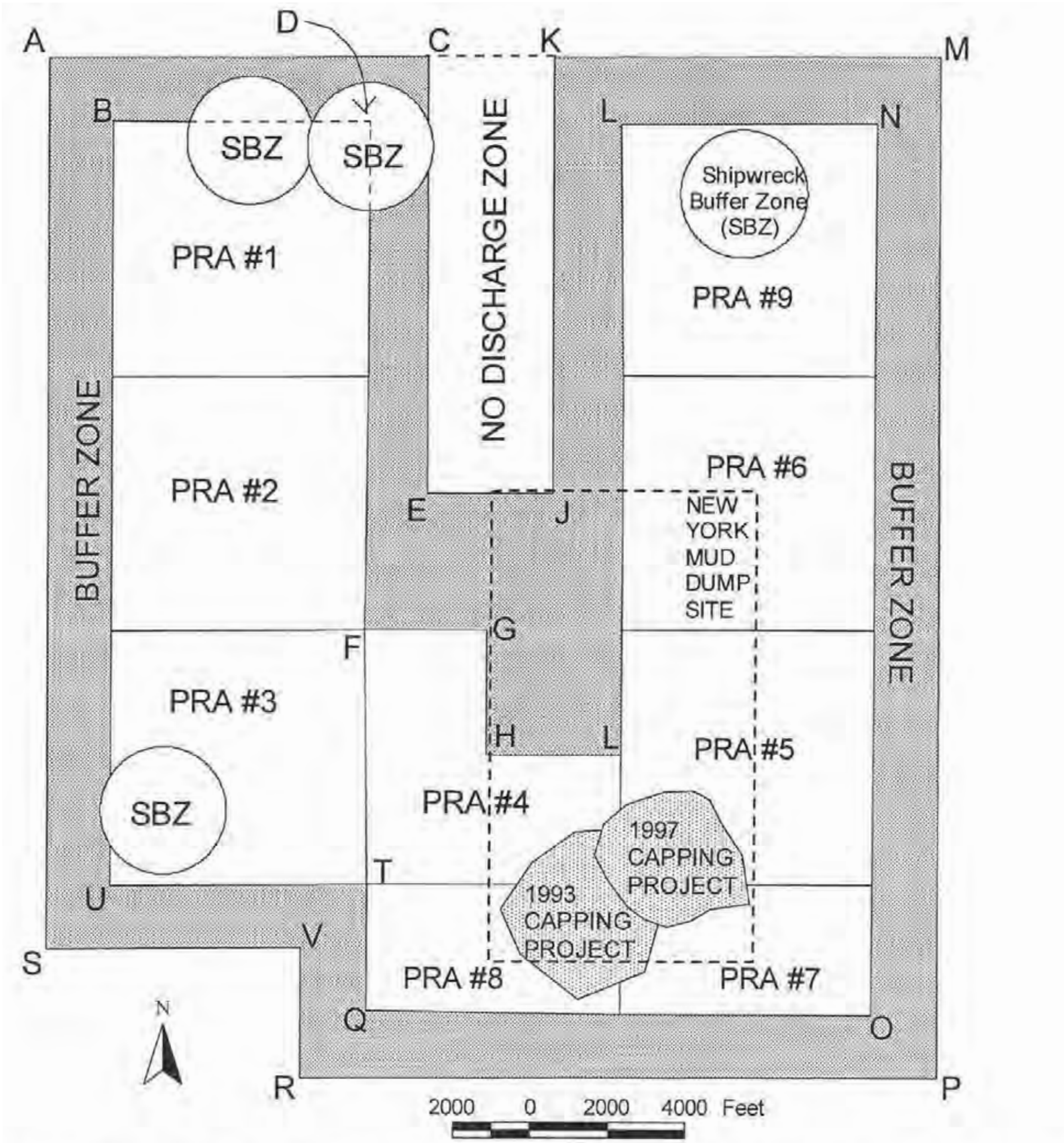
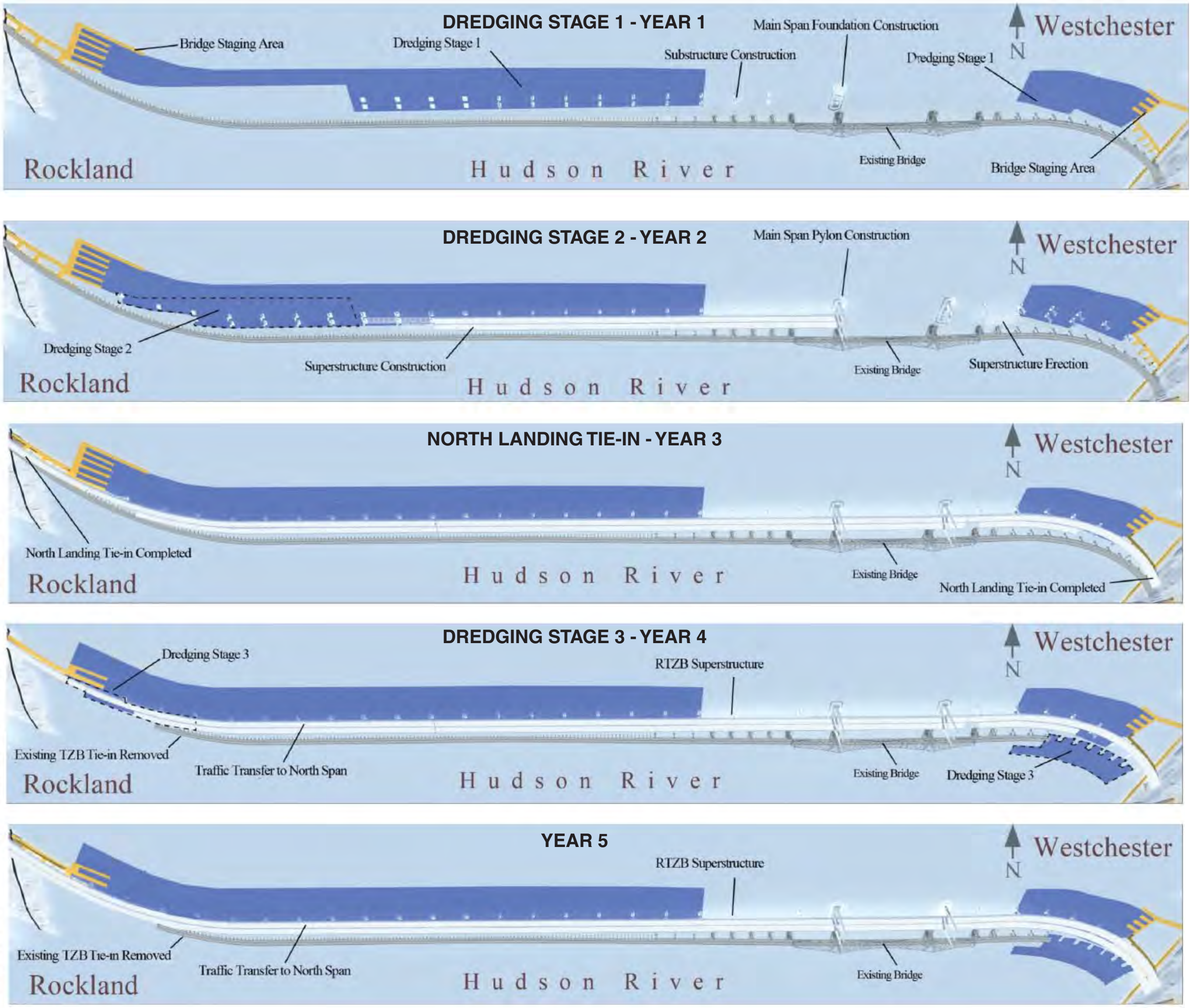


Figure 16
Priority Remediation Areas, Buffer Zone and No Discharge Zone



Note: Long Span Option is depicted, Short Span Option will be similar

Figure 17
Dredging Sequence, Years 1 to 5

1.4.12

Figure 18
Potential Upland Staging Areas

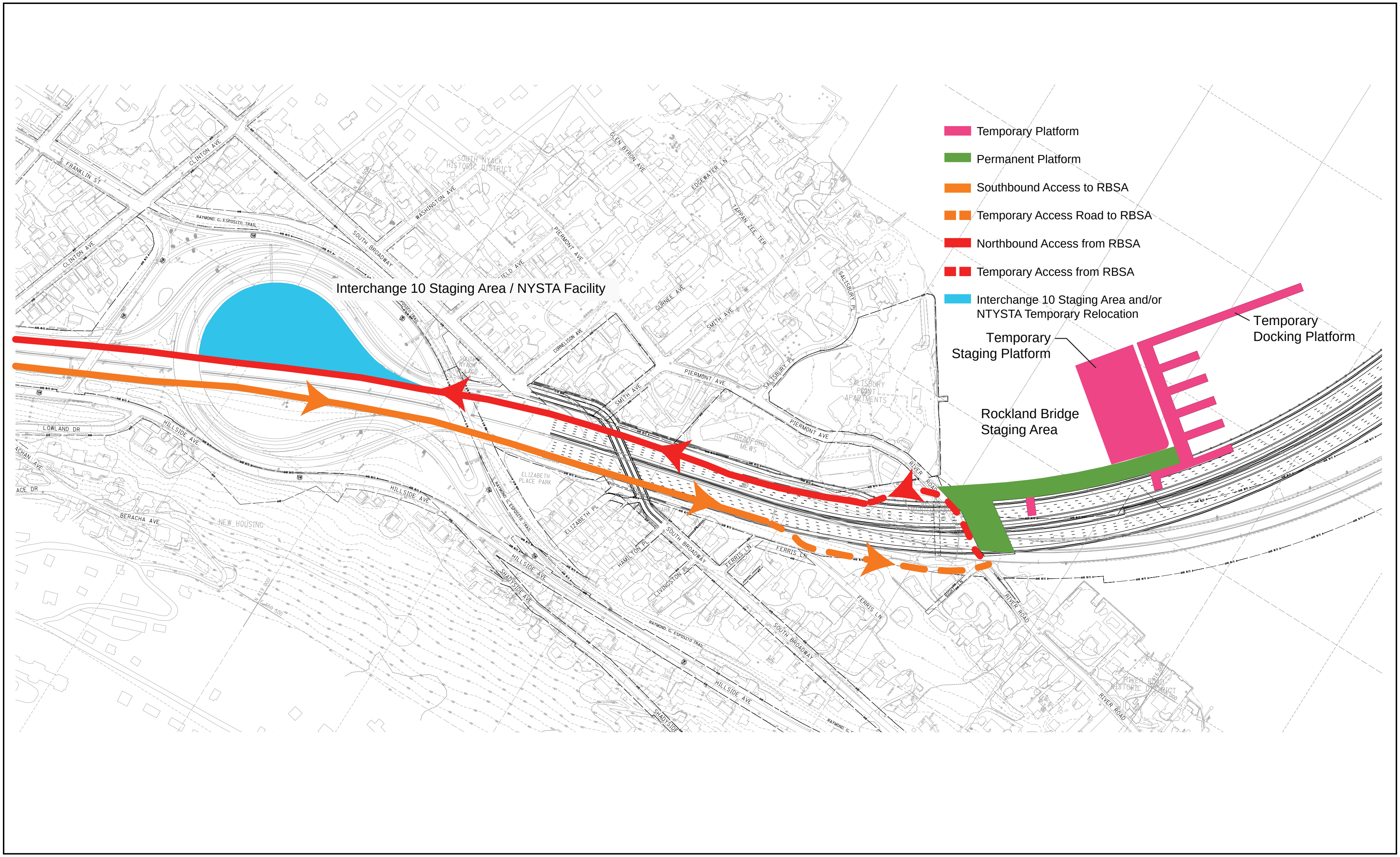


Figure 19
Rockland Landing Construction Access

1.5.12

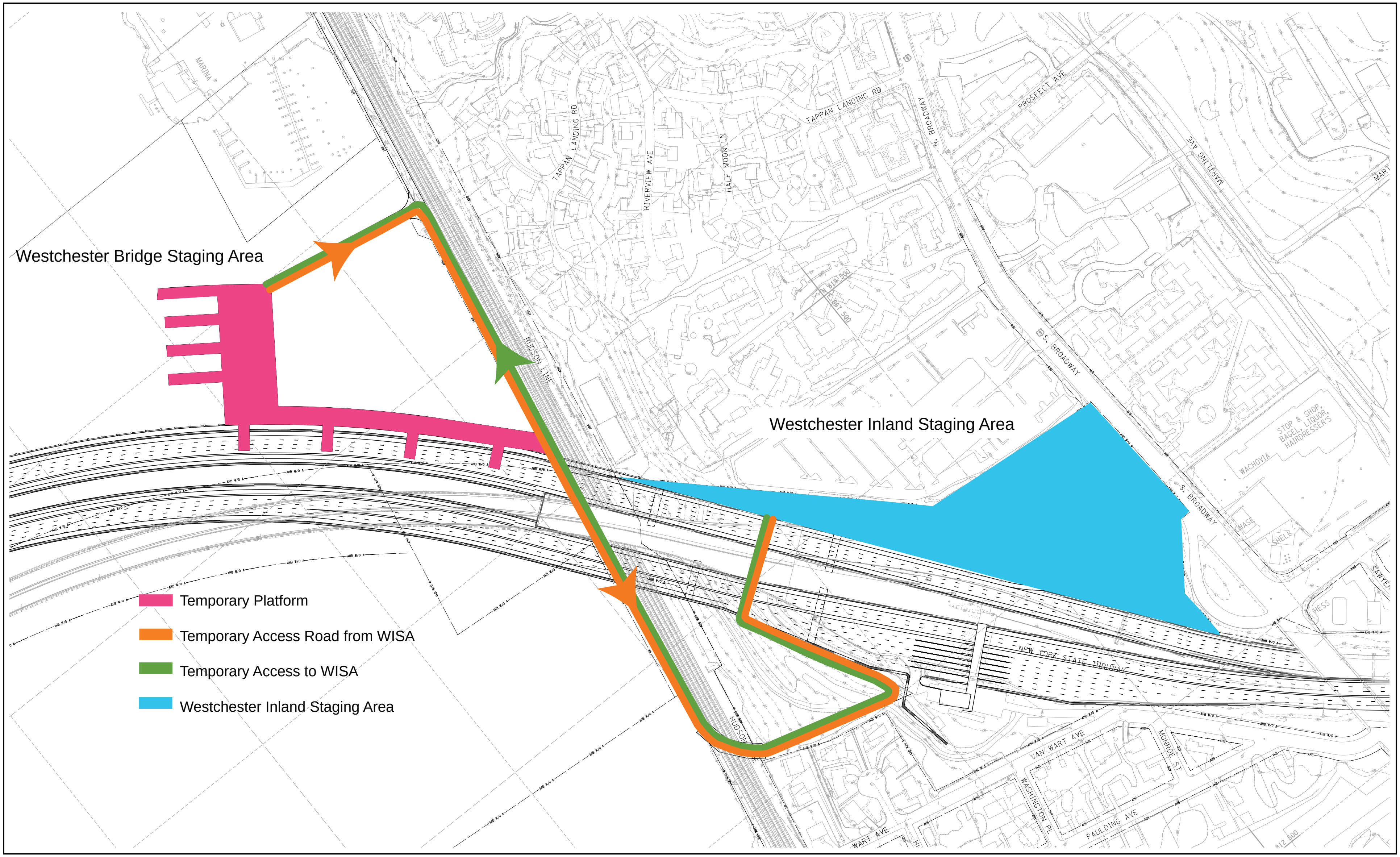
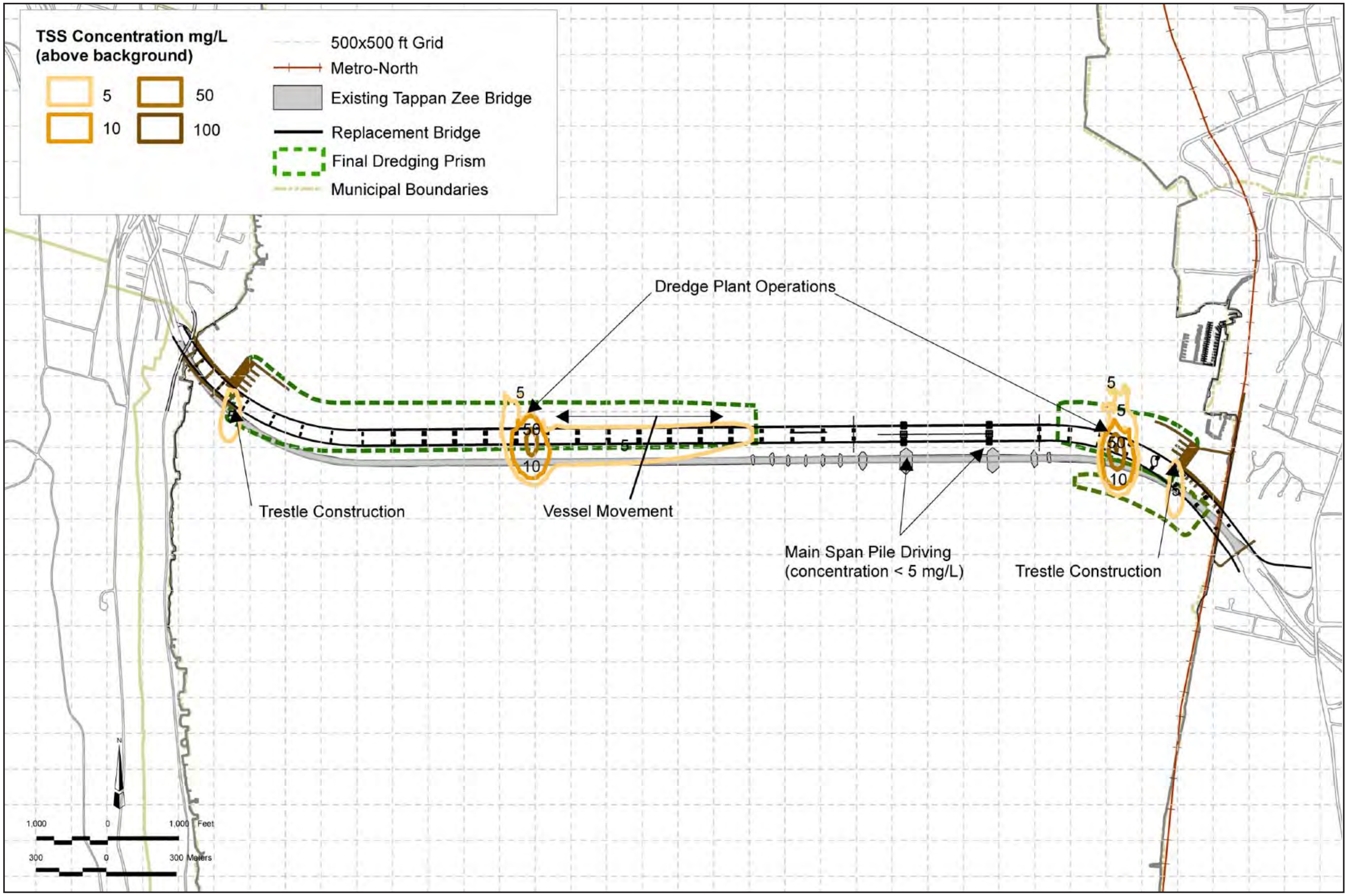


Figure 20
Westchester Landing Construction Access

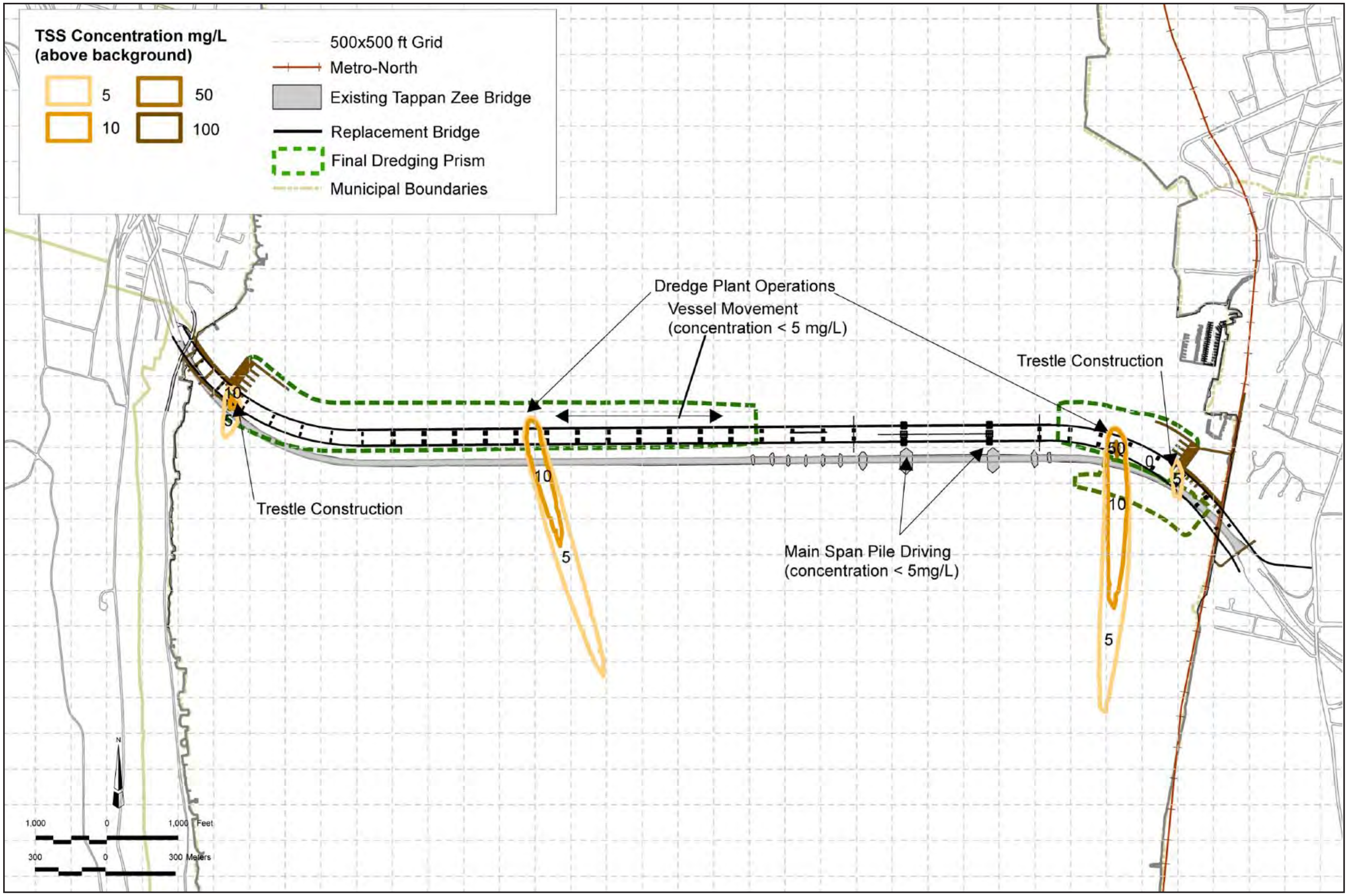


Projected Total Suspended Sediment Concentration for the Long Span Replacement Bridge Option* During Stage 1 Dredging-Near Slack Tide

*Note: Short Span Option would be similar

Figure 21

Projected Total Suspended Sediment Concentration for the Long Span Replacement Bridge Option During Stage 1 Dredging – Near Slack Tide

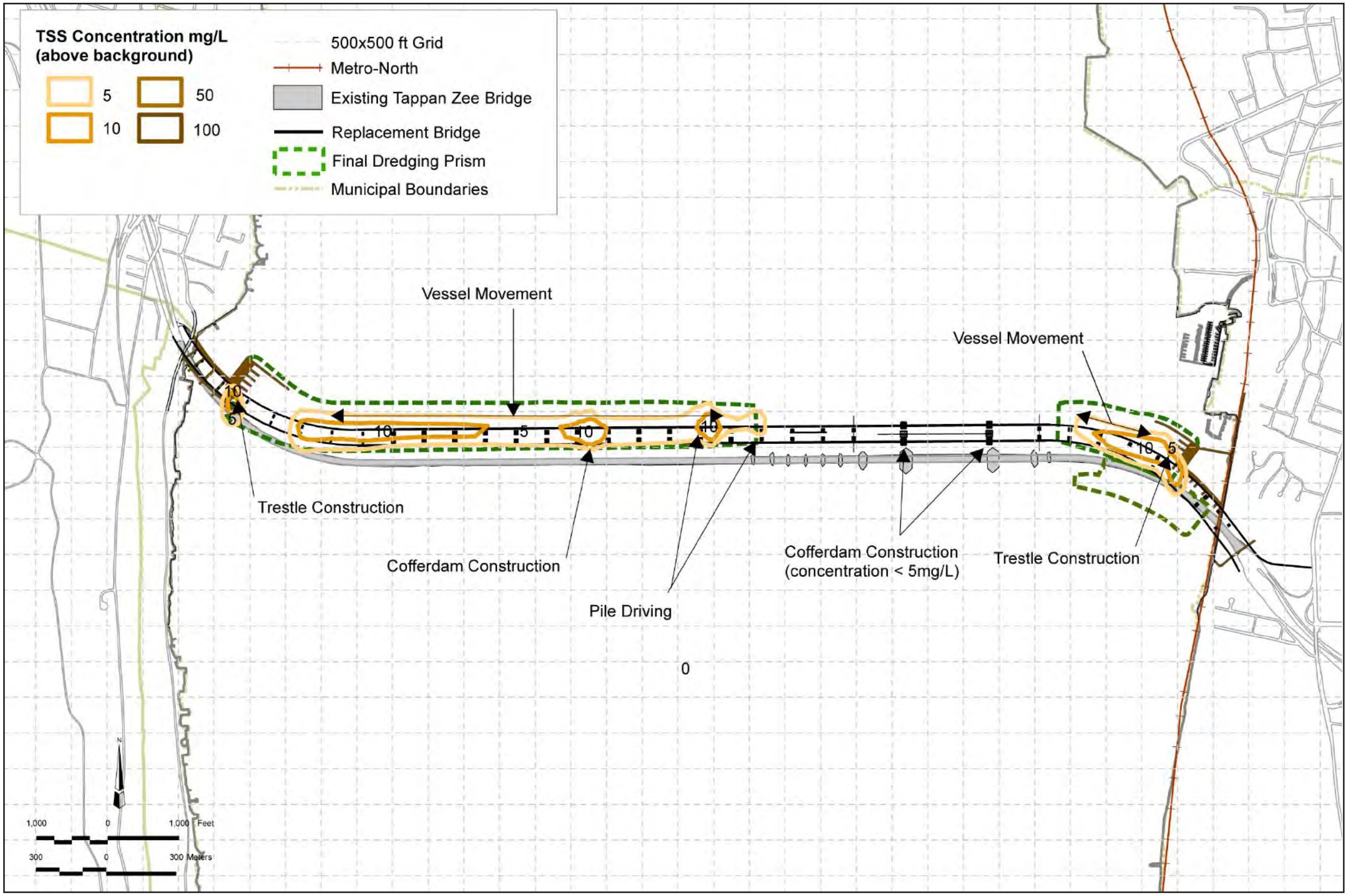


Projected Total Suspended Sediment Concentration for the Long Span Replacement Bridge Option* During Stage 1 Dredging-Ebb Tide

*Note: Short Span Option would be similar

Figure 22

Projected Total Suspended Sediment Concentration for the Long Span Replacement Bridge Option During Stage 1 Dredging – Ebb Tide

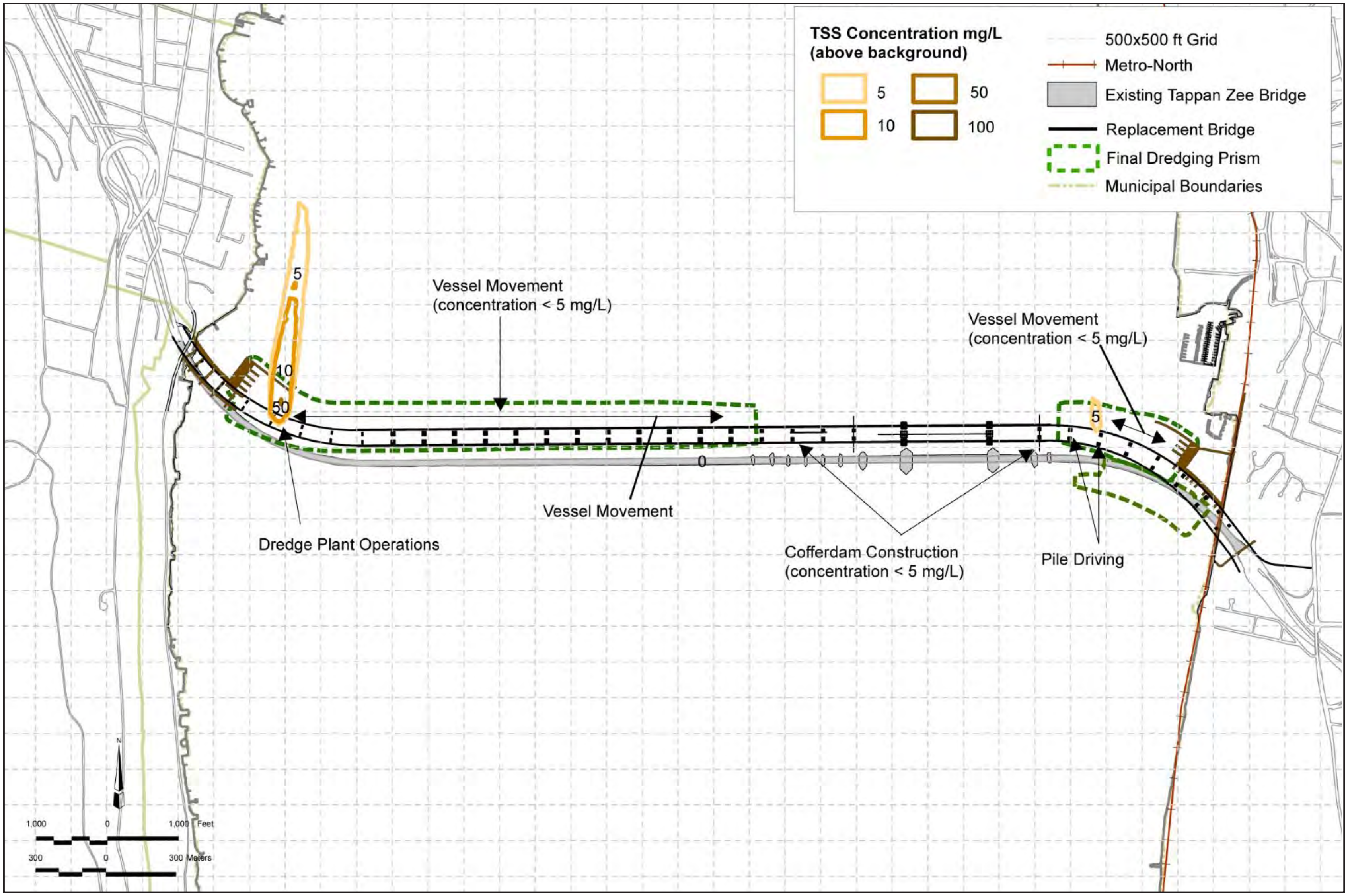


Projected Total Suspended Sediment Concentration for the Long Span Replacement Bridge Option* Zones C and B Construction After Dredging and Armoring – Near Slack Tide

*Note: Short Span Option would be similar

Figure 23

Projected Total Suspended Sediment Concentration for the Long Span Replacement Bridge Option Zones C and B Construction After Dredging and Armoring – Near Slack Tide



Projected Total Suspended Sediment Concentration for the Long Span Replacement Bridge Option* During Stage 2 Dredging and Zones C and B Construction– Flood Tide

*Note: Short Span Option would be similar

Figure 24

Projected Total Suspended Sediment Concentration for the Long Span Replacement Bridge Option During Stage 2 Dredging and Zones C and B Construction – Flood Tide

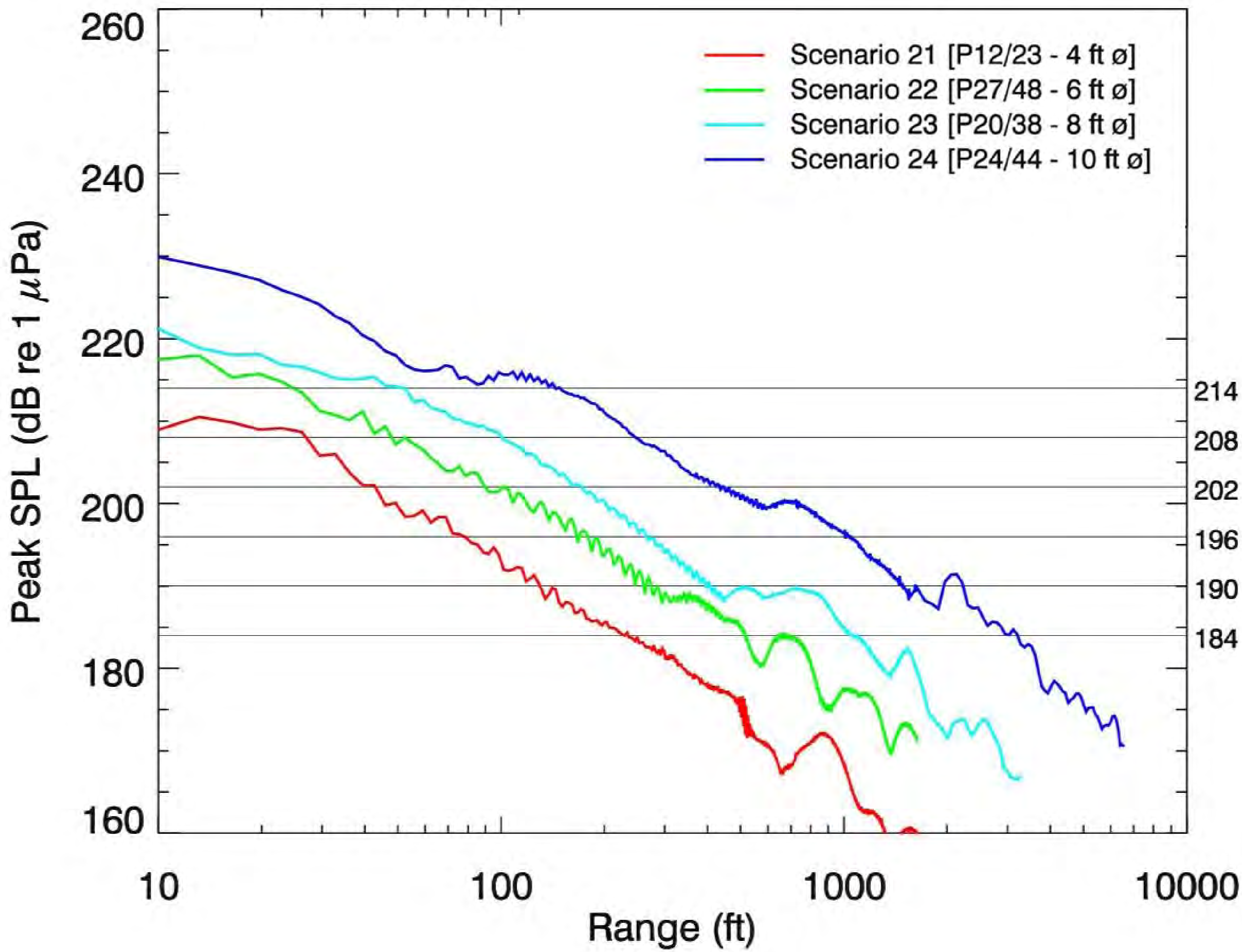


Figure 25

Impact Hammering of 4, 6, 8 and 10 Feet Diameter Piles with BMPs

1.4.12

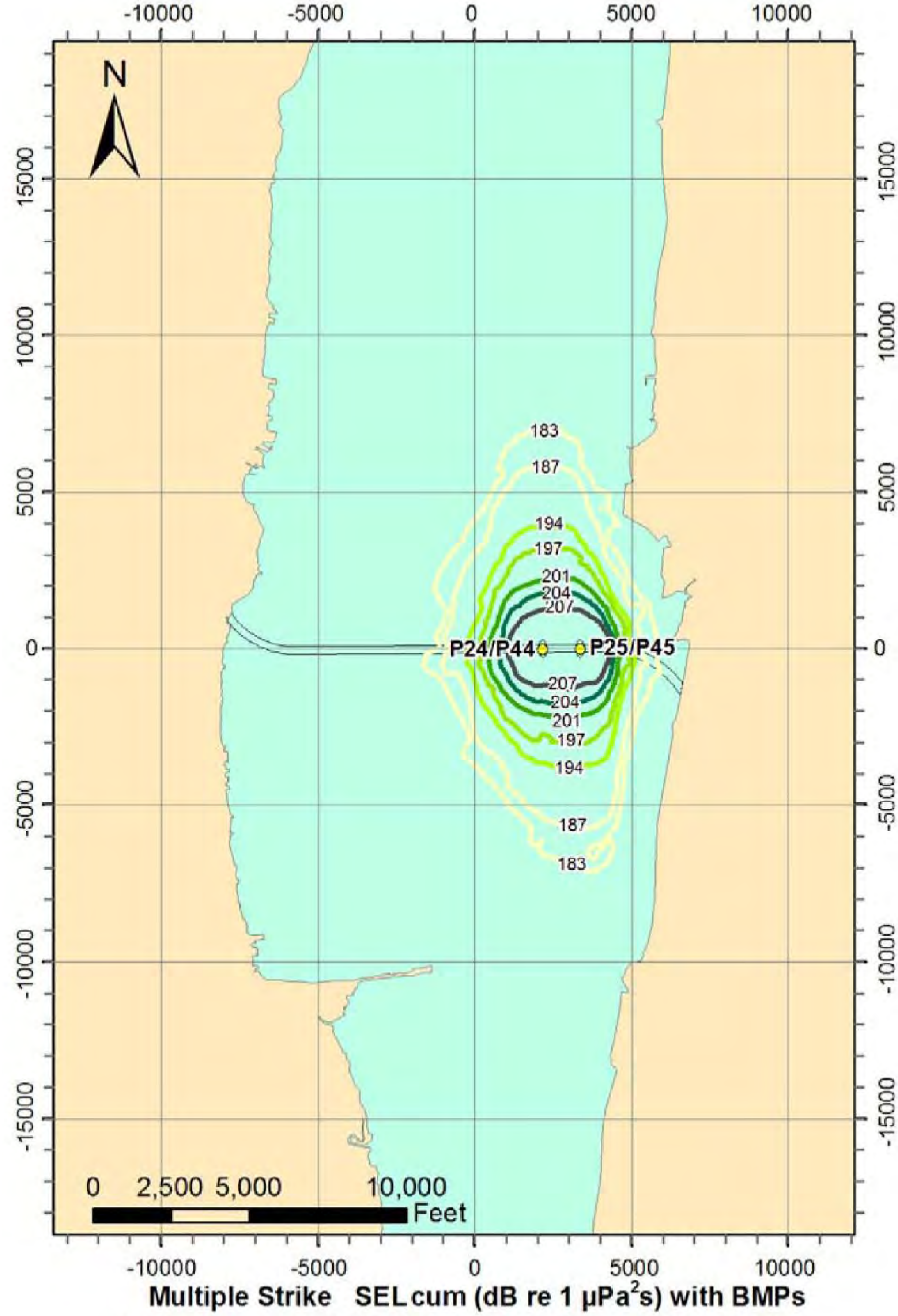


Figure 26

Isopleths for Short and Long Span Options - Driving of Two 10 Foot Piles at Piers 24, 25, 44 & 45

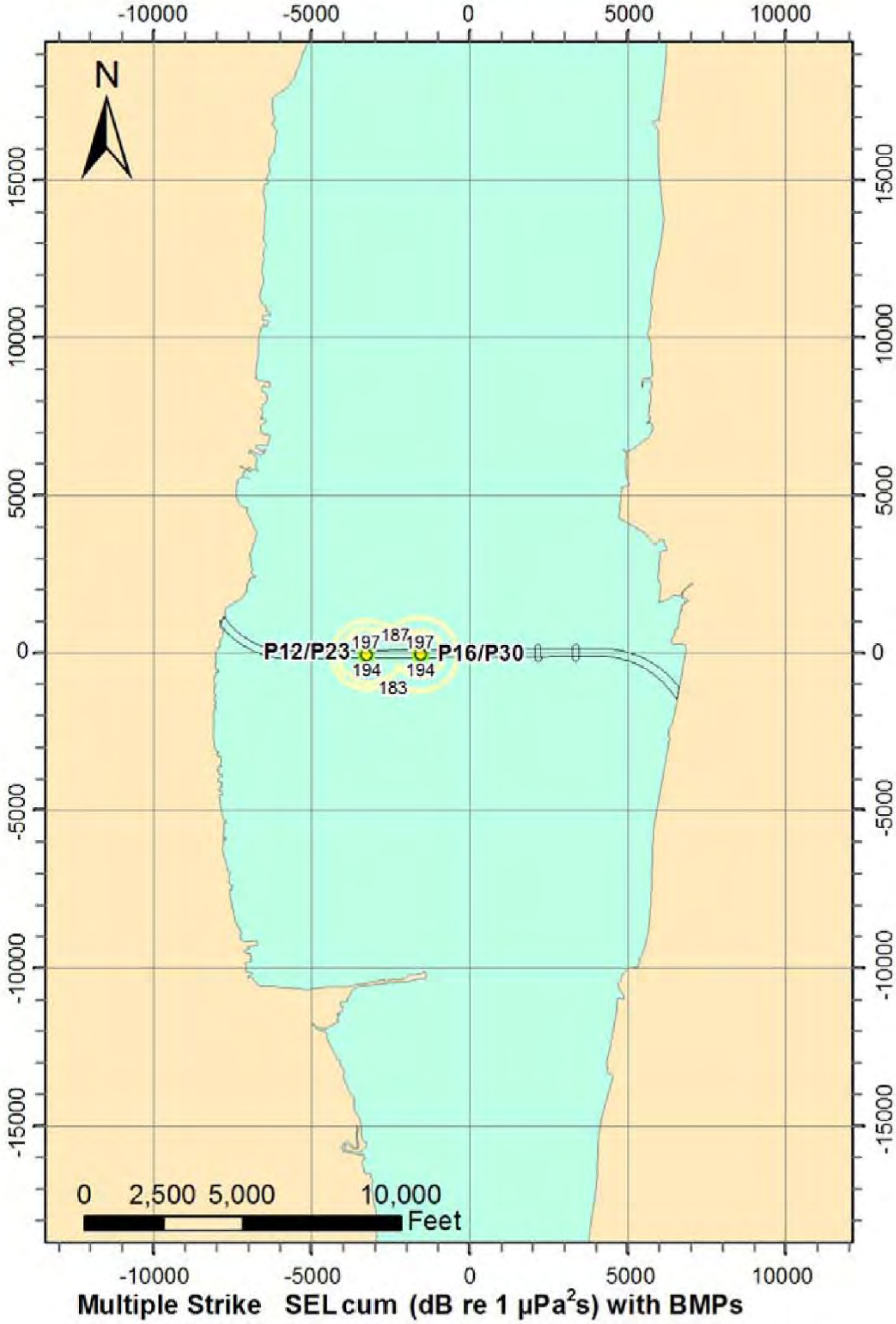


Figure 27

Isopleths for Short and Long Span Options - Driving of Four 4 Foot Piles at Piers 12, 16, 23 & 30

4.12.12

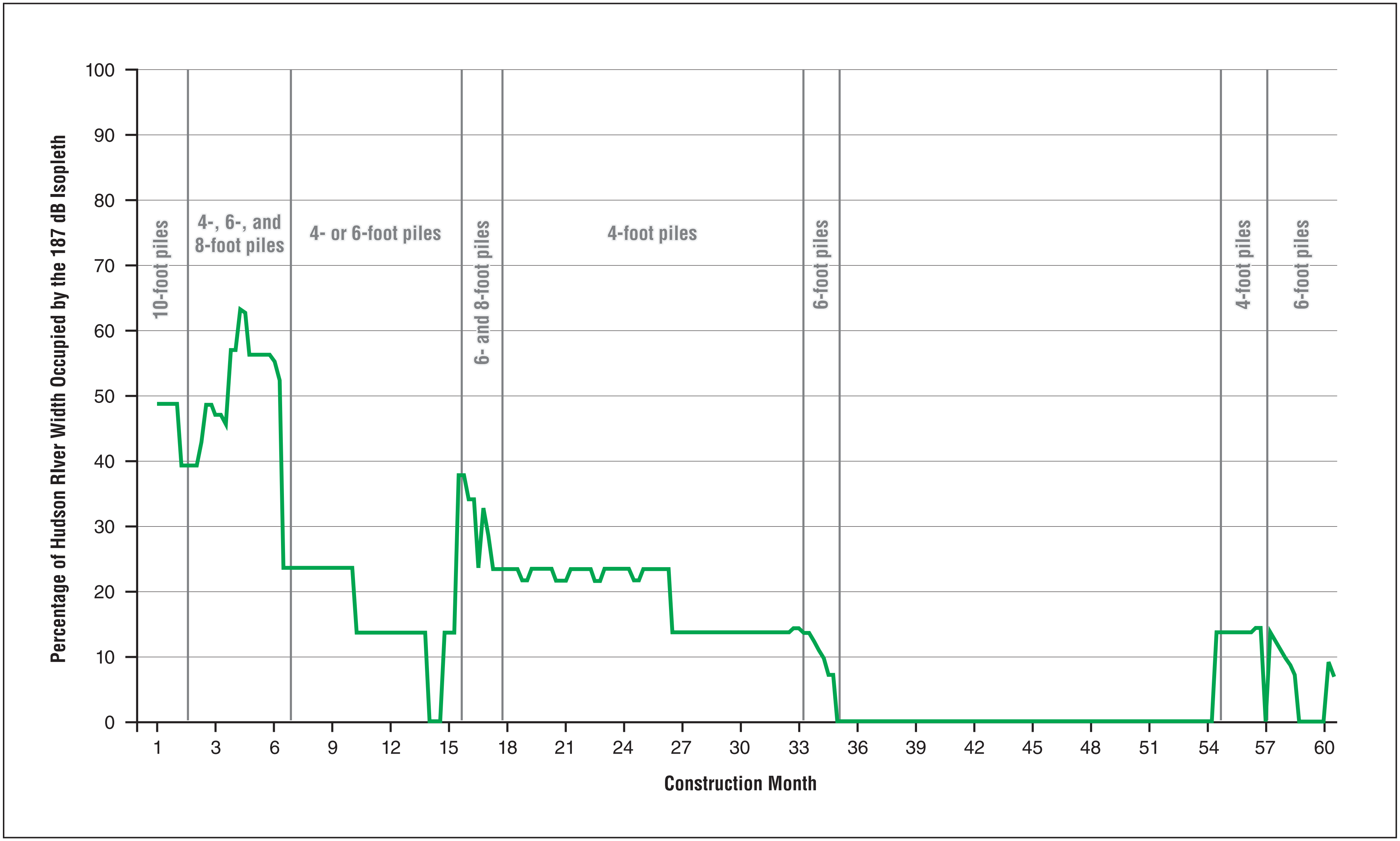


Figure 28

Percent of the Hudson River Width Occupied by the SEL_{cum} 187 dB re 1 μPa²·s Isopleth During Pile Driving at the Proposed Tappan Zee Crossing Short Span Option

TAPPAN ZEE HUDSON RIVER CROSSING

Essential Fish Habitat

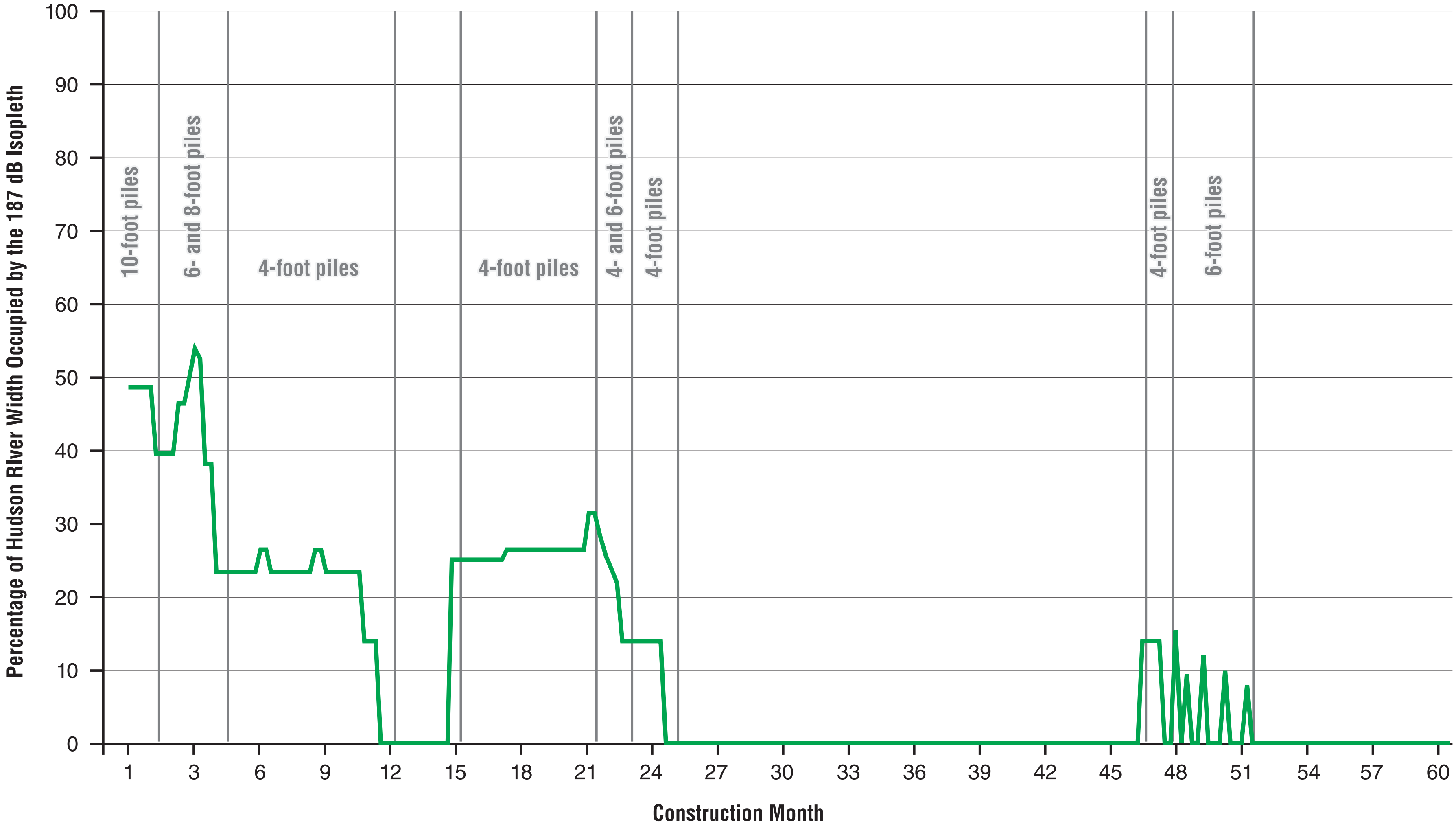


Figure 29

Percent of the Hudson River Width Occupied by the SEL_{cum} 187 dB re 1 μPa^2·s Isopleth During Pile Driving at the Proposed Tappan Zee Crossing Long Span Option

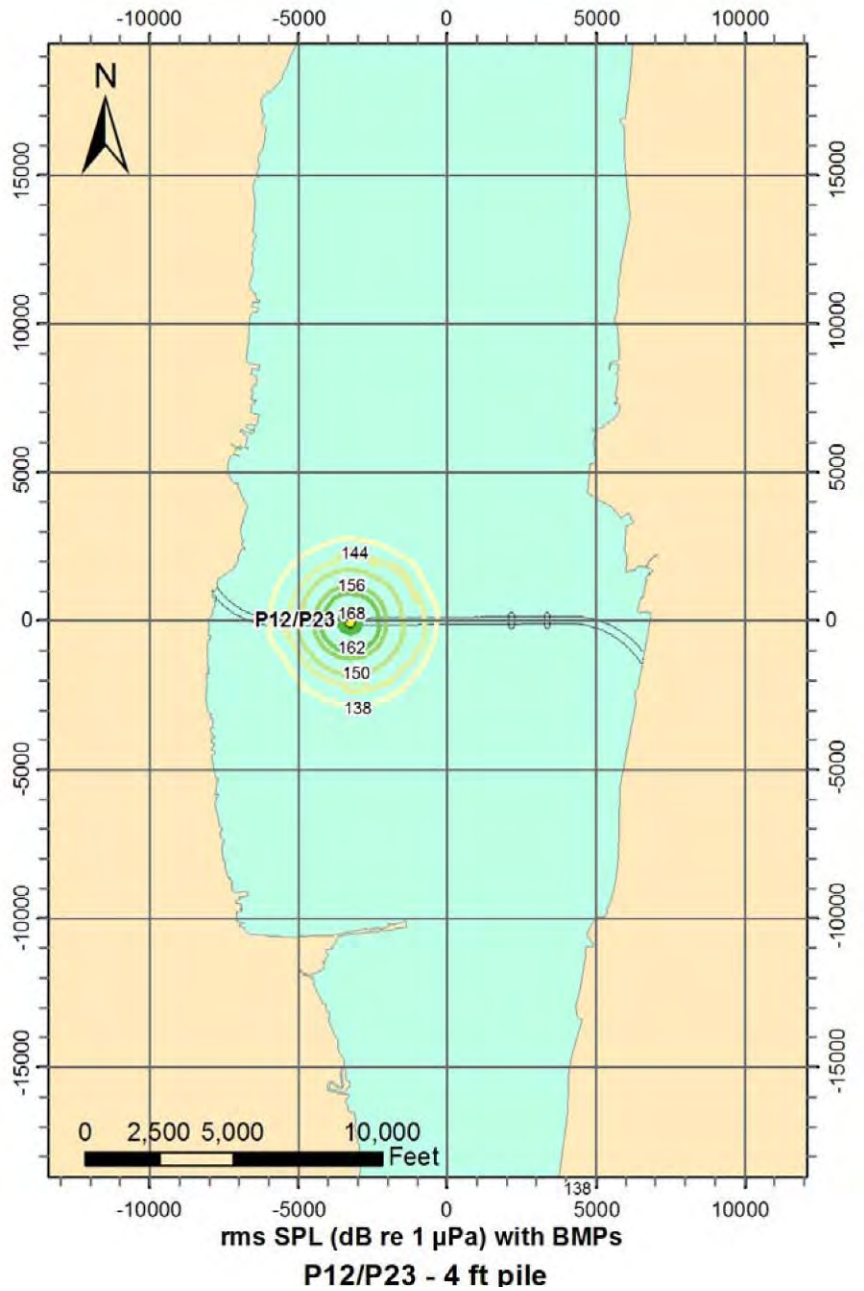
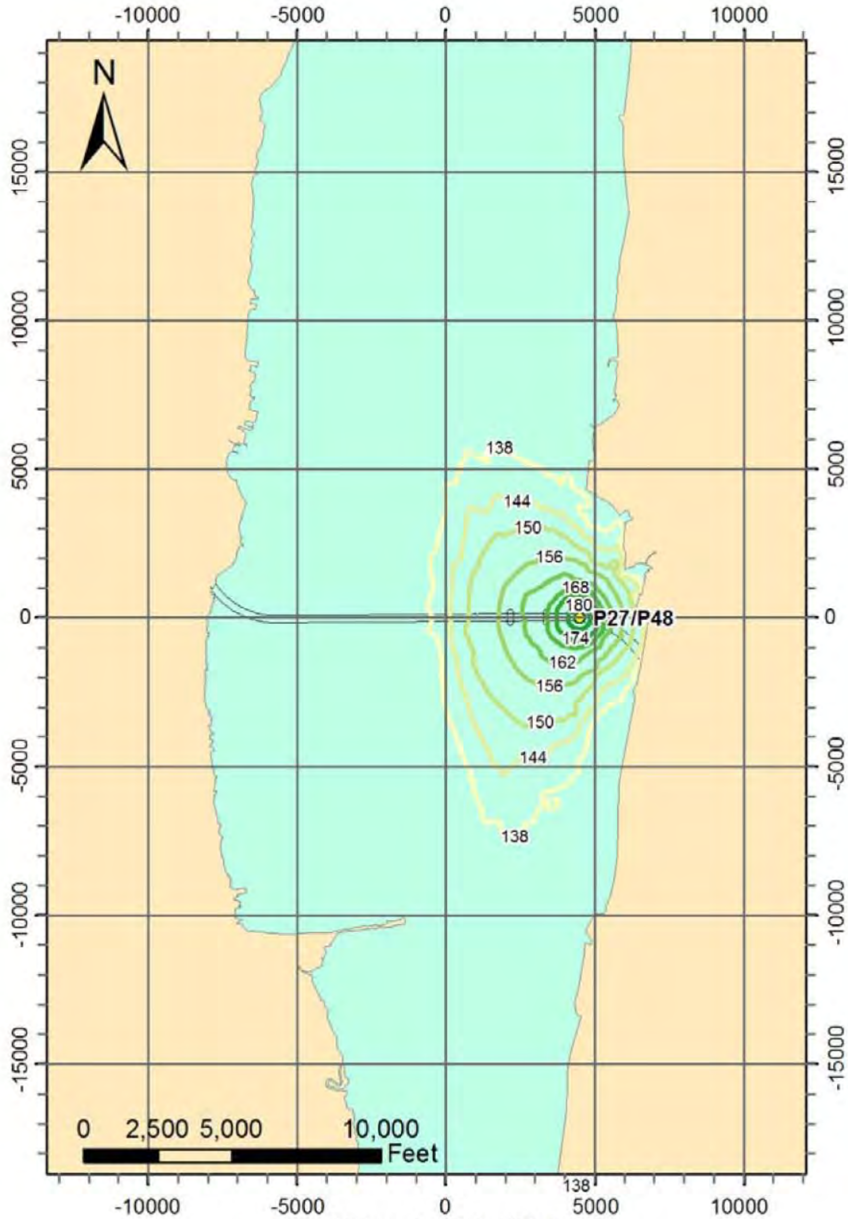


Figure 30

Peak Sound Pressure Levels for Short and Long Span Options, Single 4-foot Diameter Pile BMPs Applied



rms SPL (dB re 1 μPa) with BMPs

P27/P48 - 6 ft pile

Figure 31

Peak Sound Pressure Levels for Short and Long Span Options, Single 6-foot Diameter Pile BMPs Applied

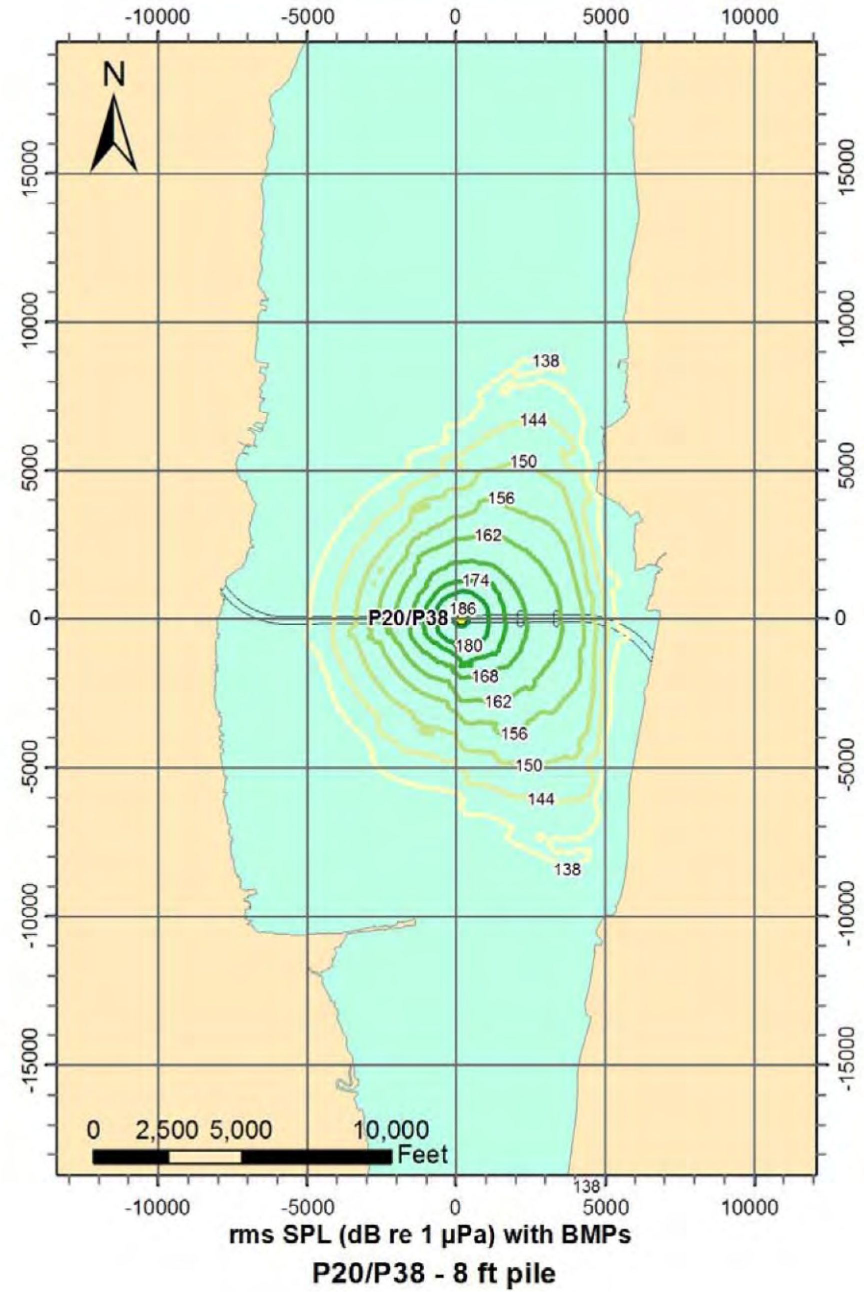


Figure 32

Peak Sound Pressure Levels for Short and Long Span Options, Single 8-foot Diameter Pile BMPs Applied

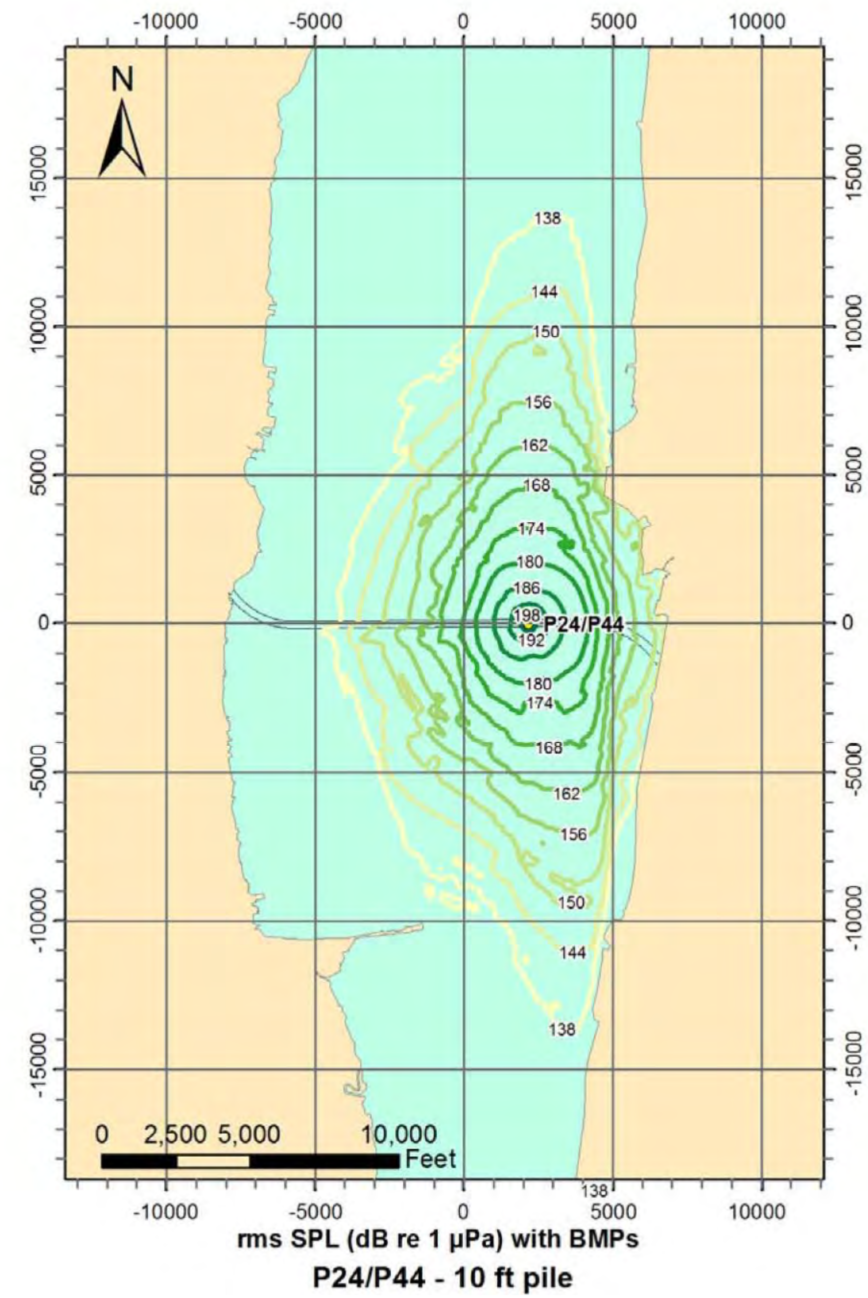


Figure 33
Peak Sound Pressure Levels for Short and Long Span Options, Single 10-foot Diameter Pile BMPs Applied

Exhibit 4: General Conformity

TAPPAN ZEE HUDSON RIVER CROSSING PROJECT

Construction Emissions
General Conformity Analysis

Prepared for: New York State Department of Transportation
and New York State Thruway Authority

Prepared by: AKRF

July 12, 2012

1. Background

The Tappan Zee Hudson River Crossing (TZHRC) project involves the construction of a replacement bridge and ancillary facilities and the removal of the existing Tappan Zee Bridge. A detailed description of the project components and the proposed construction process can be found in the Tappan Zee Hudson River Crossing Draft Environmental Impact Statement (DEIS). This Conformity Analysis applies to emissions associated with the following actions by federal agencies:

1. The U.S. Army Corps of Engineers: Section 404/10 Permit;
2. The U.S. Army Corps of Engineers: Section 103 Joint Ocean Disposal Acceptability Determination; and
3. The U.S. Coast Guard: General Bridge Act of 1946 Permit.

The Clean Air Act, as amended in 1990, defines a non-attainment area as a geographic region that has been designated as not meeting one or more of the National Ambient Air Quality Standards (NAAQS). The project is located in the counties of Rockland and Westchester, which have been designated by the EPA as part of the New York–Northern New Jersey–Long Island, NY–NJ–CT $PM_{2.5}$ non-attainment area and ozone non-attainment area, and are also within an ozone transport region. Both counties are in attainment of the lead, sulfur dioxide (SO_2), carbon monoxide (CO), and annual-average nitrogen dioxide (NO_2) NAAQS. EPA re-designated the New York-N. New Jersey-Long Island, NY-NJ-CT area, which includes Westchester County, as in attainment for CO on April 19, 2002 (67 FR 19337); the Clean Air Act requires that a maintenance plan ensure continued compliance with the CO NAAQS for the former non-attainment area. As is the case for all areas in the U.S., both counties are also designated temporarily as unclassifiable/attainment for the 2010 1-hour average NO_2; this designation will be revisited once additional monitoring data is collected as required by the new standard.

A State Implementation Plan (SIP) is a state's plan on how it will meet the NAAQS under the deadlines established by the Clean Air Act and includes emissions budgets for the applicable pollutants and precursors.

The general conformity requirements in 40 CFR Part 93, Subpart B, apply to those federal actions that are located in a non-attainment area or maintenance area, and that are not subject to transportation conformity requirements at 40 CFR Part 51, Subpart T, or Part 93, Subpart A. Since the project operations are subject to transportation conformity, only emissions associated with construction, which are not addressed via the transportation conformity process, have been reviewed via the general conformity process.

If an applicability analysis determines that the action's direct and indirect emissions have the potential to emit one or more of the six criteria pollutants (or precursors, in the case of ozone and $PM_{2.5}$) at emission rates equal to or exceeding the prescribed emission rates at 40 CFR § 93.153(b), a conformity determination is required. The annual rates applicable to the project are 50 tons of VOCs or 100 tons of NO_x (ozone transport region); 100 tons of CO (maintenance area); and 100 tons of $PM_{2.5}$, SO_2, or NO_x, ($PM_{2.5}$ non-attainment area).

The New York State Department of Transportation (NYSDOT) and the New York State Thruway Authority (NYSTA), as joint lead agencies, have determined that the total annual direct and indirect NO_x and CO emissions are predicted to exceed the prescribed rate of 100 tons per year during construction; accordingly, NYSDOT and NYSTA have concluded that a determination of conformity with the ozone SIP, $PM_{2.5}$ SIP, and CO maintenance plan is required. This report was developed by NYSDOT and NYSTA and will be used by the USCG to support a general conformity determination for the General Bridge Act of 1946 permit. As shown in Table 2 in Appendix B of this report, total direct and indirect emissions associated with the USACE permits for the project are below the general conformity applicability thresholds; thus, the USACE has concluded that a general conformity determination for the USACE permits is not required.

2. Requirements of the Conformity Determination

The purpose of the conformity analysis is to establish that the project would conform to the New York ozone SIP, $PM_{2.5}$ SIP, and CO maintenance plan, thereby demonstrating that total direct and indirect emissions of CO and the ozone precursors, NO_x and VOC, from the project would not:

- cause or contribute to any new violation of any standard in the area;
- interfere with provisions in the applicable SIP for maintenance of any standard;
- increase the frequency or severity of any existing violation of any standard in any area; or
- delay timely attainment of any standard or any required interim emission reductions or other milestones in the SIP for purposes of—
    1. A demonstration of reasonably further progress (RFP);
    2. A demonstration of attainment; or
    3. A maintenance plan.

For the purposes of a general conformity determination, direct and indirect emissions are defined as follows (40 CFR § 93.152):

- *Direct Emissions*: Those emissions of a criteria pollutant or its precursors that are caused or initiated by the federal action and originate in a nonattainment or maintenance area and occur at the same time and place as the action and are reasonably foreseeable;
- *Indirect Emissions*: Those emissions of a criteria pollutant or its precursors:
    1. That are caused or initiated by the federal action and originate in the same nonattainment or maintenance area but occur at a different time or place as the action;
    2. That are reasonably foreseeable;

3. That the agency can practically control; and
4. For which the agency has continuing program responsibility.

NYSDOT and NYSTA have concluded that the pollutants of concern regarding SIP conformity are CO and the ozone precursors: NO_x and VOCs. These precursors were the basis for the ozone SIP analysis for the ozone non-attainment area, and are therefore used for this general conformity analysis. NYSDOT and NYSTA have determined that the only predicted emissions due to the project would include direct emissions from engines operating on-site during construction, and indirect emissions from construction-related vehicles traveling to and from the site.[1]

3. Determination of Conformity

The air quality analyses conducted for the project are consistent with the requirements of 40 CFR Part 93 Subpart B, ''Determining Conformity of General Federal Actions to State or Federal Implementation Plans (SIP)." A detailed description of the methodology and results of the project emissions inventory analysis and the CO microscale analysis are presented in Appendix B.

The project would be located in an area designated as a CO maintenance area. The direct and indirect emissions during construction of the project were predicted to exceed the prescribed level for CO maintenance areas (100 tons per year of CO).

The project would be located in an area designated as a $PM_{2.5}$ non-attainment area. The direct and indirect emissions during construction of the project were not predicted to exceed the prescribed $PM_{2.5}$ or SO_2 emission rates for $PM_{2.5}$ non-attainment areas (100 tons per year of $PM_{2.5}$ or SO_2, a precursor to $PM_{2.5}$), but were predicted to exceed the prescribed NO_x emission rate for $PM_{2.5}$ non-attainment areas (100 tons per year of NO_x, a precursor to $PM_{2.5}$).

The project would be located in an area designated as a moderate non-attainment area under the 1997 8-hour average ozone NAAQS, a marginal non-attainment area under the 2008 8-hour average ozone NAAQS effective July 20, 2012, and is within an ozone transport region. The direct and indirect emissions during construction of the project were not predicted to exceed the prescribed VOC emission rate for ozone non-attainment areas within an ozone transport region (50 tons per year of VOC), but were predicted to exceed the prescribed NO_x emission rate for ozone non-attainment areas within an ozone transport region (100 tons per year of NO_x).

Therefore, NYSDOT and NYSTA, in consultation with the New York State Department of Environmental Conservation (NYSDEC) (as described in NYSDEC's written SIP commitment letter, Appendix A), have reviewed the CO, $PM_{2.5}$, NO_x, and VOC emissions modeling and the CO microscale analyses for the project and have determined the following:

- The methods for estimating direct and indirect emissions from the project and the local CO modeling presented in the project's DEIS (summarized in Appendix B)

[1] The operational phase of the TZHRC will be included in the transportation air quality conformity determination for the New York Metropolitan Transportation Council 2011-2015 TIP and Regional Transportation Plan prior to the completion of the TZHRC FEIS. The TZHRC DEIS demonstrated that the local CO and PM "hot-spot" air quality impacts were fully considered and meet the transportation air quality conformity requirements per 40 CFR Part 93 Subpart A.

meet the requirements of 40 CFR § 93.159. The emissions scenario used in the air quality analysis is expected to produce the greatest off-site impacts on a daily and annual basis. Non-road engine emissions were predicted using the NONROAD model—the latest EPA model for determining emissions from non-road engines. On-road emissions were predicted using the MOBILE6.2 model—an EPA approved model for predicting emissions from on-road vehicles. Resuspension of road dust, as appropriate, was estimated using the latest EPA guidance set forth in "AP-42—Compilation of Emission Factors." Local (microscale) CO dispersion analyses were prepared using EPA's AERMOD models—an EPA preferred model for dispersion analysis. All of the above modeling procedures were conducted based on the latest EPA guidance and in a manner consistent with the procedures used by the New York State Department of Environmental Conservation in preparation of the SIPs.[2]

- NYSDEC has determined that an area-wide modeling analysis of CO concentrations is not required, as per 40 CFR Part 93.158(a)(4)(i).
- The project was predicted to result in the following NO_x emissions in the New York State portion of the non-attainment areas (total tons per year):

Year:[3]	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Dredging and Armoring:	69.6	44.9	0.0	40.2	40.2	0.0
Bridge:	4.4	4.5	4.6	3.6	1.6	1.0
Plaza, landings, approaches:	383.0	377.2	390.1	334.6	241.3	173.1
Total:	*457.0*	*426.6*	*394.8*	*378.4*	*283.1*	*174.1*

Note that the emissions presented in the table above are lower than those disclosed in NYSDEC's written SIP commitment (Appendix A). The analysis was refined to include a 68 percent engine load factor for tug boats based on Port Authority of New York and New Jersey emissions inventory data from 2008; this inventory was developed in a manner consistent with EPA's methodologies and is the accepted inventory for marine emissions in the New York region. The preliminary analysis presented to NYSDEC conservatively modeled tug boats operating at full load (100 percent). In addition, as discussed further in Appendix B, project changes may potentially result in slightly lower total emissions than presented here.

- Pursuant to 40 CFR § 93.158(a)(5)(i)(B), NYSDEC has documented in a written commitment to EPA—

[2] New York is in the process of transitioning to the use of the new Motor Vehicle Emission Simulator (MOVES) model for SIP analyses. USEPA defined a grace period ending March 2, 2013 for transitioning from MOBILE model to the MOVES model, which is applicable to general conformity (EPA, "Policy Guidance on the Use of MOVES2010 and Subsequent Minor Revisions for State Implementation Plan Development, Transportation Conformity, and Other Purposes", EPA-420-B-12-010, April 2012.)

[3] The exact start date of construction is unknown at this time. The first year of construction is assumed to be 2013. Since the most intense emissions would occur in the first year, should the construction-year not coincide with the calendar-year, the maximum calendar-year emissions would be lower.

1. A specific schedule for adoption and submittal of a revision to the ozone and $PM_{2.5}$ SIP which would achieve the needed emission reductions prior to the time emissions from the project would occur;
2. Identification of specific measures for incorporation into the SIPs which would result in a level of emissions which, together with all other emissions in the non-attainment or maintenance area, would not exceed any emissions budget specified in the applicable SIPs;
3. A demonstration that all existing applicable SIP requirements are being implemented in the area for NO_x, and that local authority to implement additional requirements has been fully pursued;
4. A determination that NYSDOT and NYSTA have required all reasonable mitigation measures associated with their action; and
5. Written documentation including all air quality analyses supporting the conformity determination;

- The project does not cause or contribute to any new violation, or increase the frequency or severity of any existing violation, of the standards for the pollutants addressed in 40 CFR § 93.158.
- The project does not violate any requirements or milestones in the ozone or $PM_{2.5}$ SIPs or the CO maintenance plan.

Based on these determinations, the project would conform to the applicable SIPs for the project area. The activities that would conform include construction–related activities of the project.

Appendix A

New York State
Department of Environmental
Conservation Written SIP Commitment

ANDREW M. CUOMO
GOVERNOR

JOE MARTENS
COMMISSIONER

STATE OF NEW YORK
DEPARTMENT OF ENVIRONMENTAL CONSERVATION
ALBANY, NEW YORK 12233-1010

MAY 24 2012

Ms. Judith Enck
Regional Administrator
United States Environmental
Protection Agency - Region 2
290 Broadway, 26th Floor
New York, New York 10007-1866

Dear Ms. Enck:

The Department of Environmental Conservation (DEC) has been actively participating in the review of the Draft Environmental Impact Statement (DEIS) for the Tappan Zee Hudson River Crossing (TZHRC) project. As part of that process, DEC is in agreement with the United States Army Corps of Engineers (USACE) and the United States Coast Guard (USCG) determination that general conformity applies to the emissions associated with the TZHRC construction. These emissions include those associated with bridge construction, demolition of the existing bridge, dredging activities and transport of dredged materials to the Historic Area Remediation Site (HARS). In addition to the inclusion of these emissions in the Final Environmental Impact Statement (FEIS) by the project sponsors, please let this serve as DEC's commitment to adopt and submit the necessary state implementation plan (SIP) revisions to include construction emissions from the TZHRC project.

In particular, the FEIS for the TZHRC will demonstrate that the emissions of carbon monoxide (CO) and oxides of nitrogen (NO_X) exceed the *de minimis* thresholds in 40 CFR Part 93.153(b)(1). Specifically, peak construction emissions are estimated to be 106.5 tons per year of CO in the New York State portion of the New York-New Jersey-Connecticut CO maintenance area and 560.5 tons per year of NO_X in the New York State portion of the New York-New Jersey-Connecticut ozone and $PM_{2.5}$ nonattainment areas.

For CO, DEC has reviewed the hot-spot analysis in the DEIS and agrees that the FEIS will include a demonstration that emissions from construction and operation of the TZHRC will not cause or contribute to any new CO violations, increase the frequency or severity of any existing CO violations, or delay timely attainment of the CO standard or any required CO emissions milestones in the SIP. DEC believes that the analysis to support this conclusion meets all applicable United States Environmental Protection Agency (USEPA) modeling criteria and the general conformity criteria for CO emissions in 40 CFR Parts 93.158(a)(4)(i), 93.158(b), and 93.159.

To address the general conformity NO_X *de minimis* exceedance, DEC is committing, per 40 CFR Part 93.158(a)(5)(i)(B), to include the 560.5 tons per year of NO_X in the $PM_{2.5}$ maintenance plan currently under development for submission to EPA by the fall of 2012. DEC will include an analysis demonstrating that all SIP requirements and milestones will continue to be met with the inclusion of the NO_X emissions from the TZHRC. This submission will include the identification of specific measures that have been incorporated into the plan as well as a demonstration that all existing applicable SIP requirements are being implemented in the area for the pollutants affected by the Federal action. In addition, DEC has determined, based on a review of the DEIS, that the responsible Federal agencies are requiring all reasonable mitigation measures associated with their actions (Clean Fuels, Best Available Tailpipe Reduction Technologies, Utilization of Newer Equipment, Tug Boat Emissions Reduction, Concrete Batch Plant Controls, and Idling Restrictions as described in Chapter 18 of the DEIS) and that they have included a detailed air quality analysis supporting their conformity determination. In addition, DEC is committing to submit a SIP revision for ozone within 18 months that will document the Department's plan to include NO_X emissions from TZHRC construction in the ozone SIP.

Please call me at (518) 402-8540 if you have any questions.

Sincerely,

Joseph J. Martens

cc: M. Toni, FHWA-NY
J. Burns, FHWA
J. Rich, FHWA-NY
L. Knutsen, USEPA
M. Zeman, USEPA
M. Laurita, USEPA
R. Tomer, USACE
G. Kassof, USCG
D. Hitt, NYSDOT
P. Lentlie, NYSDOT
M. Anderson, NYSDOT
E. Novak, NYSTA

Appendix B

Project Construction Activity
Emissions Inventory
and
Microscale CO Analysis

1. Introduction

This Appendix summarizes the air quality analyses prepared for the Tappan Zee Hudson River Crossing relevant to this general conformity determination. The analysis represents the reasonable worst-case scenario of the two construction options identified, i.e. the Short Span Option and Long Span Option. The Short Span Option would result in higher emissions.

As noted in the main body of this report, the emissions estimates presented here are lower than those stated in NYSDEC's written SIP commitment (Appendix A). This difference occurred because the preliminary draft analysis provided to NYSDEC to initiate the SIP revision process conservatively modeled tug boats to be operating at full load (100 percent). The analysis presented in this report was refined to include a tug boat engine load factor of 68 percent based on the Port Authority of New York and New Jersey's emissions inventory data.[1] The 68 percent load factor is also consistent with load factors assumed in the construction CO and PM microscale analyses presented in the DEIS and anticipated to be presented in the FEIS.

In addition, subsequent to preparation of this analysis, the design of the Rockland County landing was modified to reduce the profile of the highway between South Broadway and the bridge abutment at River Road. As a result, the project will no longer include the reconstruction of the South Broadway Bridge. The lower profile applies to both the Short and Long Span Options. The modified Rockland County landing will be formally incorporated into the Replacement Bridge Alternative in the Final Environmental Impact Statement (FEIS). The associated change in construction air pollutant emissions will be relatively minor, and would reduce emissions as compared to the existing analysis presented below.

For a detailed description of the construction, the regulatory context, and other analyses, see "Draft Environmental Impact Statement for Tappan Zee Hudson River Crossing Project", FHWA, 2012.

2. Emission Reduction Measures

Per the DEIS, the construction contracts will require the following Environmental Performance Commitments to reduce PM and NO_x emissions:

- *Clean Fuel.* All diesel fuel used for the project will contain 15 parts per million (ppm) or less sulfur by weight. This includes on-road, nonroad, and tug boats operating on-site.
- *Best Available Tailpipe Reduction Technologies.* All land-based nonroad diesel engines with a power rating of 50 horsepower (hp) or greater and controlled truck fleets (i.e., truck fleets under long-term contract) including but not limited to concrete mixing and pumping trucks, would utilize the best available tailpipe (BAT) technology for reducing diesel PM emissions. Diesel particle filters (DPFs) have been identified as being the tailpipe technology currently proven to have the highest PM reduction capability. Construction contracts would specify that all diesel land-

[1] PANYNJ, 2008 Multi-Facility Emissions Inventory, pp 140, December 2010. This inventory was developed in a manner consistent with EPA's methodologies and is the accepted inventory for marine emissions in the New York region.

based nonroad engines rated at 50 hp or greater would utilize DPFs, either installed on the engine by the original equipment manufacturer (OEM) or retrofit with a DPF verified by the United States Environmental Protection Agency (USEPA) or the California Air Resources Board, and may include active DPFs,[2] if necessary; or other technology proven to reduce diesel PM by at least 90 percent.

- *Utilization of Newer Equipment.* All nonroad construction equipment (excluding tug boat engines) rated at 50 hp or greater would meet at least the Tier 3 emissions standard; all nonroad construction equipment rated at less than 50 hp would meet at least the Tier 2 emissions standard.
- *Tug Boat Emissions Reduction.* The total combined PM emission rate from all tug boats used for the project will be limited to 3,700 grams per hour at peak power, including auxiliary engine emissions.[3] This limit may be achieved by installing retrofits, using new engines, repowering or engine replacement, or various combinations of these measures, along with limitations on the engine size and number of tug boats on site.[4]
- *Concrete Batch Plant Controls.* The concrete batch plant would vent the cement weigh hopper, gathering hopper, and mixing loading operations to a baghouse or filter sock. Storage silo chutes would be vented to a baghouse. Baghouses should have a PM control efficiency of at least 99.9 percent. Roadways and all unloading and loading material handling operations at the concrete batch plant would have a dust control plan providing at least a 50 percent reduction in PM_{10} and $PM_{2.5}$ emissions from fugitive dust through wet suppression.
- *Idling Restrictions.* All efforts will be made to address heavy duty vehicle idling at the project site in order to reduce fuel usage (and associated costs) and emissions. On-road diesel fueled trucks are subject to New York's heavy duty vehicle idling prohibition. These vehicles may not idle for more than five consecutive minutes except under certain specific conditions as described in Subpart 217-3. In addition to enforcing the on-road idling prohibition, all reasonable efforts will be made to reduce non-productive idling of nonroad diesel powered equipment.

3. Methodology

On-Site Construction Activity Assessment

The construction schedule is presented in **Figure 1**, presenting an overview of the construction phasing. The construction periods with activities closest to sensitive receptors (i.e., residences, institutional buildings, and open spaces) and with the most

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2 There are two types of DPFs currently in use: passive and active. Most DPFs currently in use are the "passive" type, which means that the heat from the exhaust is used to regenerate (burn off) the PM to eliminate the buildup of PM in the filter. Some engines do not maintain temperatures high enough for passive regeneration. In such cases, "active" DPFs can be used (i.e., DPFs that are heated either by an electrical connection from the engine, by plugging in during periods of inactivity, or by removal of the filter for external regeneration).

3 This level of emissions would occur with available retrofit technology and the number and size of tug boats currently estimated to be necessary to perform the construction work. Subsequently, later in this section, this level of emissions was found to achieve the air quality goals of the project.

4 For example, the analysis in this section assumed eight 1,500 hp tug boats with EPA Tier 2 rating each with an 80 kw auxiliary engine, with all engines retrofit with a diesel oxidation catalyst.

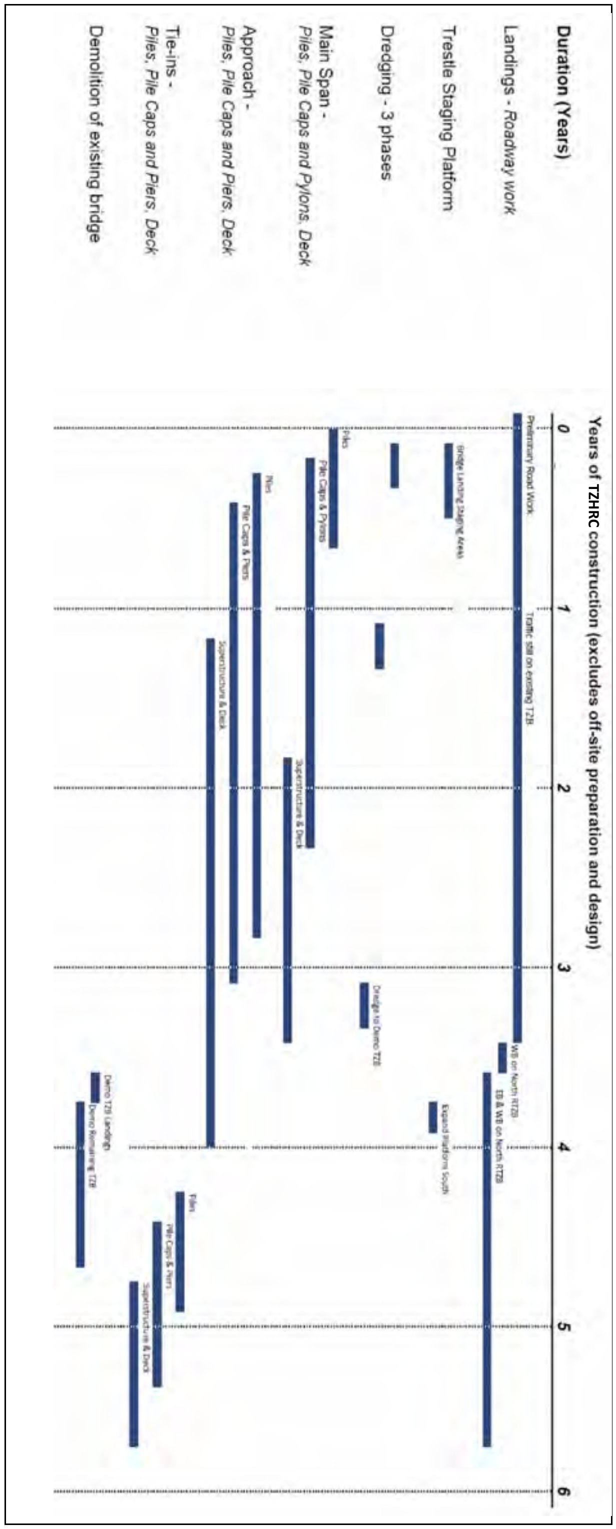

Figure 1
Short-Span Global Schedule

intense activities and highest emissions were selected as the worst-case periods for microscale analysis. Construction-related emissions were estimated for all subtasks of construction, based on the construction schedule and engine emissions factors described below.

Detailed analyses were performed for the following construction periods:

- *Rockland Landing—Reconstruction of the South Broadway Bridge*: The Rockland landing is defined as the portion of the corridor that extends from the abutment of the bridge to just west of the South Broadway Bridge. During this period of construction, the South Broadway Bridge would be replaced and heavy diesel equipment such as cranes, excavators and loaders would be used. The peak construction activities during this period would occur near sensitive residential receptors and would last for several months. Due to project design modifications, the reconstruction of the South Broadway Bridge is no longer included in the project. However, the mesoscale emissions estimates presented in this report reflect the project as initially proposed which included the reconstruction of the South Broadway Bridge. Therefore, the emissions estimates presented in this report are conservative.

- *Rockland Landing—Approach Roadway Construction*: The side slopes south of existing Interstate 87/287 from South Broadway to the river would be removed, the retaining walls would be constructed and temporary pavement would be placed. Heavy diesel equipment such as cranes, excavators and loaders would be used. The peak construction activities during this period would occur near sensitive residential receptors and would last for several months. Due to project design modifications, the construction work in this area may be less intense or of shorter duration due to the lower roadway elevation. However, the mesoscale emissions estimates presented in this report reflect the project as initially proposed. Therefore, the emissions estimates presented in this report are conservative.

- *Rockland Inland Staging Area*: A staging area would be required for a concrete batch plant and miscellaneous construction vehicle storage. The precise location of this area is unknown at this time, and therefore this analysis was performed for a generic plant meeting the needs of the project. The concrete batch plant would be a source of particulate matter emissions. Fugitive sources associated with a concrete batch plant include the transfer of sand and aggregate, truck loading, mixer loading, vehicle traffic, and wind erosion from sand and aggregate storage piles. Estimates of air emissions from these activities were derived based on EPA procedures delineated in AP-42 Section 11.12.

- *Bridge Construction—Rockland Approach and Main Span*: There would be 3 principal in-river work areas, including the main span, Rockland approach, and Westchester approach. Tug boats and barges would be used during in-river construction activities. The substructure construction at each area would include dredging, cofferdam construction, assembly work, pile driving, construction of the pile cap, construction of the columns and deck erection. Pile driving was identified as the substructure construction activity with the highest air quality emissions due to the high amount of heavy equipment employed during this task, including pile drivers and large generators. The period when pile driving would occur at spans that are closest to the Rockland shoreline and therefore closest to sensitive receptors was selected for analysis. Pile driving at spans near the shoreline would last for approximately two months for the north structures and another two months for the south structures at a later period. Similar pile driving work would occur at spans further away from the shoreline at an earlier time. Construction activities at the Main Span that would overlap with the Rockland Approach during this peak period were also included in the analysis, as well as roadway and earthworks at the Rockland Landing.

- *Westchester Landing*: This period of construction would include the relocation of the NYSTA Tappan Zee Bridge Maintenance Facility and New York State Police (NYSP) facilities directly north of the Interstate 87/287 near the Toll Plaza. In addition, a temporary bridge would be constructed to connect the temporary access road west of the railroad tracks and the existing bridge area east of the railroad tracks. Heavy diesel equipment such as cranes, excavators and loaders would be used. The peak construction activities during this period would occur near sensitive residential receptors and would last for several months.
- *Bridge Construction—Westchester Approach and Main Span*: Tug boats and barges would be used during in-river construction activities for the Westchester Approach. Pile driving was identified as the substructure construction activity with the highest air quality emissions due to the high amount of heavy equipment employed during this task, including pile drivers and large generators. The period when pile driving would occur at spans that are closest to the Westchester shoreline and therefore closest to sensitive receptors was selected for analysis. Pile driving at spans near the shoreline would last for approximately two months for the north structures and another two months for the south structures at a later period. Similar pile driving work would occur at spans further away from the shoreline at an earlier time. Construction activities at the main span that would overlap with the Westchester approach during this peak period were also included in the analysis, as well as roadway and earthworks at the Westchester landing.

Engine Exhaust Emissions

The projected usage factors, sizes, types, and number of construction equipment were estimated based on detailed construction activities. Emission factors for NO_x, CO, and $PM_{2.5}$ from on-site construction engines were developed using the EPA's NONROAD2008 Emission Model (NONROAD). Since emission factors for truck-mounted concrete pumps are not available from either the EPA MOBILE6.2 emission model or NONROAD, emission factors specifically developed for this type of application were used.[5] With respect to trucks, emission rates for VOC, NO_X, CO, and $PM_{2.5}$ for truck engines were developed using MOBILE6.2. A maximum of 5-minute idle time was employed for the heavy trucks. For analysis purposes, it was assumed that each concrete truck would operate on-site for 45 minutes per delivery. Tugboat emissions were estimated according to the latest emission factors and methodologies delineated

5 Concrete pumps are usually truck mounted and use the truck engine to power pumps at high load. This application of truck engines is not addressed by the MOBILE6 model, and since it is not a nonroad engine, it is not included in the NONROAD model. Emission factors were obtained from a study which developed factors specifically for this type of activity. Source: *FEIS for the Proposed Manhattanville in West Harlem Rezoning and Academic Mixed-Use Development*, CPC–NYCDCP, November 16, 2007.

by US. Environmental Protection Agency (EPA) as applied in the PANYNJ emissions inventory.[6]

Engine size, quantity, usage, and emission factors data are presented in Attachment 1.

Fugitive Emission Sources

Particulate matter emissions would be generated by material handling activities (i.e., loading/drop operations for fill materials and excavate), truck transports, and concrete batching at the Inland Staging Area. Estimates of air emissions from these activities were developed based on EPA procedures delineated in AP-42 Table 13.2.3-1.

Dispersion Modeling

Projected pollutant concentration increments resulting from the construction of the project were predicted using the EPA/AMS AERMOD dispersion model.[7] AERMOD is a state-of-the-art dispersion model, applicable to rural and urban areas, flat and complex terrain, surface and elevated releases, and multiple sources.

For the short-term model scenarios, all stationary sources that idle in a single location while unloading, were simulated as point sources. Other engines, which would move around the site on any given day, were simulated as area sources. In the annual analyses, all sources would move around the site throughout the year and were therefore simulated as area sources.

Meteorological Data

The meteorological data set consisted of five consecutive years of meteorological data: surface data collected at LaGuardia Airport (2006–2010) and concurrent upper air data collected at Brookhaven, New York.

Receptor Locations

Thousands of receptors (locations in the model where concentrations are predicted) were placed along the sidewalks closest to the construction sites that would be publicly accessible, at residential and other sensitive uses at both ground-level and elevated locations (e.g., residential windows), and at open spaces. In addition, a ground-level receptor grid of approximately two thousand receptors was also included in the dispersion modeling to assist in the analysis of potential impacts.

Microscale Mobile Source Assessment

Traffic flow on Interstate 87/287 would be maintained throughout the construction period while roadway work is performed. During those times, traffic would be diverted to temporary roadway segments and remain in the temporary location for an extended period before being shifted again. A shift in the roadway would reduce the distance between the heavily traveled Interstate 87/287 and residences located near the temporary segment, potentially increasing pollutant concentrations at those locations. In

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6 PANYNJ, 2008 Multi-Facility Emissions Inventory, pp 140, December 2010.

7 EPA, AERMOD: Description Of Model Formulation, 454/R-03-004, September 2004; and EPA, User's Guide for the AMS/EPA Regulatory Model AERMOD, 454/B-03-001, September 2004 and Addendum December 2006.

addition, construction vehicles would be added to the projected traffic volumes in some locations. Microscale analyses were performed for both the Rockland and the Westchester sides to assess the effect of these temporary roadway shifts on air quality. Since the project does not exceed the prescribed emission thresholds for $PM_{2.5}$, the $PM_{2.5}$ microscale analyses presented in the DEIS were not required for the purposes of general conformity and are not included in this general conformity report.

Vehicle Emissions

Vehicular exhaust emission factors, which were computed by NYSDOT using the USEPA Mobile Source Emissions Model, MOBILE6.2,[8] and presented in NYSDOT's *The Environmental Manual (TEM)*,[9] were used for the CO microscale analyses. The database includes emission factors by county, vehicle class, roadway functional class, and speed. MOBILE6.2 is capable of calculating engine emission factors for various vehicle types, based on the fuel type (gasoline, diesel, or natural gas), meteorological conditions, vehicle speeds, vehicle age, roadway types, number of starts per day, engine soak time, and various other factors that influence emissions, such as inspection maintenance programs.

Dispersion Model for Microscale Analyses

Maximum CO concentrations resulting from vehicle emissions at the bridge landing site in Rockland County were predicted using USEPA's CAL3QHC model version 2.0.[10] The CAL3QHC model employs a Gaussian (normal distribution) dispersion assumption and includes an algorithm for estimating vehicular queue lengths at signalized intersections. CAL3QHC is used to conservatively predict the dispersion from idling and moving vehicles based on peak traffic and meteorological conditions.

A different modeling approach was used to analyze impacts around the bridge landing area in Westchester County, including the bridge's toll plaza. The toll plaza operates as a series of many line sources including queues, and is, therefore, better represented as an area source. Area sources are better simulated by the USEPA-approved model AERMOD. AERMOD is a steady-state plume dispersion model and simulates dispersion from multiple point, area, or volume sources. Dispersion characteristics may be selected to model rural or urban conditions, and terrain effects can be modeled to reflect simple or complex terrain. The model employs hourly sequential preprocessed meteorological data to estimate concentrations for selected averaging times from one hour to one year.

Meteorology

In general, the transport and concentration of pollutants from vehicular sources are influenced by three principal meteorological factors: wind direction, wind speed, and atmospheric stability. Wind direction influences the direction in which pollutants are

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[8] EPA, User's Guide to MOBILE6.1 and MOBILE6.2: Mobile Source Emission Factor Model, EPA420-R-03-010, August 2003.

[9] NYSDOT, The Environmental Manual, January 2001.

[10] USEPA, User's guide to CAL3QHC—A Modeling Methodology for Predicting Pollutant Concentrations Near Roadway Intersections, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina, September 1995.

dispersed from a given source, and wind speed and atmospheric stability affect the extent of mixing in the atmosphere.

Following the *TEM* and USEPA guidelines,[11] CAL3QHC computations were performed using a wind speed of 1 meter per second, and the neutral stability class, D (for urban environments). The wind angle was varied to determine the maximum concentrations at each receptor under all wind conditions, regardless of frequency of occurrence. 8-hour average CO concentrations were estimated by multiplying the predicted 1-hour average CO concentrations by a factor of 0.70 to account for persistence of meteorological conditions. A surface roughness of 1.08 meters was chosen. These assumptions ensured that worst-case meteorology was used to estimate impacts.

The latest available five years of hourly meteorological data were employed in the AERMOD model: surface data collected at LaGuardia Airport and concurrent upper air data collected at Brookhaven, Suffolk County, New York from 2005 through 2009. All hours were modeled, and the highest resulting concentration for each averaging period is presented.

Traffic Data

Traffic data for the air quality analysis were modeled based on existing traffic counts, projected future growth in traffic, and other information developed as part of the traffic analysis for the project (see Chapter 4 of the DEIS, “Transportation”). Traffic data for the construction period with and without the project were employed in the respective air quality modeling scenarios. Peak hour periods were used for microscale CO analysis around the bridge landing site in Rockland County (using CAL3QHC), producing the maximum anticipated project-generated traffic and the greatest potential for air pollutant emissions. This assumption results in conservatively high concentrations since the peak hour traffic is used for all hours. The modeling of bridge traffic at the landing area in Westchester County (using AERMOD) applied hourly traffic distribution.

Background Concentrations

Background concentrations are pollutant concentrations originating from distant sources that are not directly included in the modeling analysis, which directly accounts for vehicular emissions within 1,000 feet and in the line of sight of the analysis site. Background concentrations are added to modeling results to obtain total pollutant concentrations at an analysis site.

Background concentrations were assumed to be the same as those monitored in the existing condition.

Receptor Locations

Concentrations were modeled at multiple receptors at both analysis sites. The receptors were placed at spaced intervals along sidewalk or roadside locations with continuous public access, and at residential locations. The receptors placed on sidewalks were located at least 3 meters from each of the traveled roadways. Concentrations were

[11] USEPA, Guidelines for Modeling Carbon Monoxide from Roadway Intersections, USEPA Office of Air Quality Planning and Standards, EPA-454/R-92-005, 1992.

calculated at receptors placed at 25-meter intervals along the sidewalk. Ground-level receptors were placed at a height of 1.8 meters, and elevated residential windows were included as well.

Combined Microscale Impact

Since emissions from on-site construction equipment and mobile sources may contribute to concentration increments concurrently, the combined effect was assessed. Total concentrations were estimated by combining the results from the on-site construction analysis with the construction-related mobile source increments at the same location. The combined total is a conservatively high estimate of potential impacts, since it is likely that the highest results from different sources would occur under different meteorological conditions (e.g., different wind direction and speed), and would not necessarily occur when the highest background concentrations are present.

Area-Wide (Mesoscale) Emissions

Total emissions within the non-attainment areas were summed based on the emissions analyses methods described above for on-site and on-road emissions. In addition to the on-site emissions, the mesoscale emissions include all on-road emissions and tug boat emissions associated with marine transport of materials within the non-attainment areas.

4. Results

Local (Microscale) Construction Activity Assessment

Total maximum combined concentration increments were estimated by combining the results from the on-site construction analysis with the construction-related mobile source increments from the mobile source receptor closest to the location of the on-site increment. The overall combined CO concentrations, including background concentrations, are presented in **Table 1** below, and do not exceed the NAAQS.

Table 1
Maximum Total Combined CO Concentrations (ppm)

Period	Westchester	Rockland	NAAQS
1-hour Average	14.5	10.7	35
8-hour Average	7.5	6.1	9

Area-Wide (Mesoscale) Emissions

Annual construction activity and transport emissions associated with the dredging activity and armoring are presented in **Table 2**. Dredging, armoring, and transport of dredged material are under the jurisdiction of the USACE Section 404/10 and Section 103 Permits.

Annual construction activity and on-road emissions associated with bridge construction only (abutment to abutment) are presented in **Table 3**, including temporary and permanent platform construction, bridge construction, and demolition of the existing bridge. This activity is under the jurisdiction of the USCG General Bridge Act of 1946 Permit.

Annual construction activity and on-road emissions associated with all aspects of project construction included in the NYSDEC SIP revision commitment letter in Appendix A are presented in **Table 4**. More detailed results by year are presented in Attachment 2.

Table 2
Emissions from Dredging and Armoring Only (ton/yr)

	$PM_{2.5}$	NO_x	VOC	CO	SO_2
Year 1	2.1	69.6	2.8	3.8	0.05
Year 2	1.3	44.9	1.8	2.4	0.03
Year 3	0.0	0.0	0.0	0.0	0.00
Year 4	1.2	40.2	1.6	2.1	0.02
Year 5	1.2	40.2	1.6	2.1	0.02
Year 6*	none	none	none	none	none

Note: * The last year of construction includes only 8 months of activity, and no dredging activity.
Includes all transportation associated with this activity, including transport to the Historic Area Remediation Site.

Table 3
Emissions from Bridge Construction and Demolition Only
Abutment to Abutment (ton/yr)

	$PM_{2.5}$	NO_x	VOC	CO	SO_2
Year 1	10.1	383.0	21.4	96.1	0.44
Year 2	10.1	377.2	20.6	56.9	0.41
Year 3	10.9	390.1	19.1	41.7	0.37
Year 4	9.7	334.6	14.5	27.7	0.28
Year 5	6.9	241.3	11.7	30.8	0.25
Year 6*	5.1	173.1	7.5	13.5	0.16

Note: * The last year of construction includes only 8 months of activity, and no dredging activity.
Includes all transportation associated with this activity.

Table 4
Total Emissions from All Construction Activities (ton/yr)

	$PM_{2.5}$	NO_x	VOC	CO	SO_2
Year 1	12.2	457.0	24.6	101.7	0.5
Year 2	11.5	426.6	22.8	62.0	0.4
Year 3	10.9	394.8	19.7	45.3	0.4
Year 4	11.0	378.4	16.5	31.9	0.3
Year 5	8.1	283.1	13.5	33.4	0.3
Year 6*	5.1	174.1	7.7	14.1	0.2

Notes: * The last year of construction includes only 8 months of activity.
Total emissions include emissions listed above in Tables 2 and 3, as well as approaches, landings, toll plaza, and other items. Includes all transportation associated with this activity.

Attachment 1: Engine and Emissions Data

Rockland Landing-Reconstruction of the South Broadway Bridge
Nonroad Emissions

Equipment	Engine Size (hp)	Quantity	Shifts / Day	Hours / Shift	BAT: Pollutant Load after Control (%)		Peak Trucks per Day	Average Trucks per Day	$PM_{2.5}$ Emission Factor (g/hp-hr)	PM_{10} Emission Factor (g/hp-hr)	NOx Emission Factor (g/hp-hr)	CO Emission Factor (g/hp-hr)
Compressors - surface tools	275	2	1	8	10%				0.043	0.045	1.107	0.263
Concrete pump - general	250	2	1	8	10%				0.042	0.042	1.546	0.552
Crane - all-terrain (80t)	175	1	1	8	10%				0.079	0.081	1.237	0.351
Crane - crawler (100t)	603	1	1	8	10%				0.044	0.045	1.174	0.479
Excavator - long reach, tracked	203	1	1	8	10%				0.096	0.099	1.434	0.540
Excavator - mini-excavator	84	2	1	8	10%				0.233	0.240	1.980	1.974
Front-end loader - wheeled, large	349	1	1	8	10%				0.051	0.053	0.640	0.328
Front-end loader - wheeled, mid	197	1	1	8	10%				0.051	0.053	0.640	0.328
Generator - large	426	1	1	8	10%				0.040	0.041	1.250	0.300
Generator - mid	110	1	1	8	10%				0.068	0.071	1.251	0.340
Pump - general, water	8	1	1	8	100%				0.075	0.081	1.731	211.073
Telescopic boom - self-propelled	75	1	1	8	10%				0.062	0.064	0.818	0.807
Telescopic forklift handler	101	1	1	8	10%				0.169	0.175	1.451	0.703
Paver	224	1	1	8	10%				0.095	0.098	1.527	0.556
Vibratory Compactor Roller	18	1	1	8	100%				0.204	0.211	2.612	1.523
Truck - concrete	405	2	1	8	10%		2	1	0.003	0.003	0.062	0.053
Truck - delivery & haul-away	310	1	1	8	100%		1	1	0.003	0.003	0.081	0.069
Truck - muck-away	300	4	1	8	100%		4	2	0.003	0.004	0.084	0.072

Rockland Landing-Approach Roadway Construction

Nonroad Emissions

Equipment	Engine Size (hp)	Quantity	Shifts / Day	Hours / Shift	BAT: Pollutant Load after Control (%)		Peak Trucks per Day	Average Trucks per Day	$PM_{2.5}$ Emission Factor (g/hp-hr)	PM_{10} Emission Factor (g/hp-hr)	NOx Emission Factor (g/hp-hr)	CO Emission Factor (g/hp-hr)
Compressors - surface tools	275	2	1	8	10%				0.043	0.045	1.107	0.263
Concrete pump - general	250	2	1	8	10%				0.042	0.042	1.546	0.552
Crane - all-terrain (80t)	175	1	1	8	10%				0.079	0.081	1.237	0.351
Crane - crawler (100t)	603	1	1	8	10%				0.044	0.045	1.174	0.479
Excavator - long reach, tracked	203	1	1	8	10%				0.096	0.099	1.434	0.540
Excavator - mini-excavator	84	2	1	8	10%				0.233	0.240	1.980	1.974
Front-end loader - wheeled, large	349	1	1	8	10%				0.051	0.053	0.640	0.328
Front-end loader - wheeled, mid	197	1	1	8	10%				0.051	0.053	0.640	0.328
Generator - large	426	1	1	8	10%				0.040	0.041	1.250	0.300
Generator - mid	110	1	1	8	10%				0.068	0.071	1.251	0.340
Pump - general, water	8	1	1	8	100%				0.075	0.081	1.731	211.073
Telescopic boom - self-propelled	75	1	1	8	10%				0.062	0.064	0.818	0.807
Telescopic forklift handler	101	1	1	8	10%				0.169	0.175	1.451	0.703
Paver	224	1	1	8	10%				0.095	0.098	1.527	0.556
Vibratory Compactor Roller	18	1	1	8	100%				0.204	0.211	2.612	1.523
Truck - concrete	405	2	1	8	10%		2	1	0.003	0.003	0.062	0.053
Truck - delivery & haul-away	310	1	1	8	100%		1	1	0.003	0.003	0.081	0.069
Truck - muck-away	300	4	1	8	100%		4	2	0.003	0.004	0.084	0.072

Tappan Zee Hudson River Crossing Project

Rockland Inland Staging Area- Concrete Batching Plant

Emission Rates	PM_{10} Short-Term Emissions (g/s)	$PM_{2.5}$ Short-Term Emissions (g/s)	$PM_{2.5}$ Annual Emissions (g/s)	CO Emissions (g/s)	NOx Emissions (g/s)
Unloading to Elevated Storage Silo (C&CS)	2.20E-03	3.96E-04	1.59E-04	--	--
Mixer Loading into Concrete Trucks	1.30E-02	2.34E-03	9.38E-04	--	--
Weigh Hopper Loading	3.87E-05	5.87E-06	2.35E-06	--	--
Delivery to Ground Storage (S&A)	1.59E-02	2.41E-03	9.63E-04	--	--
Transfer to Conveyor (S&A)	1.59E-02	2.41E-03	9.63E-04	--	--
Transfer to Elevated Storage (S&A)	3.18E-05	4.81E-06	1.93E-06	--	--
Storage Piles	7.42E-03	1.04E-03	4.16E-04	--	--
Equipment (Engine Emissions + Road Dust)	6.27E-04	3.57E-04	1.38E-04	7.95E-06	1.30E-05
Crawler Crane	1.89E-04	1.83E-04	9.15E-05	1.43E-02	4.47E-03

Bridge Construction- Rockland Approach and Main Span
Nonroad Emissions

Equipment	Engine Size (hp)	Quantity	Shifts / Day	Hours / Shift	BAT: Pollutant Load after Control (%)		Peak Trucks per Day	Average Trucks per Day	$PM_{2.5}$ Emission Factor (g/hp-hr)	PM_{10} Emission Factor (g/hp-hr)	NOx Emission Factor (g/hp-hr)	CO Emission Factor (g/hp-hr)
Eastbound approach near River road												
Paver	224	1	1	8	10%				0.095	0.098	1.527	0.556
Vibratory Compactor Roller	18	1	1	8	100%				0.204	0.211	2.612	1.523
Truck - delivery & haul-away	310	1	1	8	100%		1	1	0.003	0.003		0.069
Truck - muck-away	300	4	1	8	100%		4	2	0.003	0.004		0.072
Bridge work												
Sheetpile vibratory hammer	300	2	1	8	10%				0.045	0.047	1.105	0.266
Barge mounted 500 Ton Ringer Crane	450	1	1	8	10%				0.046	0.047	1.247	0.309
Barge mounted 200 Ton Crane	340	2	1	8	10%				0.046	0.047	1.247	0.309
Barge mounted 100 Ton Crane	230	4	1	8	10%				0.045	0.047	1.105	0.266
Pile vibratory hammer	300	1	1	8	10%				0.045	0.047	1.105	0.266
Pile driving hammer – 500 kJ	1000	1	1	8	10%				0.048	0.050	1.513	0.335
Pile driving hammer – 800 kJ	1500	1	1	8	10%				0.048	0.050	1.513	0.335
Welding huts (supporting up to 10 welders)	35											
Rock Socket Drilling Rig	209	4	1	8	10%				0.040	0.041	1.122	0.261
Tugboats (1500 HP)- Main Engine	1500	8	1	8	60%				0.492	0.537	9.843	0.820
Tugboats Auxiliary Engine	107	8	1	8	60%				0.276	0.298	7.457	1.268
Flat deck barges (materials transport)												
Concrete delivery barges												
Concrete pumping barges												
Pile delivery barges												
Segment delivery barges												
Truss delivery barges												
Deck segment erection gantry	194	2	1	8	10%				0.045	0.047	1.105	0.266
Truss Lifting winches												
Jacking T-Cranes (pylons)	194	8	1	8	10%				0.045	0.047	1.105	0.266
Compressors - surface tools	275	20	1	8	10%				0.043	0.045	1.107	0.263
Concrete pump - general	250	3	1	8	10%				0.042	0.092	1.546	0.552
Excavator - long reach, tracked	203	1	1	8	10%				0.096	0.099	1.434	0.540
Freeze pipe rotary drilling rig	200	1	1	8	10%				0.040	0.041	1.122	0.261
Freezing plant (construction)	550											
Generator - large	426	8	1	8	10%				0.040	0.041	1.250	0.300
Generator - mid	110	15	1	8	10%				0.068	0.071	1.251	0.340
Pump - general, water	8	20	1	8	100%				0.075	0.081	1.731	211.073
Telescopic boom - self-propelled	75	8	1	8	10%				0.062	0.064	0.818	0.807
Telescopic forklift handler	101	8	1	8	10%				0.169	0.175	1.451	0.703
Vibratory Compactor Roller	18	1	1	8	100%				0.204	0.211	2.612	1.523
Truck - concrete	405	60	1	8	10%		60	30	0.003	0.003	0.062	0.053
Truck - delivery & haul-away	310	20	1	8	100%		20	10	0.003	0.003	0.081	0.069
Truck - muck-away	300	20	1	8	100%		20	10	0.003	0.004	0.084	0.072

Westchester Landing
Nonroad Emissions

Equipment	Engine Size (hp)	Quantity	Shifts / Day	Hours / Shift	BAT: Pollutant Load after Control (%)		Peak Trucks per Day	Average Trucks per Day	$PM_{2.5}$ Emission Factor (g/hp-hr)	PM_{10} Emission Factor (g/hp-hr)	NOx Emission Factor (g/hp-hr)	CO Emission Factor (g/hp-hr)
Compressors - surface tools	275	2	1	8	10%				0.043	0.045	1.107	0.263
Concrete pump - general	250	2	1	8	10%				0.042	0.042	1.546	0.552
Crane - all-terrain (80t)	175	1	1	8	10%				0.079	0.081	1.237	0.351
Crane - crawler (100t)	603	1	1	8	10%				0.044	0.045	1.174	0.479
Excavator - long reach, tracked	203	1	1	8	10%				0.096	0.099	1.434	0.540
Excavator - mini-excavator	84	2	1	8	10%				0.233	0.240	1.980	1.974
Front-end loader - wheeled, large	349	1	1	8	10%				0.051	0.053	0.640	0.328
Front-end loader - wheeled, mid	197	1	1	8	10%				0.051	0.053	0.640	0.328
Generator - large	426	1	1	8	10%				0.040	0.041	1.250	0.300
Generator - mid	110	1	1	8	10%				0.068	0.071	1.251	0.340
Pump - general, water	8	1	1	8	100%				0.075	0.081	1.731	211.073
Telescopic boom - self-propelled	75	1	1	8	10%				0.062	0.064	0.818	0.807
Telescopic forklift handler	101	1	1	8	10%				0.169	0.175	1.451	0.703
Paver	224	1	1	8	10%				0.095	0.098	1.527	0.556
Vibratory Compactor Roller	18	1	1	8	100%				0.204	0.211	2.612	1.523
Truck - concrete	405	2	1	8	10%		2	1	0.003	0.003	0.062	0.053
Truck - delivery & haul-away	310	1	1	8	100%		1	1	0.003	0.003	0.081	0.069
Truck - muck-away	300	4	1	8	100%		4	2	0.003	0.004	0.084	0.072

Bridge Construction - Westchester Approach and Main Span
Nonroad Emissions

Equipment	Engine Size (hp)	Quantity	Shifts / Day	Hours / Shift	BAT: Pollutant Load after Control (%)		Peak Trucks per Day	Average Trucks per Day	$PM_{2.5}$ EF (g/hp-hr)	PM_{10} EF (g/hp-hr)	NOx EF (g/hp-hr)	CO EF (g/hp-hr)
Landing- Road work												
Paver	224	1	1	8	10%				0.095	0.098		0.556
Vibratory Compactor Roller	18	1	1	8	100%				0.204	0.211		1.523
Generator - mid	110	1	1	8	10%				0.068	0.071	1.251	0.340
Compressors - surface tools	275	1	1	8	10%				0.043	0.045	1.107	0.263
Truck - delivery & haul-away	310	1	1	8	100%		1	1	0.003	0.003		0.069
Truck - muck-away	300	4	1	8	100%		4	2	0.003	0.004		0.072
Bridge work												
Sheetpile vibratory hammer	300	2	1	8	10%				0.045	0.047	1.105	0.266
Barge mounted 500 Ton Ringer Crane	450	1	1	8	10%				0.046	0.047	1.247	0.309
Barge mounted 200 Ton Crane	340	2	1	8	10%				0.046	0.047	1.247	0.309
Barge mounted 100 Ton Crane	230	4	1	8	10%				0.045	0.047	1.105	0.266
Pile vibratory hammer	300	1	1	8	10%				0.045	0.047	1.105	0.266
Pile driving hammer – 500 kJ	1000	1	1	8	10%				0.048	0.050	1.513	0.335
Pile driving hammer – 800 kJ	1500	1	1	8	10%				0.048	0.050	1.513	0.335
Welding huts (supporting up to 10 welders)	35											
Rock Socket Drilling Rig	209	4	1	8	10%				0.040	0.041	1.122	0.261
Tugboats (1500 HP)- Main Engine	1500	8	1	8	60%				0.492	0.537	9.843	0.820
Tugboats Auxiliary Engine	107	8	1	8	60%				0.276	0.298	7.457	1.268
Flat deck barges (materials transport)												
Concrete delivery barges												
Concrete pumping barges												
Pile delivery barges												
Segment delivery barges												
Truss delivery barges												
Deck segment erection gantry	194	2	1	8	10%				0.045	0.047	1.105	0.266
Truss Lifting winches												
Jacking T-Cranes (pylons)	194	8	1	8	10%				0.045	0.047	1.105	0.266
Compressors - surface tools	275	20	1	8	10%				0.043	0.045	1.107	0.263
Concrete pump - general	250	3	1	8	10%				0.042	0.092	1.546	0.552
Crane - crawler (100t)	603	2	1	8	10%				0.044	0.045	1.174	0.479
Excavator - long reach, tracked	203	1	1	8	10%				0.096	0.099	1.434	0.540
Freeze pipe rotary drilling rig	200	1	1	8	10%				0.040	0.041	1.122	0.261
Freezing plant (construction)	550											
Generator - large	426	8	1	8	10%				0.040	0.041	1.250	0.300
Generator - mid	110	15	1	8	10%				0.068	0.071	1.251	0.340
Pump - general, water	8	20	1	8	100%				0.075	0.081	1.731	211.073
Telescopic boom - self-propelled	75	5	1	8	10%				0.062	0.064	0.818	0.807
Telescopic forklift handler	101	5	1	8	10%				0.169	0.175	1.451	0.703
Vibratory Compactor Roller	18	1	1	8	100%				0.204	0.211	2.612	1.523
Truck - concrete	405	60	1	8	10%		60	30	0.003	0.003	0.062	0.053
Truck - delivery & haul-away	310	20	1	8	100%		20	10	0.003	0.003	0.081	0.069
Truck - muck-away	300	20	1	8	100%		20	10	0.003	0.004	0.084	0.072

Attachment 2: Construction Emissions by Year and Task

Year 1

		PM2.5	PM10	NOx	VOC	CO (Rockland)	CO (Westchester)	SO2
NY	Land-Based Nonroad							
	Dredge Equipment	0.002	0.002	0.345	0.026	0.047	0.047	0.001
	Other Use Equipment	0.558	0.572	63.218	6.502	20.500	55.091	0.215
	Sub Total Land-Based Nonroad	0.56	0.57	63.56	6.53	20.55	55.14	0.22
	Marine							
	Dredge On-Site Tugboats	0.866	0.944	29.107	1.092	1.255	1.255	0.015
	Other Use On-Site Tugboats	6.235	6.800	209.635	7.865	9.036	9.036	0.108
	Dredge Removal Tugboats	1.068	1.165	35.850	1.347	1.537	1.537	0.018
	Material Delivery Tugboats	2.932	3.198	98.585	3.699	4.249	4.249	0.051
	Sub Total Marine	11.10	12.11	373.18	14.00	16.08	16.08	0.19
	On-Road							
	Westchester	0.243	0.349	8.581	1.935	---	30.485	0.042
	Rockland	0.330	0.462	11.673	2.176	31.494	—	0.050
	Sub Total On-Road	0.57	0.81	20.25	4.11	31.49	30.48	0.09
	NY Total	**12.23**	**13.49**	**456.99**	**24.64**	**68.12**	**101.70**	**0.50**
NJ	On-Road	0.01	0.01	0.34	0.03		0.11	0.00
	Rail	0.14	0.14	1.97	0.00		0.42	0.13
	NJ Total	**0.15**	**0.15**	**2.31**	**0.03**		**0.54**	**0.13**

Year 2

		PM2.5	PM10	NOx	VOC	CO (Rockland)	CO (Westchester)	SO2
NY	Land-Based Nonroad							
	Dredge Equipment	0.002	0.002	0.362	0.027	0.049	0.049	0.001
	Other Use Equipment	0.440	0.453	53.993	5.269	34.000	13.139	0.175
	Sub Total Land-Based Nonroad	0.44	0.45	54.35	5.30	34.05	13.19	0.18
	Marine							
	Dredge On-Site Tugboats	0.905	0.987	30.415	1.141	1.311	1.311	0.016
	Other Use On-Site Tugboats	6.332	6.906	212.905	7.988	9.177	9.177	0.110
	Dredge Removal Tugboats	0.375	0.409	12.586	0.473	0.540	0.540	0.006
	Material Delivery Tugboats	2.932	3.198	98.585	3.699	4.249	4.249	0.051
	Sub Total Marine	10.54	11.50	354.49	13.30	15.28	15.28	0.18
	On-Road							
	Westchester	0.209	0.307	7.325	1.995	---	33.511	0.040
	Rockland	0.295	0.420	10.417	2.235	34.520	---	0.049
	Sub Total On-Road	0.50	0.73	17.74	4.23	34.52	33.51	0.09
	NY Total	**11.49**	**12.68**	**426.59**	**22.83**	**83.84**	**61.98**	**0.45**
NJ	On-Road	0.01	0.01	0.34	0.03		0.11	0.00
	Rail	0.14	0.14	1.97	0.00		0.42	0.13
	NJ Total	**0.15**	**0.15**	**2.31**	**0.03**		**0.54**	**0.13**

Year 3

		PM2.5	PM10	NOx	VOC	CO (Rockland)	CO (Westchester)	SO2
NY	Land-Based Nonroad							
	Dredge Equipment	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Other Use Equipment	0.324	0.333	37.184	3.453	22.619	4.515	0.131
	Sub Total Land-Based Nonroad	0.32	0.33	37.18	3.45	22.62	4.52	0.13
	Marine							
	Dredge On-Site Tugboats	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Other Use On-Site Tugboats	7.237	7.893	243.320	9.129	10.488	10.488	0.126
	Dredge Removal Tugboats	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Material Delivery Tugboats	2.932	3.198	98.585	3.699	4.249	4.249	0.051
	Sub Total Marine	10.17	11.09	341.91	12.83	14.74	14.74	0.18
	On-Road							
	Westchester	0.179	0.260	6.285	1.588	---	26.050	0.033
	Rockland	0.265	0.373	9.377	1.828	27.059	—	0.042
	Sub Total On-Road	0.44	0.63	15.66	3.42	27.06	26.05	0.07
	NY Total	**10.94**	**12.06**	**394.75**	**19.70**	**64.41**	**45.30**	**0.38**
NJ	On-Road	0.01	0.01	0.34	0.03		0.11	0.00
	Rail	0.14	0.14	1.97	0.00		0.42	0.13
	NJ Total	**0.15**	**0.15**	**2.31**	**0.03**		**0.54**	**0.13**

Year 4

		PM2.5	PM10	NOx	VOC	CO (Rockland)	CO (Westchester)	SO2
NY	Land-Based Nonroad							
	Dredge Equipment	0.002	0.002	0.357	0.027	0.048	0.048	0.001
	Other Use Equipment	0.130	0.134	11.993	1.003	3.803	2.548	0.071
	Sub Total Land-Based Nonroad	0.13	0.14	12.35	1.03	3.85	2.60	0.07
	Marine							
	Dredge On-Site Tugboats	0.905	0.987	30.415	1.141	1.311	1.311	0.016
	Other Use On-Site Tugboats	6.332	6.906	212.905	7.988	9.177	9.177	0.110
	Dregde Removal Tugboats	0.250	0.273	8.390	0.315	0.360	0.360	0.004
	Material Delivery Tugboats	2.932	3.198	98.585	3.699	4.249	4.249	0.051
	Sub Total Marine	10.42	11.36	350.30	13.14	15.10	15.10	0.18
	On-Road							
	Westchester	0.178	0.246	6.312	1.049	—	14.241	0.026
	Rockland	0.264	0.360	9.404	1.289	15.250	---	0.034
	Sub Total On-Road	0.44	0.61	15.72	2.34	15.25	14.24	0.06
	NY Total	**10.99**	**12.11**	**378.36**	**16.51**	**34.20**	**31.93**	**0.31**
NJ	On-Road	0.01	0.01	0.34	0.03		0.11	0.00
	Rail	0.14	0.14	1.97	0.00		0.42	0.13
	NJ Total	**0.15**	**0.15**	**2.31**	**0.03**		**0.54**	**0.13**

Year 5

		PM2.5	PM10	NOx	VOC	CO (Rockland)	CO (Westchester)	SO2
NY	Land-Based Nonroad							
	Dredge Equipment	0.002	0.002	0.362	0.027	0.049	0.049	0.001
	Other Use Equipment	0.144	0.148	15.153	1.428	7.575	5.819	0.080
	Sub Total Land-Based Nonroad	0.15	0.15	15.51	1.46	7.62	5.87	0.08
	Marine							
	Dredge On-Site Tugboats	0.905	0.987	30.415	1.141	1.311	1.311	0.016
	Other Use On-Site Tugboats	6.332	6.906	212.905	7.988	9.177	9.177	0.110
	Dregde Removal Tugboats	0.250	0.273	8.390	0.315	0.360	0.360	0.004
	Material Delivery Tugboats	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Sub Total Marine	7.49	8.17	251.71	9.44	10.85	10.85	0.13
	On-Road							
	Westchester	0.181	0.253	6.409	1.166	—	16.677	0.027
	Rockland	0.267	0.366	9.501	1.407	17.686	---	0.036
	Sub Total On-Road	0.45	0.62	15.91	2.57	17.69	16.68	0.06
	NY Total	**8.08**	**8.93**	**283.14**	**13.47**	**36.16**	**33.39**	**0.27**
NJ	On-Road	0.00	0.00	0.00	0.00		0.00	0.00
	Rail	0.00	0.00	0.00	0.00		0.00	0.00
	NJ Total	-	-	-	-		-	-

Year 6

		PM2.5	PM10	NOx	VOC	CO (Rockland)	CO (Westchester)	SO2
NY	Land-Based Nonroad							
	Dredge Equipment	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Other Use Equipment	0.032	0.033	3.032	0.250	0.251	0.842	0.033
	Sub Total Land-Based Nonroad	0.03	0.03	3.03	0.25	0.25	0.84	0.03
	Marine							
	Dredge On-Site Tugboats	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Other Use On-Site Tugboats	4.669	5.092	156.981	5.890	6.766	6.766	0.081
	Dregde Removal Tugboats	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Material Delivery Tugboats	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Sub Total Marine	4.67	5.09	156.98	5.89	6.77	6.77	0.08
	On-Road							
	Westchester	0.155	0.208	5.508	0.644	---	6.494	0.019
	Rockland	0.241	0.321	8.601	0.884	7.503	---	0.028
	Sub Total On-Road	0.40	0.53	14.11	1.53	7.50	6.49	0.05
	NY Total	**5.10**	**5.65**	**174.12**	**7.67**	**14.52**	**14.10**	**0.16**
NJ	On-Road	0.00	0.00	0.00	0.00		0.00	0.00
	Rail	0.00	0.00	0.00	0.00		0.00	0.00
	NJ Total	-	-	-	-		-	-

✷

Exhibit 5: Additional Informal Consultation under Section 7 of the Endangered Species Act

Tappan Zee Hudson River Crossing Project

Rockland and Westchester Counties, New York

Section 7 Informal Consultation Documentation

Primary Agency and Contact:

Jonathan McDade, New York Division Administrator
Federal Highway Administration

In Coordination with:

New York State Department of Transportation
New York State Thruway Authority

May 2012

A. INTRODUCTION

The Federal Highway Administration (FHWA), as the federal lead agency, and the New York State Department of Transportation (NYSDOT) and the New York State Thruway Authority (NYSTA), as joint lead agencies are proposing the Tappan Zee Hudson River Crossing Project, which would result in the construction of a new bridge crossing, consisting of two structures (Replacement Bridge), over the Hudson River between Rockland and Westchester Counties (proposed project). The project site is located on the Hudson River (River Mile [RM] 27) in the Village of Tarrytown, Westchester County, NY and the Village of South Nyack, Rockland County, NY. The proposed project would address the structural, operational, mobility, safety, and security limitations and deficiencies of the existing Tappan Zee Bridge (TZB).

Under Section 7 of the Endangered Species Act (ESA), the FHWA as the Federal Sponsor is required to consult with the United States Fish and Wildlife Service (USFWS) to determine whether any federally listed species or species proposed for listing as endangered or threatened species, or their designated critical habitats, occur in the vicinity of a proposed project. Three species are listed on the USFWS database as occurring within Rockland and/or Westchester Counties, including bog turtle (*Clemmys muhlenbergii*), New England cottontail (*Sylvilagus transitionalis*), and Indiana bat (*Myotis sodalis*).

This document addresses the proposed action in compliance with Section 7 of the ESA of 1973, as amended. Section 7 of the ESA requires that, through consultation (or conferencing for proposed species) with the U.S. Fish and Wildlife Service (USFWS), federal actions do not jeopardize the continued existence of any threatened, endangered, or proposed species or result in the destruction or adverse modification of critical habitat.

B. BOG TURTLE

The bog turtle is a federally threatened and New York State endangered species, and appears on USFWS lists of endangered, threatened, candidate, and proposed species for Rockland and Westchester Counties. However, bog turtles have been extirpated from Rockland County (USFWS 2001) and their extant status in Westchester County is based on a few observations from the early 1990's (USFWS 2001, NYNHP 2011). Any bog turtle populations that are potentially persisting in Westchester County are expected to occur in its northeastern corner, near the Connecticut border (Klemens 1993, Miller and Klemens 2002, Gibbs et al. 2007), where some of the last appropriate habitat for the species in the county remains (Miller and Klemens 2002). This is also the only portion of Westchester County in which the bog turtle was documented during preparation of the 1990-1999 NYSDEC Herp Atlas.

Bog turtles are habitat specialists, requiring calcareous fens or wet meadows with cool, shallow, slow-moving water, deep and soft soils, and tussock-forming herbaceous vegetation (Gibbs et al. 2007). During the October 18, 2011 field survey, it was clear that no habitat types within the study area are remotely suitable for the bog turtle (Mitchell et al. 2006). The NYNHP Environmental Resource Mapper also indicates no non-historical records of the bog turtle within 0.5 miles of the study area. Given the lack of suitable habitat in the study area and the questionable status of the species in Westchester County, occurrence of bog turtles in the study area is extremely improbable and the project will have no effect on the species or habitat on which it depends.

C. NEW ENGLAND COTTONTAIL

The New England cottontail is a species of Special Concern in New York State and a candidate for federal protection under the Endangered Species Act. The current distribution of the New England cottontail in New York is limited to areas east of the Hudson River in Columbia, Dutchess, Putnam, and Westchester Counties (Litvaitis et al. 2006, Tash and Litvaitis 2007).

New England cottontails are found in shrubland, thicket, and similar dense, early successional habitats. Although they will utilize small and isolated fragments of these habitats, including unmaintained and densely vegetated highway margins (Litvaitis et al. 2006, 2008), the field survey conducted on October 18, 2011 identified no densely vegetated margins or other such habitat in the study area that would be appropriate for the species. Additionally, most known populations of New England cottontails in Westchester County occur in the eastern side of the county (Novak 2011), distant from the study area. Therefore, the project will have no effect on this species based on lack of appropriate habitat in the study area.

D. INDIANA BAT

The Indiana bat is a temperate, insectivorous bat that is a New York State and federally listed endangered species. The Indiana bat’s life cycle can be coarsely divided into two primary phases- hibernation and reproduction. Indiana bats emerge from the caves in which they hibernate (i.e., hibernacula) in early spring. Males disperse and remain solitary until mating season at the end of the summer. Pregnant females form maternity colonies in which to rear the young. Maternity roosts, roosting sites of post-lactating females, and roosting sites of solitary males are usually under loose bark or in the crevices of trees. Indiana bat roosting sites have been documented in numerous species of deciduous trees. Tree availability, diameter, altitude, bark characteristics, and sun exposure appear to be the most important factors in roost site selection (Kurta 2004, USFWS 2007). Roosts in New York (Britzke et al. 2006) and elsewhere (USFWS 2007) are typically in large trees with a diameter greater than 16 inches and a height taller than 52 feet, but roosts in smaller trees can occur (USFWS 2007). The trees are usually dead or nearly dead and decayed (Menzel et al. 2001, Kitchell 2008).

Indiana bats often roost near forest gaps or edges where trees receive direct sunlight for much of the day (Callahan et al. 1997, Menzel et al. 2001). Habitats used by Indiana bats during summer are varied and include riparian, bottomland/floodplain, and upland forests (Humphrey et al. 1977, Britzke et al. 2006, Watrous et al. 2006) often within agricultural landscapes (Murray and Kurta 2004, Watrous et al. 2006, USFWS 2007). Maternity colonies are typically located in areas with abundant natural or artificial freshwater sources (Carter et al. 2002, Kurta et al. 2002, Watrous et al. 2006, USFWS 2007). Spring and autumn habitats of Indiana bats have not been well described, but appear to be largely similar to their summer habitat (Britzke et al. 2006, USFWS 2007).

During autumn, Indiana bats mate and deposit fat stores in preparation for winter hibernation. Hibernacula are typically in caves or abandoned mines where ambient temperatures remain above freezing (USFWS 2007). Only eight Indiana bat hibernacula are currently known in New York State, none of which are located within the study area or elsewhere in Rockland and Westchester Counties (NYSDEC Undated).The terrestrial ecological communities observed within the study area during the October 18, 2011 field survey, including mowed lawn, mowed lawn with trees, and successional forest, are not among those that support Indiana bats. Typical foraging habitats of the species, such as forested wetlands and forested stream and lake borders (Humphrey et al. 1977, Menzel et al. 2001, Murray and Kurta 2004), are lacking in the study area, as are large, dead or dying trees in forest gaps that would provide suitable roosting locations.

The Tappan Zee River Crossing Project is approximately 35 to 40 miles of a known hibernaculum in Ulster County, which is a distance Indiana bats may migrate from hibernacula to reach breeding grounds. A study in NY found that most reproductive female bats emerging from winter hibernacula migrate less than 40 miles to their maternity sites (Sanders et al. 2001 and Hicks 2004, as cited in USFWS 2007). Therefore, the study area appears to be within sufficient proximity to a known hibernaculum in Ulster County for individuals associated with this hibernaculum to possibly migrate to, and establish a breeding site within, the study area. However, the project area is heavily developed with residential and commercial land uses. Tree cover is sparse and limited to scattered clusters of trees in the residential neighborhoods and public rights-of-way on both sides of the bridge landings. The project site is not within a landscape of forested streams and wetlands, forest gaps, and agricultural fields that Indiana bats utilize for breeding and foraging (Humphrey et al. 1977, Menzel et al. 2001, Murray and Kurta 2004). Given these habitat limitations, occurrence of Indiana bats in the project area for roosting or foraging is improbable. Any tree removal within the project area, regardless of size, species, or other characteristics, would not be considered elimination of a potential Indiana bat roosting location given the unsuitability of the surrounding habitat for the species. Furthermore, no tree species in the study area are among those that are favored by Indiana bats for roosting (e.g., shagbark hickory).

In summary, there is a very low probability that Indiana bat would occur in the project area and there is little or no Indiana bat habitat that would be affected by the proposed project. Approximately 2.5 acres of successional forest habitat would be disturbed due to staging areas, access roads, etc., and some additional trees greater than four inches in diameter at breast height may be removed from landscaped areas. In addition, the FHWA is committed to removal of the trees during the winter hibernation season

(October 1 through March 31). For these reasons, a recommendation for a finding of, "may affect, but not likely to adversely affect" the Indiana bat has been provided by the FHWA to the USFWS for the project site. There would be no adverse impact on the continued existence of this species from the construction of the Replacement Bridge Alternative.

E. SUMMARY

For the purposes of consultation under Section 7(a)(2) of the Endangered Species Act, the project will have an insignificant or discountable effect on Indiana bat (federally and state listed), and no effect on bog turtle (federally listed) and New England cottontail (species of special concern in NY state, and candidate for federal listing) or their habitats.

STATE OF NEW YORK
DEPARTMENT OF TRANSPORTATION
ALBANY, N.Y. 12232
www.dot.ny.gov

JOAN MCDONALD
COMMISSIONER

ANDREW M. CUOMO
GOVERNOR

May 25, 2012

John Burns
Major Projects Engineer
Federal Highway Administration
Leo W. O'Brien Federal Building
11A Clinton Avenue, Suite 719
Albany, NY 12207

Re: **Request for Informal Consultation with United States Fish and Wildlife Service and Effects Determination for Federally Listed Species or Species Proposed for Listing**

Dear Mr. Burns:

On behalf of the New York State Department of Transportation (NYSDOT) and the New York State Thruway Authority (NYSTA), we ask that FHWA request a review and discussion with the United States Fish and Wildlife Service (USFWS) New York Field Office regarding the potential for the Tappan Zee Hudson River Crossing Project to affect the federally endangered Indiana bat, bog turtle, and New England cottontail. Potential effects to these species were evaluated in the Draft Environmental Impact Statement for the project and the attached Section 7 Informal Consultation Documentation.

Under Section 7 of the Endangered Species Act (ESA), the FHWA as the Federal Sponsor is required to consult with the USFWS to determine whether any federally listed species or species proposed for listing as endangered or threatened, or their designated critical habitats, occur in the vicinity of the proposed project.

The effects determinations for these three species are as follows:

- Bog turtle (*Clemmys muhlenbergii*) – No effect
- New England cottontail (*Sylvilagus transitionalis*) – No effect
- Indiana bat (*Myotis sodalis*) – May affect, but not likely to adversely affect

We appreciate your quick attention to this request. Please do not hesitate to contact me at (518) 457-4054 or dhitt@dot.state.ny.us should you have any questions or require additional information.

Sincerely,

Daniel P. Hitt, RLA
(Acting) Co-Director, Office of Environment

cc: M. Toni, FHWA
E. Novak, NYSTA
K. Edwards, NYSDOT
M. Anderson, NYSDOT
M. Roche, Arup
R. Conway, AKRF
D. Paget, SPR

U.S. Department of Transportation
Federal Highway Administration

New York Division

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11A Clinton Avenue, Suite 719
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518-431-4127
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New York.FHWA@dot.gov

May 31, 2012

In Reply Refer To:
HDA-NY

Mr. David Stilwell
U.S. Fish and Wildlife
3817 Luker Road
Cortland, NY 13045

Subject: Tappan Zee Hudson River Crossing, Threatened and Endangered Species Determination

Dear Mr. Stilwell:

The Tappan Zee Hudson River Crossing project involves the replacement of the existing structure with a new span. As part of the construction project, it is necessary to remove approximately 2.5 acres of early successional forest. Tree cutting is proposed to take place between October 1 and March 31.

The New York Division of the Federal Highway Administration (FHWA) has reviewed the documentation dated May 25 regarding Endangered Species Act consultation for the referenced project. This office concurs with the New York State Department of Transportation (NYSDOT) determination that the project "May Affect, but Not Likely to Adversely Affect" the Indiana bat.

The New York Division of FHWA is requesting concurrence with this determination from the U.S. Fish and Wildlife. As you are aware, this project is on an expedited schedule because it is an identified High-Priority Infrastructure Project pursuant to President Obama's August 31st Memorandum on Efficient and Effective Permitting and Environmental Review. Therefore, we are requesting that the Informal Consultation process be completed by June 22 so that the documentation can be included in the NEPA documentation. For instance, if the initial review from your office indicates that additional information is required for you to concur on the determination, this office wishes to have your comments as soon as possible, to allow for a resubmission, your subsequent review, and the completion of Informal Consultation, before June 22.

Thank you in advance for working with the FHWA on this expedited schedule. If you have any questions or concerns, please contact Melissa Toni at 518-431-8867.

Sincerely,

/Original signed by/

Jonathan McDade
Division Administrator

Enclosures: May 15 Letter Dan Hitt to John Burns
May 2012 Informal Consultation Documentation

cc: Melissa Toni, FHWA
Dan Hitt, NYSDOT
Michael Anderson, NYSDOT
Elizabeth Novak, NYSTA
David Capobianco, NYSTA

United States Department of the Interior

FISH AND WILDLIFE SERVICE
3817 Luker Road
Cortland, NY 13045

June 20, 2012

Mr. Jonathan McDade
Division Administrator
New York Division
Federal Highway Administration
Leo W. O'Brien Federal Building
11A Clinton Avenue, Suite 719
Albany, NY 12207

Dear Mr. McDade:

This responds to U.S. Department of Transportation's Federal Highway Administration (FHWA) May 31, 2012, threatened and endangered species determination letter regarding the proposed Tappan Zee Bridge Hudson River Crossing, in the Village of Tarrytown, Westchester County, New York, and the Village of South Nyack, Rockland County, New York. The FHWA references in their May 31, 2012, correspondence the New York State Department of Transportation's (NYSDOT) May 25, 2012, threatened and endangered species determination for this project.

Pursuant to section 7(a)(2) of the Endangered Species Act of 1973 (ESA) (87 Stat. 884, as amended; 16 U.S.C. 1531 *et seq.*), the FHWA concurred with the NYSDOT's determination that the proposed project may affect, but is not likely to adversely affect, the federally-listed endangered Indiana bat (*Myotis sodalis*). Given the project location, linear nature, and the timing of tree removal (October 1 through March 31), we do not anticipate any measurable impacts to the Indiana bat. Therefore, we concur with your determination. The NYSDOT has also determined that the proposed project will result in no effects to the federally-listed threatened bog turtle (*Clemmys muhlenbergii*) and the federal candidate species for listing, the New England cottontail (*Sylvilagus transitionalis*), as no suitable habitat occurs in the area for these species.

Therefore, at this time, no further coordination or consultation under the ESA is required with the U.S. Fish and Wildlife Service (Service). Should project plans change, or if additional information on listed or proposed species or critical habitat becomes available, this determination may be reconsidered. The most recent compilation of federally-listed and proposed threatened and endangered species in New York is available for your information. Until the proposed project is complete, we recommend that you check our website every 90 days from the date of this letter to ensure that listed species presence/absence information for the proposed project is current.*

The above comments pertaining to endangered species under our jurisdiction are provided pursuant to the ESA. This response does not preclude additional Service comments under other legislation.

The above-listed species are also listed by the state of New York. Any additional information regarding the proposed project and its potential to impact listed species should be coordinated with both this office and with the New York State Department of Environmental Conservation.

Thank you for your time. If you require additional information or assistance please contact Steve Sinkevich at (631) 286-0485.

Sincerely,

David A. Stilwell

David A. Stilwell
Field Supervisor

*Additional information referred to above may be found on our website at:
http://www.fws.gov/northeast/nyfo/es/section7.htm

cc: NYSDEC, Wildlife Diversity, Albany, NY (C. Herzog)
NYSDOT, Albany, NY (D. Hitt)