DRAFT
FISH AND WILDLIFE COORDINATION ACT
SECTION 2(b) REPORT

ASSESSMENT OF THE HUDSON-RARITAN ESTUARY, LIBERTY STATE PARK ECOSYSTEM RESTORATION PROJECT, JERSEY CITY, HUDSON COUNTY, NEW JERSEY

Prepared by:

U.S. Fish and Wildlife Service
Ecological Services, Region 5
New Jersey Field Office
Pleasantville, New Jersey 08232

November 2004

United States Department of the Interior

FISH AND WILDLIFE SERVICE

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In Reply Refer to:

FP-04/42

NOV 29 2004

Colonel Richard J. Polo, Jr.
District Engineer, New York District
U.S. Army Corps of Engineers
Jacob K. Javits Federal Building
New York, New York 10278-0090

Dear Colonel Polo:

This is the draft report of the U.S. Fish and Wildlife Service (Service) regarding potential project effects on fish and wildlife resources from the U.S. Army Corps of Engineers, New York District's (Corps) proposed Hudson-Raritan Estuary, Liberty State Park Ecosystem Restoration Project located in Jersey City, Hudson County, New Jersey. This draft report is provided in accordance with our Fiscal Year-2004 scope of work agreement and is based on plans and information provided by the Corps. A copy of this report was forwarded to the New Jersey Division of Fish and Wildlife for review and comment.

This report was prepared pursuant to Section 2(b) of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 *et seq.*). Comments are also provided under the authority of the Endangered Species Act of 1973 (87 Stat. 884, as amended; 16 U.S.C. 1531 *et seq.*) (ESA) and the Migratory Bird Treaty Act (40 Stat. 755, as amended; 16 U.S.C. 703-712), and are consistent with the intent of the Service's Mitigation Policy (Federal Register, Vol. 46, No. 15, Jan. 23, 1981).

Except for an occasional transient bald eagle (*Haliaeetus leucocephalus*), piping plover (*Charadrius melodus*), or roseate tern (*Sterna dougallii*), no other federally listed or proposed endangered or threatened flora or fauna under Service jurisdiction are known to occur within the vicinity of the proposed project site. The proposed ecosystem restoration may enhance foraging habitat for transient piping plovers and roseate terns during migration. The project may also enhance the suitability of habitats in Liberty State Park for migrant, wintering, or even nesting bald eagles. Recommendations regarding bald eagles are provided in the enclosed report.

The Service recognizes the Corps' commendable efforts in undertaking and planning for this important restoration project that will both benefit wildlife and provide educational opportunities for a large and diverse public. If you have any questions regarding this report, please contact

John Staples, Wendy Walsh, or Brian Marsh at (609) 646-9310, extensions 18, 48, and 21, respectively. The Service would appreciate any written comments on this report within 30 days.

Sincerely,

Clifford G. Day
Supervisor

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U.S. Army Corps of Engineers
New York District
New York, New York
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EXECUTIVE SUMMARY

Liberty State Park is located along the Hudson River in Jersey City, Hudson County, New Jersey. The U.S. Army Corps of Engineers, New York District (Corps) proposes ecosystem enhancements within an approximately 212-acre undeveloped site in the interior of the park (Restoration Area), including a roughly 42-acre former dredge spoil disposal area. Proposed ecosystem enhancement measures in the Restoration Area include creation of tidal marsh in the dredge spoil disposal area, protection and enhancement of freshwater wetlands, and enhancement and management of upland forests and grasslands. The proposed enhancements would be carried out in cooperation with the New Jersey Department of Environmental Protection Division of Parks and Forestry, the non-federal sponsor for the post-feasibility phases of the Liberty State Park project. The Service appreciates the Corps coordination efforts in the planning stages for this highly visible restoration project that will benefit fish and wildlife and provide opportunities for public outreach and education in a highly urban region of the State.

With adequate measures to avoid and minimize undue exposure of wildlife to environmental contaminants, the Service supports the Corps proposed habitat enhancements at Liberty State Park. The proposed project will create a 200 to 250-acre mosaic of tidal marsh, upland forest, freshwater wetland, and grassland habitats. This project is expected to benefit a variety of wildlife species in the New York-New Jersey Harbor, including wading and other marsh birds, waterfowl, raptors, grassland and forest birds, and marine fish. The project would also potentially benefit reptiles and amphibians that may eventually colonize the site.

The Service's primary recommendation for the project is to approach the creation and management of habitats in the Restoration Area from a perspective of large blocks of marsh, forest/freshwater wetland, and grassland habitats. To this end, the Service has delineated recommended Management Areas, based on existing vegetative conditions as well as the Corps' Conceptual Plan for the Restoration Area. Other key Service recommendations include adaptive management of the proposed marsh, control of invasive vegetation, control of feral dog and cat populations, and ongoing monitoring and management of key bird groups in close coordination with the New Jersey Endangered and Nongame Species Program. The Service also recommends that the Corps prepare a bald eagle contingency plan, and complete consultation on the plan during the next phase of project planning, pursuant to Section 7 of the Endangered Species Act of 1973 (87 Stat. 884, as amended; 16 U.S.C. 1531 *et seq.*).

Guidelines in published literature indicate that environmental contaminants at Liberty State Park are of ecological consequence and exposure to biota could be counter productive to successful restoration efforts. However, potential adverse impacts from contaminants can be avoided or minimized through recommended procedures: perform sampling at depths representative of restoration plans; cap open upland (non-forested) areas; line wetlands, channels, and their slopes with clean material; perform additional sampling (if capping and lining are not feasible) and ensure that contaminant guidelines are not exceeded; maximize the depth of the cap in the North Cove and use low permeable material (clay); include dieldrin, PCB, and dioxin analyses in any additional sampling performed; characterize stormwater runoff; and sample contaminants in all environmental matrices during post-construction monitoring.

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I. INTRODUCTION

This constitutes the U.S. Fish and Wildlife Service's (Service) Fish and Wildlife Coordination Act (48 Stat. 401; 16 U.S.C. 661 *et seq.*) (FWCA) Section 2(b) report describing the fish and wildlife resources and supporting ecosystems in the area of the proposed Hudson-Raritan Estuary (HRE), Liberty State Park Ecosystem Restoration Project. This report is provided in accordance with a Fiscal Year-2004 scope of work and funding transfer agreement dated June 3, 2004, between the New York District, U.S. Army Corps of Engineers (Corps) and the Service's New Jersey Field Office. Information presented in this report documents the fish and wildlife resources in the project area and environmental contaminant concerns and provides the Service's recommendations for wildlife enhancements at the site.

Liberty State Park is located along the Hudson River in Jersey City, Hudson County, New Jersey (Figure 1). The focus of the Corps' project is an approximately 212-acre undeveloped site in the interior of the park (Restoration Area), which includes a roughly 42-acre former dredge spoil disposal area. Proposed ecosystem enhancement measures in the Restoration Area include creation of tidal marsh in the dredge spoil disposal area, protection and enhancement of freshwater wetlands, and enhancement and management of upland forests and grasslands. The proposed enhancements would be carried out in cooperation with the New Jersey Department of Environmental Protection (NJDEP) Division of Parks and Forestry (DPF), the non-federal sponsor for the post-feasibility phases of the Liberty State Park project. The Service acknowledges the Corps' efforts in the planning stages for this highly visible restoration project, which is adjacent to the Liberty State Science Center and within view of the Statue of Liberty. Upon completion, the project will benefit fish and wildlife and provide outstanding opportunities for public outreach and education in a highly urban region of the State.

The Service requests that no part of this report be used out of context, and if the report is reproduced, it should appear in its entirety. Furthermore, any data, opinions, figures, recommendations, or conclusions excerpted from this report should be properly cited and include the page number from which the information was taken. This report should be cited as follows:

Walsh, W.L. and B.D. Marsh. 2004. Assessment of the Hudson-Raritan Estuary Liberty State Park Ecosystem Restoration Project, Jersey City, Hudson County, New Jersey. Draft Fish and Wildlife Coordination Act Section 2(b) Report, U.S. Department of the Interior, Fish and Wildlife Service, New Jersey Field Office, Pleasantville, New Jersey. 70 pp. + Appendices.

Questions or comments regarding this report are welcomed by the Service. Written inquiries should be addressed to:

Supervisor
New Jersey Field Office, Ecological Services
U.S. Fish and Wildlife Service
927 North Main Street, Building D
Pleasantville, New Jersey 08232

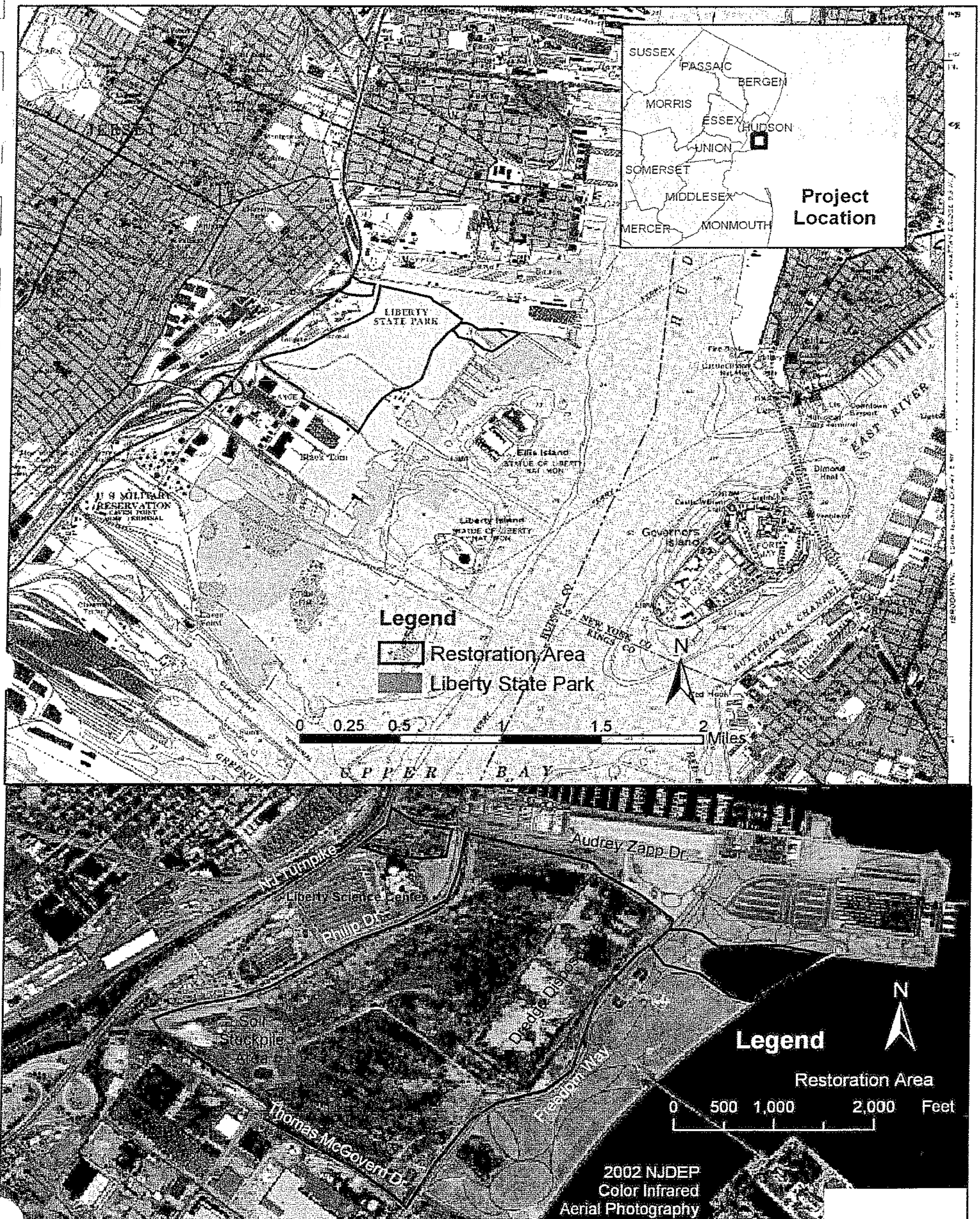

Figure 1. Project Location

II. PROJECT DESCRIPTION

The environmental restoration effort planned for Liberty State Park includes the creation of a tidal marsh in the former dredge spoil disposal area (Figure 2). The dredge disposal area would be excavated to intertidal elevations. Excavated material would be used to create a V-shaped berm along Philip Street and Thomas McGovern Drive in a part of the Restoration Area known as the soil stockpile area. The berm would be clay-lined below and capped above with 2 to 3 feet of clean material. The berm would be constructed with steep grades on the road sides and gradual grades sloping toward the interior of the Restoration Area. The remainder of the soil stockpile area would be capped with 1 foot of clean fill, and the entire area would be planted to create a grassland. The purposes of the berm are to dispose of the excavated material, to create a visual and noise barrier between the park interior and the surrounding roads and industrial areas, and to provide an elevated public viewing area (U.S. Army Corps of Engineers, 2004; Will, pers. comm., 2004).

The tidal marsh would feature a central tidal channel connected to the Hudson River via the park's North Cove. The channel would be approximately 50 feet wide at the mouth, and would narrow slightly as it flows northwest. The channel would pass under a new bridge on Freedom Way before turning southwest into the excavated dredge disposal area. The Corps proposes to leave existing rip rap along the North Cove shoreline, and tie this armor into the mouth of the channel. A small area of the North Cove would be dredged immediately adjacent to the channel mouth, with dredged material deposited in the berm described above. The cove bottom would be capped with clean sand near the channel mouth to contain any contaminated sediments. Flanking the tidal channel, the Corps would create zones of mudflat, low marsh, high marsh, and maritime shrub vegetative communities (U.S. Army Corps of Engineers, 2004; Will, pers. comm., 2004).

The Corps also proposes to create a freshwater wetland system using treated stormwater diverted from adjacent parking lots. The stormwater would be diverted from two areas: (1) a parking lot across the New Jersey Turnpike that currently discharges into a roughly 8-acre wetland adjacent to the Liberty Science Center (LSC), from which water presently flows into a ditch along Philip Street, then into the Morris Canal Basin, and finally to the Hudson River; and (2) the parking lot and other impervious surfaces associated with LSC, which currently discharge directly into the ditch along Philip Street and into the river via the Morris Canal Basin. These stormwater discharges would be diverted from the ditch to a new treatment wetland via a new pipe under Philip Street. The treatment wetlands would consist of two forebays for settlement of sediments and attenuation of flows, and a biofilter area where vegetation would be employed to remove nutrients and other pollutants. Following treatment, the water would flow to a new deep water emergent marsh, designed to hold fresh water continually. During high flows, water would spill from the deep emergent marsh into an adjacent infiltration wetland to recharge the groundwater. No surface connection is proposed between this freshwater wetland system and the new tidal marsh; mixing would occur only during extreme precipitation events (*e.g.*, 100-year flood) (U.S. Army Corps of Engineers, 2004; Roebig, pers. comm., 2004).

Figure 2. Conceptual Plan (Schneider, pers. comm., 2004)

In addition, the project includes enhancement and management of existing upland and freshwater wetland systems. Although most of these areas will be left to the continued process of natural succession, control of invasive species and limited plantings will be necessary to promote the development of desired cover types. These activities will be carried out by the DPF. The DPF is currently working with Rutgers University to study vegetative succession and the potential of plant communities to stabilize and remediate soils that contain metals above residential standards. Based on the results of these studies, the DPF will develop a forest management plan, including management of public access (U.S. Army Corps of Engineers, 2004; New Jersey Department of Environmental Protection, 2001; Gallager, pers. comm., 2004).

III. METHODS

The Service participated in Planning Development Team (PDT) meetings for Liberty State Park on September 25, 2003, December 9, 2003, and January 13, 2004, a meeting to specifically discuss wildlife concerns on December 11, 2003, and a field visit on July 20, 2004. The Service has also reviewed the Corps April 2004 Environmental Resources Inventory report (U.S. Army Corps of Engineers, 2004), and the most current conceptual design for proposed restoration.

IV. EXISTING CONDITIONS

A. PHYSICAL CHARACTERISTICS AND LAND USE HISTORY

Liberty State Park is a 1,122-acre site on the west bank of Upper New York Bay near the Statue of Liberty and Ellis Island National Monuments (Figure 1). Historically, the park was an intertidal mud flat and salt marsh that was filled and used as a railroad yard. The soils consist of historic fill materials that overlie the native marine clay. The materials, which consist primarily of debris from construction projects and refuse from New York City, were deposited to stabilize the surface between 1860 and 1919. Between 1864 and 1967 the Central Railroad of New Jersey (CRRNJ) used the site as a rail yard for both freight and passenger service. In 1967 CRRNJ discontinued operations at the site, and over the next few years the land remained abandoned until it was acquired by the DPF. Liberty State Park officially opened on July 4, 1976 (U.S. Army Corps of Engineers, 2004).

Since acquisition of Liberty State Park by the State, the DPF has created recreational and educational features in the park including an 88-acre Green Park, 4 miles of paved walkways, the historic CRRNJ Terminal building, an Interpretive Center, Liberty Landing Marina, the Liberty Science Center, Caven Point Pier, and ferry service to the Statue of Liberty and Ellis Island. Approximately 4.3 million people visit the park annually (U.S. Army Corps of Engineers, 2004).

In addition to the recreational and educational features, much of the park consists of undeveloped, vegetated, and open water areas. Extensive subtidal and intertidal areas (523 acres) occur within the park boundary. These include a 36-acre cord grass (*Spartina* sp.) dominated tidal wetland located behind the Interpretive Center, and the North Cove, which is a shallow open water cove located south of the railroad terminal building. In the center of the park is a 212-acre undeveloped area (Restoration Area) containing upland and freshwater wetland environments. The Restoration Area is currently inaccessible to the public due to contaminated sediments containing levels of hydrocarbons, pesticides, and metals that exceed protective guidelines (U.S. Army Corps of Engineers, 2004).

Within the Restoration Area is a 42-acre dredged spoil disposal area surrounded by associated containment structures (also referred to as "the impoundment"). The impoundment originally consisted of a series of 8-foot-high earthen berms constructed from existing fill materials excavated on-site. In 1981, during construction of the southern section of the seawall of the Liberty State Park causeway, approximately 93,000 cubic yards of dredged materials were placed in the impoundment. During the spring of 1987, an additional 255,000 cubic yards of dredged materials were placed in the impoundment. The dredged material was obtained from an area between the South Cove and the Middle Cove during the completion of the Liberty Walk seawall project. In 1993, the NJDEP hired a contractor to excavate and regrade the containment berms to form a cap over the dredge spoil. Vegetative cover was subsequently established (U.S. Army Corps of Engineers, 2004).

B. VEGETATION

The Corps conducted vegetation sampling and mapping as part of the Environmental Resources Inventory (U.S. Army Corps of Engineers, 2004). Results are presented in Table 1 and Figure 3.

The New Jersey Natural Heritage Program has no records for rare plant species or natural communities within 0.25 mile of Liberty State Park (Appendix B). However, the State-listed (endangered) plant Torrey's rush (*Juncus torreyi*) was observed in a maritime grassland community during field surveys (U.S. Army Corps of Engineers, 2004). This species is a perennial herb with rhizomes, and has the largest heads of any rush. Torrey's rush is found in wet prairies or meadows, sandy or muddy banks of rivers and streams, and roadside ditches (U.S. Department of Agriculture, undated). Habitats include wet sunny locations or shallow standing water (Gleason and Cronquist, 1991). Torrey's rush is a facultative wetland species in the Northeast Region, with a 67 to 99 percent chance of occurring in wetlands (U.S. Department of Agriculture, 2004a).

Table 1. Dominant Plants by Cover Type (U.S. Army Corps of Engineers, 2004)
* non-native species (U.S. Department of Agriculture, 2004b; Newcomb, 1977)

Successional Northern Hardwood	quaking aspen	*Populus tremuloidies*
	eastern cottonwood	*Populus deltoides*
	gray birch	*Betula populifolia*
	winged sumac	*Rhus copallina*
Successional Shrubland	cut-leaved blackberry *	*Rubus laciniatus*
	smooth sumac	*Rhus glabra*
	northern bayberry	*Myrica pensylvanica*
	Canada goldenrod	*Solidago canadensis*
	common reed *	*Phragmites australis*
	Japanese knotweed *	*Polygonum cuspidatum*
Successional Old Field	Chee reed grass *	*Calamagrostis epigeios*
	common mullein *	*Verbascum thapsus*
	spotted knapweed *	*Centauria maculosa*
	butter and eggs *	*Linaria vulgaris*
	Canada goldenrod	*Solidago canadensis*
	staghorn sumac	*Rhus typhina*
	quaking aspen	*Populus tremuloidies*
	eastern cottonwood	*Populus deltoides*
Maritime Shrubland	winged sumac	*Rhus copallina*
	smooth sumac	*Rhus glabra*
	staghorn sumac	*Rhus typhina*
	Canada goldenrod	*Solidago canadensis*
	common reed *	*Phragmites australis*
	mugwort *	*Artemisia vulgaris*
	gray birch	*Betula populifolia*
	quaking aspen	*Populus tremuloidies*
Maritime Grassland	saltmeadow cordgrass	*Spartina patens*
	butter and eggs *	*Linaria vulgaris*
	common reed *	*Phragmites australis*
	purple loosestrife *	*Lythrum salicaria*
	eastern Baccharis	*Baccharis halimifolia*
	marsh elder	*Iva frutescens*
	winged sumac	*Rhus copallina*
	staghorn sumac	*Rhus typhina*
	quaking aspen	*Populus tremuloidies*
	eastern cottonwood	*Populus deltoidies*
Common Reed/Mugwort	mugwort *	*Artemisia vulgaris*
	common reed *	*Phragmites australis*
	hemp dogbane	*Apocynum cannabinum*
	common mullein*	*Verbascum thapsus*
	purple loosestrife *	*Lythrum salicaria*
	winged sumac	*Rhus copallina*
	quaking aspen	*Populus tremuloidies*

Table 1 (Continued)

Mowed Lawn	annual bluegrass *	*Poa annua*
Paved/Unpaved Road	mugwort *	*Artemisia vulgaris*
	white sweet clover *	*Melilotus alba*
	common mullein *	*Verbascum thapsus*
	wild carrot *	*Daucus carota*
	spotted knapweed *	*Centauria maculosa*
Floodplain Forest Wetland	gray birch	*Betula populifolia*
	eastern cottonwood	*Populus deltoides*
	sensitive fern	*Onoclea sensibilis*
Shrub Swamp Wetland	cut-leaved blackberry *	*Rubus laciniata*
	winged sumac	*Rhus copallina*
	staghorn sumac	*Rhus typhina*
	common reed *	*Phragmites australis*
	purple loosestrife *	*Lythrum salicaria*
	sensitive fern	*Onoclea sensibilis*
	quaking aspen	*Populus tremuloidies*
Shallow Emergent Marsh	purple loosestrife *	*Lythrum salicaria*
	common reed *	*Phragmites australis*
	wool grass	*Scirpus cyperinus*
	Steeplebush	*Spiraea tomentosa*
	gray birch	*Betula populifolia*
Common Reed-dominated Wetland	common reed *	*Phragmites australis*
	purple loosestrife *	*Lythrum salicaria*
	sensitive fern	*Onoclea sensibilis*

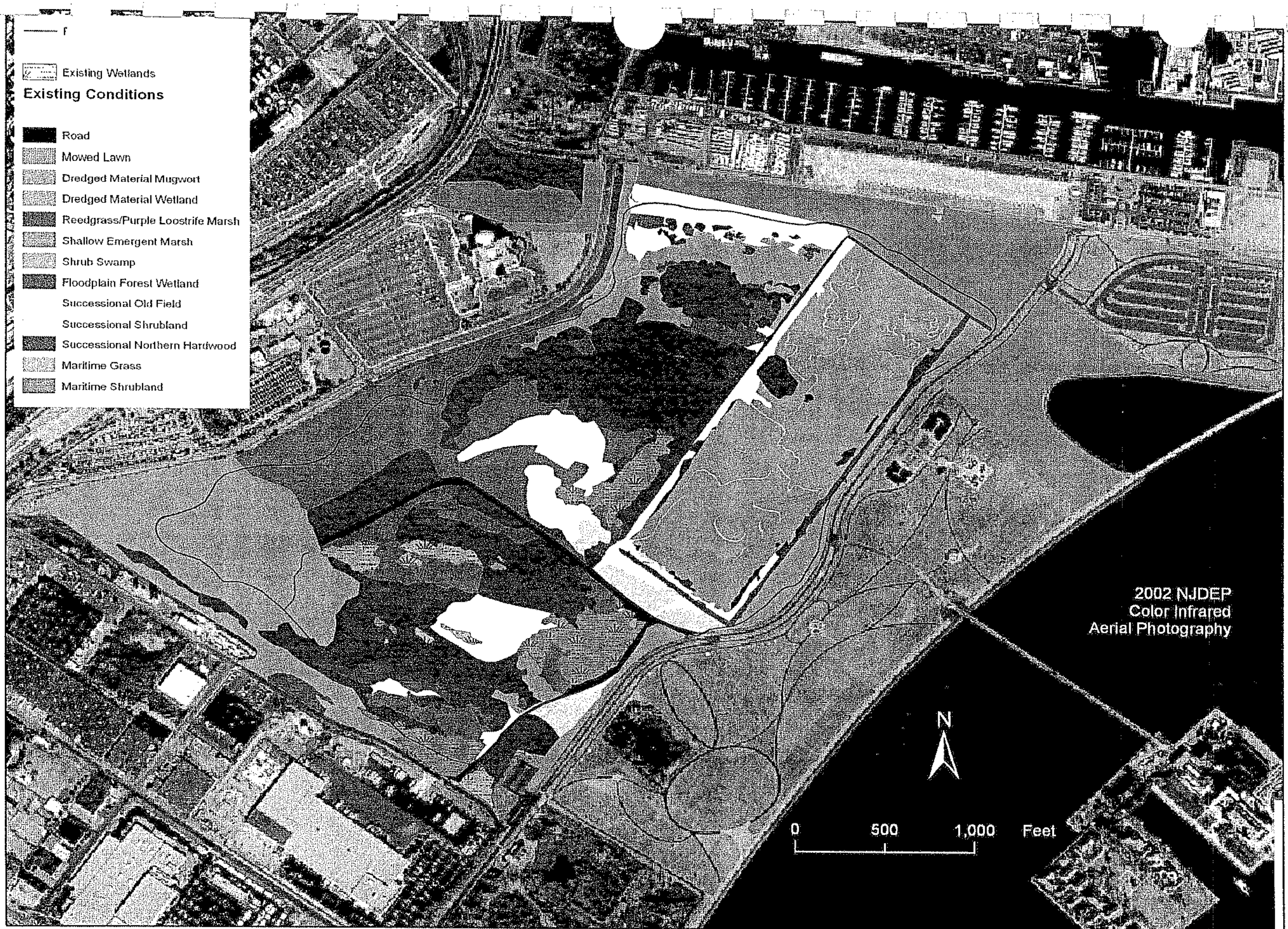

Figure 3. Existing Conditions Vegetation Map (U.S. Army Corps of Engineers, 2004; Schneider, pers. comm., 2004)

C. WILDLIFE

1. Federally Listed Species

Appendix C gives all bird species observed in Liberty State Park that are federally listed, State-listed, or designated as federal or State species of concern (New Jersey Department of Environmental Protection, 2000). Federally listed species are addressed here; other species are discussed below in Section 3 (Birds). Appendix C includes two species that are federally listed under the Endangered Species Act (87 Stat. 884, as amended; 16 U.S.C. 1531 *et seq.*) (ESA): the bald eagle (*Haliaeetus leucocephalus*) and piping plover (*Charadrius melodus*), both listed as threatened. Both species occur as visitors to Liberty State Park from spring through fall (New Jersey Department of Environmental Protection, 2000). Piping plovers and bald eagles observed in the park to date were most likely transient individuals moving through on migration. The federally listed (endangered) roseate tern (*Sterna dougallii*) may also pass through the area during migration. None of these three species currently nests in the vicinity of the park.

The proposed ecosystem restoration may enhance foraging habitat for transient piping plovers and roseate terns that pass through Liberty State Park during migration. The project is not expected to create nesting habitat for these species. Given the distance to known nesting areas, neither piping plovers or roseate terns are expected to make significant use of the project area as foraging habitat during the nesting season. The project is not likely to adversely affect these species; therefore, no further consultation pursuant to Section 7 of the ESA is required by the Service for the piping plover or roseate tern at this time.

The project may enhance the suitability of habitats in Liberty State Park for migrant bald eagles. Eagle populations are expanding in New Jersey, and improved habitat conditions may attract eagles to initiate nesting and/or establish a significant wintering area in the park following completion of the project. The Service anticipates that the proposed habitat modifications will not adversely affect bald eagles. However, indirect adverse effects (*i. e.*, disturbance, low reproductive success) of attracting eagles to the newly enhanced habitats may occur without proper species management.

The Service recommends that the Corps prepare a brief contingency plan for bald eagle management, and complete informal consultation on the plan pursuant to Section 7 of the ESA, during the Planning, Engineering, and Design (PED) phase of the project. If desired, the Corps may designate the DPF as its non-federal representative to prepare and implement the plan, and to conduct consultation. Recommended plan elements include:

- participation in the NJDEP Endangered and Nongame Species Program's (ENSP) eagle monitoring program;
- participation in the ENSP's blood sampling and nestling banding program;
- restricted public access within 1.0 mile of any nest site or 0.25 mile of any important wintering sites, in accordance with site-specific recommendations of the ENSP;

- ENSP and Service review of any major construction activities proposed in the future within 1.0 mile of any nest site or 0.25 mile of any important wintering sites (seasonal restrictions and habitat protections may be recommended on a case by case basis).

Except for the above-mentioned species, no other federally listed or proposed endangered or threatened flora or fauna under Service jurisdiction are known to occur within the vicinity of the proposed project site. Principal responsibility for threatened and endangered marine species is vested with the National Marine Fisheries Services (NMFS). As the proposed project will affect marine environments in the North Cove, the NMFS must be contacted to fulfill consultation requirements pursuant to Section 7 of the ESA:

National Marine Fisheries Service
Habitat and Protected Resources Division
Sandy Hook Laboratory
Highlands, New Jersey 07732
(732) 872-3023

2. Mammals

The Corps conducted mammal sampling from August through October 2003. Results are presented in Table 2 (U.S. Army Corps of Engineers, 2004).

Table 2. Mammals Documented in Liberty State Park (U.S. Army Corps of Engineers, 2004)

eastern cottontail	*Sylvilagus floridanus*	uncommon
woodchuck	*Marmota monax*	uncommon
gray squirrel	*Sciurus carolinensis*	uncommon
white-footed mouse	*Peromyscus leucopus*	very common
meadow vole	*Microtus pennsylvanicus*	common
muskrat	*Ondatra zibethicus*	uncommon
Norway rat	*Rattus norvegicus*	uncommon
house mouse	*Mus musculus*	uncommon
raccoon	*Procyon lotor*	uncommon
domestic cat	*Felis catus*	common
feral dog	*Canis familiaris*	common

The Service recommends that the DPF (local sponsor) initiate and maintain a program to control populations of feral cats and dogs in the park. Left unchecked, these feral animals may undermine the wildlife enhancements of the proposed project by disturbing and preying on small mammals and birds, including State-listed species.

3. Birds

According to the Corps 2003 wildlife surveys, birds are the most abundant and diverse wildlife in Liberty State Park. This is expected, as the extreme isolation of the park's habitats within an urban landscape impedes colonization by terrestrial mammals, reptiles, and amphibians. Flight, and the highly migratory nature of many birds, allow these species to utilize the habitats of

Liberty State Park, including the Restoration Area, the salt marsh along the South Cove, and the adjacent open waters of the Hudson River including the park's North and South Coves. All migratory birds are a federal trust resource, protected under the Migratory Bird Treaty Act (40 Stat. 755; 16 U.S.C. 703-712). The Service considers migratory birds a priority for habitat enhancements at Liberty State Park.

The Corps conducted point counts in the Restoration Area in August 2003, and collected incidental bird observations in the course of other field work throughout 2003. A total of 131 species were observed during 2003 by Corps, contractor, and park staff. A list of all bird species known to occur in Liberty State Park is provided in Appendix C, based on the 2003 field work as well as park records, with a total of 241 species (New Jersey Department of Environmental Protection 2000; U.S. Army Corps of Engineers, 2004). [Scientific names for all species mentioned below are provided in Appendix C.]

a. <u>Species of Concern</u>

In its database of rare, threatened, and endangered species, the New Jersey Natural Heritage Program has a record of only the State-listed (endangered) Northern harrier within Liberty State Park (Appendix B). The NJDEP's Landscape Project maps show habitat for only the Northern harrier and peregrine falcon within the park (Niles *et al.*, 2001). However, the master bird list in Appendix C includes 50 species that are listed as endangered or threatened by the Service or the NJDEP, or are considered Service or State species of concern (see Appendices A-D). These 50 species are known to use park habitats at different times of year, with most using the park as wintering and migratory stopover habitat only. Only three of these species, Northern harrier, spotted sandpiper (State species of concern), and marsh wren (Service species of concern), have documented nesting attempts in the area, according to Breeding Bird Atlas records (Walsh *et al.*, 1999). Although not known to breed in the park, peregrine falcons nest within 0.75 mile of the Restoration Area, according to Landscape Project maps; these and other nearby nesting peregrines likely use park habitats during the breeding season. Nineteen of these 50 species are State-listed, including two species that are also federally listed (piping plover and bald eagle, as discussed above). Information regarding the biology and status of these 19 State-listed species is provided in Appendix E. The ENSP's general conservation recommendations for these 19 species are provided in Table 3.

b. <u>Breeding Birds</u>

Thirty-eight of the species listed in Appendix C are known to breed in the Breeding Bird Atlas block that includes Liberty State Park (Walsh *et al.*, 1999). As the park encompasses virtually all of the New Jersey land area in this atlas block, it can be assumed that these species have been documented breeding within Liberty State Park. Breeding species include dabbling ducks (American black duck, mallard, gadwall), swallows (tree and barn), short-distance migrant passerines (American robin, Eastern towhee, brown thrasher, gray catbird, Northern mockingbird, Northern cardinal, American goldfinch, house finch), and common urban species (rock dove, mourning dove, European starling, house sparrow, American crow, common grackle). Some noteworthy breeding species include the State-listed (endangered) Northern

Table 3. General Conservation Recommendations for State and Federally Listed Avian Species Known to Occur in Liberty State Park (Beans and Niles, 2003)

pied-billed grebe	➢ Protect existing wetlands, particularly those ≥ 25 acres that contain a mix of emergent vegetation, submergent vegetation, and open water. ➢ Protect smaller wetlands ≤ 12.5 acres that provide habitat for single pairs. ➢ Preserve buffers surrounding breeding habitat. ➢ Create man-made wetlands to bolster low populations. ➢ Include pied-billed grebes in waterfowl management plans for public land. ➢ Maintain the successional stage of wetland vegetation by periodic cutting of tracts on a rotational basis. ➢ Manage breeding ponds to contain floating and submerged aquatic vegetation as well as emergent vegetation. ➢ Maintain stable water levels during the breeding season. ➢ Do not conduct draw-downs during the nonbreeding season that completely dry the marsh. ➢ Protect wetlands from pollution and siltation, and monitor water quality. ➢ Restrict human activity during the breeding season.
American bittern	➢ Protect emergent wetlands through land use and environmental regulations. ➢ Consider adequate buffers in habitat acquisition. ➢ Restrict human activity around known nesting areas. ➢ Manage or restore habitats to a mix of dense emergent vegetation, submerged and floating aquatic vegetation, and open water with water depths a maximum of 4 inches; minimum marsh area of 5 to 12.5 acres is recommended with a buffer of dense, woody vegetation. ➢ Suppress vegetative succession in the marsh through cutting or controlled burning during the nonbreeding season. ➢ Control invasive plant species on a rotational basis to provide areas of undisturbed habitat each year. ➢ Survey for breeding sites, monitor existing nesting areas, and determine population trends. ➢ Develop and implement specific habitat management guidelines for bitterns on State and federal lands.
black-crowned night heron	➢ Protect existing colonies and areas of potential habitat. ➢ Control predators as necessary. ➢ Create nesting and roosting habitat on artificial islands 5 to 50 acres, and 3.3 to 9.9 feet above the high-water line; do not cover existing nest sites or suitable habitat when raising elevation of existing islands; carefully evaluate impacts from contaminated sediment. ➢ Maintain 330 to 650-foot buffers for human activity around heronries, including watercraft; fence colonies before the arrival of nesting birds as needed to enforce the buffer. ➢ Provide telescopes and educational materials to encourage low-impact observation of rookeries.
yellow-crowned night heron	➢ Same as black-crowned night heron.
osprey	➢ Closely monitor osprey as an indicator of water quality and aquatic ecosystem health. ➢ Erect new nesting platforms and maintain existing platforms. ➢ Prohibit human activity, especially the use of personal watercraft, in marshes and water bodies containing nesting osprey.
bald eagle	➢ Monitor active nests and minimize human disturbance near nests in conjunction with the ENSP's volunteer program.

	➢ Participate in the ENSP's banding and contaminant monitoring efforts. ➢ Protect habitat near nest sites and in recognized wintering areas through acquisition, landowners agreements, and enforcement of land use regulations.
northern harrier	➢ Identify and protect existing breeding and roosting locations. ➢ Prohibit human activity within a 1,000-foot buffer of nesting sites. ➢ Protect, maintain, or create high-marsh habitats. ➢ Acquire and manage upland fields adjacent to coastal marshes. ➢ Convert dense stands of *Phragmites* to high marsh containing a mosaic of salt meadow cordgrass (*Spartina patens*), saltgrass (*Distichylis* sp.), rushes (*Juncus* sp.), and marshelder (*Iva* sp.), with only scattered patches of *Pharagmites*. ➢ Manage large grasslands to create habitat for harriers; encourage tall grassy vegetation and control woody growth through annual or biennial mowing or controlled burns, after all young have fledged, on a rotating schedule.
Cooper's hawk	➢ Protect large, contiguous forests, both wetland and upland. ➢ Target wooded tracts surrounding known nesting sites, particularly those within large forests, for protection. ➢ Restrict human activity within 0.25 mile of nest sites during the breeding season, early April through late July. ➢ Plant groves of [native] conifers and offer a mosaic of wooded, edge, and field habitats for wintering and migrant birds.
northern goshawk	➢ Protect and/or acquire blocks of mature, contiguous forest containing large canopy trees and an open understory, with priority for such areas that are adjacent to already protected sites. ➢ Restrict development and timber harvest within buffers around areas of high-quality habitat. ➢ Restrict human activity at known nesting sites; close hiking and vehicle trails and campsites within or adjacent to goshawk territories during the nesting season.
peregrine falcon	➢ Participate in ENSP's management of nest sites, including banding and contaminants testing. ➢ Consider peregrine nest locations when conducting maintenance or construction on buildings and bridges; conduct activities that may disturb birds outside the breeding season, which is March 1 to July 31.
piping plover	➢ Participate in ENSP's management of nesting areas, including fencing, monitoring, predator control, restriction of human activity, and education. ➢ Design beach replenishment projects to incorporate plover needs and create habitat.
red knot	➢ Protect horseshoe crab populations. ➢ Avoid oil spills. ➢ Verify and control laughing gull population increases as needed.
least tern	➢ Same as piping plover.
black skimmer	➢ Same as piping plover.
long-eared owl	➢ Provide dense stands of [native] conifers and fallow open fields; plant additional groves of evergreens. ➢ Protect existing roost sites. ➢ Implement management efforts on pubic and private lands. ➢ Maintain grasslands, meadows, fallow fields, and low-impact agriculture through cutting, low-density grazing, or controlled burns. ➢ Rotate agricultural crops with fallow fields annually. ➢ Avoid large agricultural monocultures and promote a mosaic of smaller fields containing diverse species. ➢ Limit use of rodenticide.

short-eared owl	➢ Protect large tracts of salt-hay marshes from ditching, tidal restoration efforts, and human activity. ➢ Target upland fields adjacent to salt-hay marshes for acquisition, and maintain as grasslands. ➢ Suppress vegetative succession though mowing, grazing, or controlled burns during the nonbreeding season, on a rotational basis. ➢ Restrict human activity within a 1,000-foot buffer of any nest site. ➢ Survey for nesting owls in areas of suitable habitat, especially where nesting has been suspected or confirmed in the past; check for nesting birds during the summer in areas where owls were seen in late spring.
sedge wren	➢ Protect and manage marshes, especially those ≥ 12 acres and containing tall, dense stands of sedges and grasses with scattered shrubs. ➢ Control vegetative succession through selective cutting of parcels during the nonbreeding season, on a rotational basis. ➢ Prohibit herbicide and pesticide use on marshes occupied by sedge wrens. ➢ Prohibit human activity within a 300-foot buffer of nesting sites during the breeding season. ➢ Conduct research on the habitat requirement of this species.
bobolink	➢ Maintain, restore, or create and manage grassland nesting sites. ➢ Participate in farmland preservation and cooperative efforts. ➢ Cultivate warm-season native grasses such as little bluestem (*Schizachyrium scoparium*), poverty grass (*Danthonia spicata*), switchgrass (*Panicum virgatum*), and Indian grass (*Sorghastrum nutans*). ➢ Maintain open habitats through mowing, grazing, or controlled burns during the nonbreeding season (after mid- to late July) on a 2 to 5-year rotational schedule.
savannah sparrow	➢ Maintain grasslands. ➢ Suppress vegetative succession through annual mowing, light grazing, or controlled burns during the nonbreeding season (outside May 15 to August 1) on a rotational basis; burn on a 4-year basis. ➢ Plant a mix of tall and short grasses and forms at restoration sites. ➢ Protect vegetated coastal dunes as habitat for wintering sparrows.

harrier, the State species of concern spotted sandpiper, American woodcock, barn owl, and marsh species including common moorhen, red-winged blackbird, and marsh wren (a Service species of concern).

c. Migratory Birds

Of the 445 species of birds documented in New Jersey, about half are migratory (New Jersey Audubon Society, 2004). Although the focus of research and conservation efforts for Neotropical migrants has been on breeding and wintering grounds, habitat used during migration may be equally important to the survival of a species. Migrating birds following "programmed" pathways must be able to satisfy energy requirements, avoid predators, and minimize environmental stress during stopovers (U.S. Fish and Wildlife Service, 1997).

The latitude, geography, and habitats of New Jersey are key reasons for the noteworthy abundance and diversity of birds that pass through the State during migration (Dunne, 1989; New Jersey Audubon Society, 2004). The Hudson River and the urban core of the New York City metropolitan area provide important migration corridors and stopover habitat for Neotropical migrant landbirds (U.S. Fish and Wildlife Service, 1997). A large number of migratory birds are funneled through the New York urban core by the orientation of the coastline and other geographic features of the area, and these birds are further concentrated in the small amounts of remaining open space. Rivers, including the Hackensack and the Hudson, concentrate migrants, especially during fall migration when birds get pushed to the shorelines by strong northwesterly winds. Woodlands and wetlands along these rivers are critical to migrants (Dunne, 1989; New Jersey Audubon Society, 2004). Even isolated woodland pockets along major river corridors provide essential stopover habitats, serving as "urban oases" for energetically-stressed migrants. Protection of remaining open space and restoration of additional areas, especially forested areas, should be a priority in the urban core (Dunne, 1989; U.S. Fish and Wildlife Service, 1997; Maryland Partners in Flight, 1998; Rosenberg *et al.*, 1999; New Jersey Audubon Society, 2004).

Ninety-two of the species listed in Appendix C occur in Liberty State Park during migration. With habitat enhancements proposed by the Corps and the DPF, the park may attract still more species during their migrations.

d. Waterfowl

Not including pelagic birds and sea ducks, 32 native species of waterfowl regularly use the estuarine, riverine, lacustrine, and palustrine wetlands and adjacent uplands in the New York Bight watershed[1] for breeding, migrating, or over-wintering. Twelve species of waterfowl nest and breed in the New York Bight watershed, of which mallard, American black duck, and Canada goose are the most prevalent (U.S. Fish and Wildlife Service, 1997). Occasional nesters include gadwall, green-winged teal, and blue-winged teal (U.S. Army Corps of Engineers, 2004).

The primary use of the New York Bight by waterfowl is for resting and feeding during fall migration, which peaks in November, and for wintering. In transit from the major breeding grounds in the Midwest, Canadian prairies, and Arctic to their wintering grounds along the Atlantic coast, several species of waterfowl migrate in substantial numbers down the Hudson River or along the Atlantic coast, stopping to rest and feed in the New York Bight watershed (U.S. Fish and Wildlife Service, 1997). This southbound migratory pattern funnels birds through the New York-New Jersey Harbor (NY-NJ Harbor). The northward migration from the NY-NJ Harbor begins as early as February for some species, but for most occurs in March (U.S. Army Corps of Engineers, 2004).

For several species of waterfowl, the mid-winter populations occurring in the New York Bight account for a major part of their total Atlantic flyway population. For example, about one-third of the Atlantic flyway population of American black duck winters in the New York Bight. Wintering black ducks are found, along with mallards, distributed in bays, marshes, and flats along the Hudson River and the NY-NJ Harbor. The New York Bight watershed is at the center of both the breeding and wintering ranges for this species (U.S. Fish and Wildlife Service, 1997).

In addition, sea ducks, loons, and grebes are found in the waters of the New York Bight. Concentration areas, species composition, and densities of nonbreeding birds shift seasonally,

[1] Includes the Hudson River drainage in New York State, and all areas draining to the Atlantic Ocean in Long Island and New Jersey.

depending upon the distribution of migration habitats and food resources. However, the NY-NJ Harbor, located at the apex of the Bight, appears to host high concentrations of these birds all year (U.S. Fish and Wildlife Service, 1997).

Common waterfowl species in the NY-NJ Harbor include American black duck, mallard, brant, greater scaup, canvasback, and Canada goose, along with lesser numbers of bufflehead, long-tailed duck, red-breasted merganser, common goldeneye, and American wigeon; overwintering species include gadwall, American black duck, northern pintail, and mallard. All of these species have been observed in the waters adjacent to Liberty State Park (Appendix C). Within the NY-NJ Harbor, concentrations of waterfowl occur along the Staten Island shoreline, in Caven's Cove (Liberty State Park), in the Kill van Kull, and along the lower Hudson River. Black duck, mallard, and Canada goose were the most abundant species documented during 2003 field surveys, and are expected to use the waters of the park's North and South Coves (U.S. Army Corps of Engineers, 2004).

e. Colonial Waterbirds

The Service surveyed waterbird colonies from Maine to Virginia in the mid-1970s, mid-1980s, and mid-1990s (Conservation Management Institute, 2001). The bays and islands of the New York Bight are important for nesting and foraging by long-legged waders (herons, egrets, and ibises), with a total of over 7,500 pairs recorded in the most recent (1995) surveys. In 1985, a similar number of waders in the Bight accounted for about 23 percent of the total Atlantic coast population from Maine to Virginia. Glossy ibis, snowy egret, and black-crowned night-heron are the most common species of long-legged waders nesting in the Bight. These birds prefer to nest in large colonies in shrubs or trees on salt marsh, dredged material, or rocky islands and are most common where there is a prevalence of vegetated islands, especially salt marsh and dredged material islands. Populations of long-legged waders within the New York Bight have been fairly stable over the past two decades, although recent declines in snowy egret and cattle egret are of concern. For both of these species, especially the cattle egret, most of these declines have occurred in the Arthur Kill colonies of the NY-NJ Harbor, formerly one of the largest colonies in the region (U.S. Fish and Wildlife Service, 1997).

The colonies of gulls and terns in the New York Bight are also a significant component of the total Atlantic coast population. In 1985, the New York Bight colonies of gulls and terns (excluding least tern) accounted for about 40 percent of the Atlantic coast population from Maine to Virginia. Gulls and terns nest on sparsely vegetated dredged material islands, rocky islands, dunes, beaches, and salt marsh islands. Populations of all three species of nesting gulls, as well as two species of terns (common and roseate), have declined since 1989. The most significant decline has been observed for the common tern, which has declined 72 percent since 1989 (U.S. Fish and Wildlife Service, 1997).

The islands of the NY-NJ Harbor are important nesting areas for colonial species (U.S. Fish and Wildlife Service, 1997). Seventeen of the colonies documented during Service surveys are located within 15 miles of the Liberty State Park Restoration Area, including colonies in the Hackensack Meadowlands, on and around Staten Island (including Arthur Kill and Kill van Kull islands), on the islands of Jamaica Bay and the East River, and on open water islands in Lower New York Bay. In 1995, these 17 colonies supported seven species of wading birds and seven species of gulls and terns, plus double-crested cormorants and black skimmers (Conservation Management Institute, 2001).

The New York City Audubon Society has monitored colonies on islands in the NY-NJ Harbor for the past 20 years. In 2003, the survey effort included 14 islands, including eight of the colonies documented during Service surveys. A total of 1,837 pairs of herons, egrets, and ibis of eight species were documented nesting on seven of the 14 surveyed islands. These numbers were about 20 percent greater than in 2002, and only slightly lower than peak counts documented in the mid-1990s (Kerlinger, 2003a). The relative numbers of species have not changed dramatically over the years, except for cattle egrets, which have virtually disappeared from the Harbor (Kerlinger, 2003b).

In areas with numerous islands, the locations of heronries may shift significantly from year to year and from island to island (U.S. Fish and Wildlife Service, 1997). This shifting appears to be the case in the NY-NJ Harbor. Islands in the Arthur Kill and Kill van Kull were gradually abandoned in the late 1990s, and have not supported nesting herons, egrets, or ibis for several years. As the birds on the Arthur Kill islands declined, populations on other Harbor islands increased. The reasons for the abandonment of the Arthur Kill islands is unclear (Kerlinger, 2003b). However, given overall population trends on Harbor islands, it is likely that birds have relocated to other nesting sites.

Several species of wading birds are known to forage in Liberty State Park, primarily in the South Cove marsh. Common species using the park include snowy egrets, great egrets, and green herons. State-listed (threatened) black-crowned and yellow-crowned night herons are also frequently observed. In addition, the shallow waters of the park's North and South Coves provide foraging habitat for several species of gulls and terns. The most abundant are great black-backed gulls, herring gulls, ring-billed gulls, and laughing gulls; however, several other species have been noted including the State-listed (endangered) black skimmer and least tern (U.S. Army Corps of Engineers, 2004).

f. <u>Shorebirds</u>

Thirty species of migratory shorebirds and related species regularly use marine and freshwater habitats and adjacent habitats in uplands in the New York Bight watershed for breeding, wintering, and migration. Most of these species breed in interior regions of North America, especially in the Arctic and subarctic, and spend two-thirds to three-quarters of the year on migration routes and wintering grounds. Seven shorebird species nest within the New York Bight watershed, including beach-nesting shorebirds and grassland-nesting species. Shorebirds show a strong affinity for wetlands, and typically swarm beaches, marshes, and tidal flats during migration (U.S. Fish and Wildlife Service, 1997).

Shorebirds migrate through the New York Bight almost all year, with northward migration beginning in late winter and lasting through June, and southward migration beginning in late

June with peaks in late July and lasting into the fall. Shorebirds rely on a mosaic of shallow coastal or freshwater wetlands and adjacent upland areas. Foraging habitats are found in beaches, mudflats, sandflats, salt marshes, impoundments, flooded agricultural fields, and grasslands. In coastal areas, preferred food items include macroinvertebrates such as polychaete worms, crustaceans, mollusks, or insects. Roosting habitats, usually used at night or during high tide periods when primary feeding areas are not accessible, include salt marshes, sandflats and beaches above the tide line, and sparsely vegetated islands free of predators (U.S. Fish and Wildlife Service, 1997).

Large numbers of migratory shorebirds travel great distances between breeding and wintering grounds and concentrate in small stopover areas with seasonally-abundant food resources to accumulate energy reserves for continuing their long-distance flights. Because large numbers of shorebirds are concentrated in just a few areas during migration, loss or degradation of key sites could devastate these populations. Given relatively few sites that consistently support large numbers of shorebirds, the Service has identified seven sites located partially or wholly within the New York Bight watershed with counts of 5,000 or more shorebirds during spring, autumn, or winter. Although the NY-NJ Harbor in the immediate vicinity of Liberty State Park is not among these key shorebird sites, migrating shorebirds occur throughout the shallow bays and estuaries of the New York Bight, especially during the autumn migration (U.S. Fish and Wildlife Service, 1997).

The most abundant shorebird species in the Harbor area are semipalmated sandpiper (*Calidris pusilla*), semipalmated plover, sanderling, ruddy turnstone, black-bellied plover, dunlin, short-billed dowitcher, greater and lesser yellowlegs, and least sandpiper. Shorelines along Liberty State Park, including marsh and mudflats, provide foraging and resting habitats for shorebirds, as do the freshwater wetlands within the Restoration Area (U.S. Army Corps of Engineers, 2004).

g. Raptors

Several raptors utilize foraging, nesting and overwintering habitats within the NY-NJ Harbor area. Red-tailed hawk, Northern harrier, osprey, barn owl, and peregrine falcon are the most common species observed during the breeding season. Common winter residents include Northern harrier, rough-legged hawk, American kestrel, barn owl, short-eared owl, long-eared owl, and peregrine falcon. Raptors often observed within the vicinity of Liberty State Park include osprey, Northern harrier, red-tailed hawk, barn owl, and peregrine falcon. The small mammal and songbird populations of the area provide prey for resident and migratory raptor populations (U.S. Army Corps of Engineers, 2004).

h. Forest Interior Birds

There are 24 species of Neotropical migrants that breed in the New York Bight watershed whose overall populations significantly declined from 1966 to 1990. Of these, 7 species, or 29 percent, are associated with mature forest (U.S. Fish and Wildlife Service, 1997). Additional forest interior migrants are declining locally or regionally. Numerous factors may contribute to population declines of these forest species, including collisions with man-made structures, exposure to environmental contaminants, and loss of wintering or migratory stopover habitats. However, loss and fragmentation of forested habitats, especially in the Northeast, are generally considered the primary reasons for the declines of forest interior birds (U.S. Fish and Wildlife Service, 1997; 2002a).

Most forest interior birds are long-distance migrants that winter in Central and South America (Ambuel and Temple, 1983; Askins and Philbrick, 1987; Robbins, 1988). A few forest interior species, notably woodpeckers and certain other cavity-nesters, are year-round residents in the Northeast (Galli *et al.*, 1976; Robbins *et al.*, 1989). Forest edge species tend to be short-distance migrants, often generalists, and frequently adapted to agricultural and suburban habitats (Blake and Karr, 1984; Hobson and Bayne, 2000, Robbins *et al.*, 1989).

Area dependence is the distinguishing feature of forest interior species. Numerous studies over the past 30 years have shown that the probability of occurrence and/or the reproductive success of many forest-nesting species are strongly correlated with woodlot area. In fact, area can often explain more variation in species occurrence among woodlots than vegetative and other habitat characteristics (Ambuel and Temple, 1983; Andrén and Angelstam, 1988; Blake and Karr, 1987; Forman *et al.*, 1976; Galli *et al.*, 1976; Hobson and Bayne, 2000; Robbins *et al.*, 1989). In contrast, short-distance migrants (edge-adapted species) tend to be area independent, or show a negative relationship to woodlot area (Robbins *et al.*, 1989). Area requirements of forest interior species should not be confused with territory size, as certain species appear to require vastly greater areas for nesting than are actually defended.

The degree of habitat isolation is also key to forest interior birds. Minimum area requirements for various species tend to decrease with the distance to nearest "large" forest, or with increasing percent regional forest cover. In fact, area dependency appears to be a result of fragmented landscapes, as area sensitivity for many species becomes negligible in highly forested (over 70 percent) landscapes. Along with surface area, several studies have shown that degree of isolation is an important predictor of the occurrence of various species in a given woodlot (Blake and Karr, 1987; Hobson and Bayne, 2000; Robbins *et al.*, 1989; Rosenberg *et al.*, 1999; Dettmers and Rosenberg, 2000; Maryland Partners in Flight, 1998).

Edge effects are the prevailing explanation for area dependency of forest birds in fragmented landscapes (Manolis *et al.*, 2000; Ontario Ministry of Natural Resources, 2001; Rodewald, 2001; Rosenberg *et al.*, 1999). Edge effects are primarily biotic interactions (predation, parasitism, competition) between forest-nesters and suburban or agricultural species in the surrounding landscape that lower reproductive success of the forest birds. These interactions are concentrated around the perimeter of a woodlot. Several studies have found higher rates of nest predation in the edges versus the interiors of woodlands (Andrén and Angelstam, 1988; Gates and Gysel, 1978; Wilcove, 1985), as well as higher rates of nest parasitism by brown-headed cowbirds (Brittingham and Temple, 1983; Gates and Gysel, 1978). Species adapted to edge conditions, which include many short-distance migrants, may displace interior species around the margins of woodlots (Askins and Philbrick, 1987; Forman *et al.*, 1976; Robbins, 1988). In addition to biotic interactions, edge habitats are also degraded by increased exposure to human disturbance, noise, pollution, wind, hydrologic change, and invasive species, and offer a lower diversity and abundance of insect prey and microhabitats (Cochrane, 2001; Ontario Ministry of Natural Resources, 2001; Rodewald, 2001; Robbins *et al.*, 1989).

The distance an edge effect extends into a woodland is variable, but most studies point to about 330 feet (100 meters) (Ontario Ministry of Natural Resources, 2001; Robbins, 1988; Rodewald, 2001; Rosenberg *et al.*, 1999; Rusak, Undated; Maryland Partners in Flight, 1998). Because of edge effects, the acreage of interior habitat defined as at least 330 feet from an edge, or the area-to-perimeter ratio, are better measures of habitat available for interior species than area alone. Patch size and shape are key, as round or square woodlots have proportionally less edge than irregular or elongated woodlots (Ontario Ministry of Natural Resources, 2001; Robbins *et al.*, 1989, Rosenberg *et al.*, 1999). Regardless of shape, patches under one-half acre are virtually all edge (Galli *et al.*, 1976). One large forest (with less edge effect) will generally support a higher diversity of interior species than a similar acreage split over two or more distinct woodlots (with greater edge effect) (Ambuel and Temple, 1983; Forman *et al.*, 1976). Cleared corridors as narrow as 52 feet within a forest have been shown to cause edge effects such as increased predation and parasitism, although birds may not perceive distinct habitat patches at such narrow breaks (Rich *et al.*, 1994).

Several studies have attempted to calculate minimum area requirements for forest interior birds. Because interior species show differences in their minimum areas, diversity of interior birds increases with the size of a woodland. Thus, the bird communities in various sized woodlands in a fragmented landscape can be thought of as "nested subsets" of the overall regional avifauna, increasing with area until the full diversity of interior species is reached in the largest forests (many thousand acres) (Ambuel and Temple, 1983; Blake, 1991; Galli *et al.*, 1976; Robbins *et al.*, 1989; Maryland Partners in Flight, 1998). No forested areas of this size are available in the urban landscape surrounding Liberty State Park.

Twenty-one species of forest interior birds are known from Liberty State Park (Appendix C). All but two have been documented in the park as migrants. Wood thrush is a summer visitor, and hairy woodpecker is a year-round resident. Only one species, American redstart, is documented to breed in the area. The age of this breeding record is unknown, but this species was not known from Liberty State Park records prior to 2003 surveys. Given available information, it should not be assumed that American redstarts are currently breeding in the park.

The forested portions of the Liberty State Park Restoration Area are most likely too immature, too fragmented, and too small to support interior nesting species, particularly given the extreme isolation of park habitats from other forests within a highly urban landscape. However, as vegetational succession proceeds, the park may eventually attract those forest interior nesting species at the lower end of area requirements. Estimates of nesting area requirements for interior species documented in Liberty State Park are given in Table 4 for those species where information is available.

Table 4. Nesting Area Requirements for Forest Interior Birds Documented in Liberty State Park

Common Name	Nesting Area Requirements (acres)
hairy woodpecker	5 (Galli *et al.*, 1976); 17 (Robbins *et al.*, 1989)
Acadian flycatcher	37 (Robbins *et al.*, 1989)
brown creeper	
blue-gray gnatcatcher	37 (Robbins *et al.*, 1989)
veery	50 (Robbins *et al.*, 1989)
Swainson's thrush	
hermit thrush	
wood thrush	2 (Galli *et al.*, 1976); 2.5 (Robbins *et al.*, 1989)
yellow-throated vireo	
red-eyed vireo	2 (Galli *et al.*, 1976); 6 (Robbins et al., 1989)
black and white warbler	17.5 (Galli *et al.*, 1976); 544 (Robbins et al., *1989)*
American redstart	
Northern parula	1,285 (Robbins *et al.*, 1989)
black-throated blue warbler	2,471 (Robbins *et al.*, 1989)
black-throated green warbler	
Blackburnian warbler	
ovenbird	10 (Galli *et al.*, 1976); 15 (Robbins *et al.*, 1989)
Northern waterthrush	494 (Robbins *et al.*, 1989)
Louisiana waterthrush	865 (Robbins *et al.*, 1989)
Canada warbler	988 (Robbins *et al.*, 1989)
scarlet tanager	7.5 (Galli *et al.*, 1976); 30 (Robbins *et al.*, 1989); 129 (Rosenberg *et al.*, 1999)
Sources	
Galli *et al.*, 1976	Minimum size in which species was detected in at least 1 of 8 samples.
Robbins *et al.*, 1989	Forest areas at which probability of occurrence is at 50% the maximum observed.
Rosenberg *et al.*, 1999	In a landscape with 20% forest cover, 129-acre patch is considered low-suitability habitat for scarlet tanager.
	With 10% regional forest cover, the minimum area required exceeds the regional availability of forest.
	The Liberty State Park landscape is about 14% forested, including the park itself, based on NJDEP land use maps.

Although the Service supports management to promote nesting by forest interior species at Liberty State Park, the wooded interior must be managed carefully to avoid creating a population sink for these species (Askins and Philbrick, 1987; Hobson and Bayne, 2000; Robbins, 1988; U.S. Fish and Wildlife Service, 1997). Even if succession eventually produces a forested central area, the shape and acreage of the wooded portion of the Restoration Area may be near the minimum necessary to support nesting species. Especially given the park's isolation, this forest could attract interior nesting birds, but be unable to support successful reproduction. Even absent nesting activity, the importance of the park's forests to forest species during migration is evident from the high diversity of forest interior birds that have been documented passing through.

i. Grassland Birds

Of the 24 species of declining Neotropical migrants that breed in the New York Bight watershed, 17 species, or 71 percent, are associated with early successional habitats such as grasslands (U.S. Fish and Wildlife Service, 1997). Grassland birds have experienced steeper, more consistent, and more widespread population declines than any other North American avian group (Rothstein, 2001; Vickery *et al.*, 1999; Dettmers and Rosenberg, 2000; Winter and Faaborg, 1999; Maryland Partners in Flight, 1998; U.S. Fish and Wildlife Service, 1997). Most grassland species migrate medium distances, wintering in the southern United States and Mexico. Thus, changing agricultural practices and loss of farmlands in the U.S. affect these species on both wintering and breeding grounds (Murphy, 2003; Vickery *et al.*, 1999). Although the Northeast does not support the majority of grassland bird populations, nesting birds in this region represent an important component of range-wide diversity for these species (Dettmers and Rosenberg, 2000).

The area requirements and edge effects of grassland birds have been less studied than forest interior birds, particularly in the Northeast. However, the same factors reducing habitat suitability and nesting success are thought to apply to grasslands, namely predation, parasitisim, competition, and disturbance (Bay, 1996; Winter and Faaborg, 1999). As with forest interior birds, probability of occurrence, reproductive success, and diversity of grassland species often increases with area (Bay, 1996; Helzer and Jelinski, 1999). Also like forests, the degree of isolation also appears to influence minimum patch sizes, probably through effects on reproductive success (Helzer and Jelinski, 1999; Johnson and Igl, 2001).

Minimum area requirements for grassland species occurring in the Northeast are given in Table 5. Johnson and Igl (2001) note that minimum patch size can vary regionally. When fully enhanced by the proposed project, the shape and acreage of grasslands within the Restoration Area may be near the minimum necessary to attract certain grassland nesting birds. As with forest interior species, the Service recommends habitat management to promote nesting within the project area, but suggests proceeding with caution to avoid Liberty State Park's grasslands developing as a population sink (Winter and Faaborg, 1999).

Liberty State Park's grasslands are valuable to wildlife even absent additional nesting species. Six obligate grassland species have already been documented in the park (Appendix C), including the State-listed bobolink and savannah sparrow that pass through on migration, the State-listed short-eared owl that winters in the park, and the State-listed Northern harrier that is a year-round resident with documented nesting attempts. Other species that depend on a mosaic of forested and grassland habitats are also known to occur in the park's open field habitats, including the State-listed long-eared owl and Cooper's hawk, woodcock, and killdeer, which is known to breed in the area.

Table 5. Nesting Area Requirements of Grassland Birds Found in the Northeast

Common Name	Nesting Area Requirements (acres)
bobolink*	5-10 (Jones and Vickery, 1997); 114 (Helzer and Jelinski, 1999)
Eastern meadowlark*	15-20 (Jones and Vickery, 1997)
grasshopper sparrow	20-30 (Helzer and Jelinski, 1999); 30 (Jones and Vickery, 1997); 30 (Walk and Warner, 1998); 50-74 (Dettmers and Rosenberg, 2000); 247 (Vickery *et al.*, 1994)
Henslow's sparrow	Na
horned lark*	Na
Northern harrier*	136 (Walk and Warner, 1998)
savannah sparrow*	20-25 (Dettmers and Rosenberg, 2000); 20-40 (Jones and Vickery, 1997); 185 (Walk and Warner, 1998)
short-eared owl*	Na
upland sandpiper	124-150 (Helzer and Jelinski, 1999); 150 (Jones and Vickery, 1997); 160 (Walk and Warner, 1998); 494 (Vickery *et al.*, 1994)
vesper sparrow	30 (Jones and Vickery, 1997); 50 (Vickery *et al.*, 1994)

*Documented in Liberty State Park

4. Reptiles and Amphibians

The findings of previous surveys suggested that amphibian and reptile use of the Restoration Area was minimal; only one amphibian (Fowler's toad [*Bufo woodhouseii fowleri*]) and one reptile (eastern painted turtle [*Chrysemys p. picta*]) were documented in a 1976 survey. The Corps conducted reptile and amphibian surveys in 2003. Three species of amphibians and four species of reptiles were identified in Liberty State Park. Amphibian species observed were Fowler's toad, green frog (*Rana clamitans melanota*), and wood frog (*Rana sylvatica*). Reptiles observed were the northern brown snake (*Storeria d. dekayi*), eastern garter snake (*Thamnophis s. sirtalis*), northern water snake (*Nerodia s. sipedon*), and northern diamondback terrapin (*Malaclemys t. terrapin*) (U.S. Army Corps of Engineers, 2004).

Although the Liberty State Park Restoration Area appears to have suitable habitat for several amphibians and reptiles, many expected species were not found. Regionally common wetland frogs, such as northern spring peeper (*Hyla crucifer crucifer*) were not observed. No salamanders were found, although northern redback salamander (*Plethodon c. cinereus*) is common in northern New Jersey. Reptiles were also underrepresented, with only three snake species identified. No regionally common northern ringneck snakes (*Diadophis punctatus edwardsi*), or eastern milk snakes (*Lampropeltis t. triangulum*) were found. Common turtles [*e.g.*, snapping turtle (*Chelydra serpentine*), eastern painted turtle, and eastern box turtle (*Terrapene Carolina*)] were not observed (U.S. Army Corps of Engineers, 2004).

Liberty State Park's isolation within an urban landscape is probably a key factor in the low diversity and abundance of reptiles and amphibians. The relatively young age of habitats within the Restoration Area (generally less than 40 years), great distances to other areas of suitable habitat, hostility of the intervening urban matrix, and the terrestrial nature of reptile and amphibian species have most likely produced a low colonization rate. Certain environmental parameters may have also reduced the suitability of park habitats for reptiles and amphibians. For example, freshwater wetlands may suffer from saltwater intrusion, low pH from underlying acidic fill material (coal ash), or other degradations that reduce the suitability of these areas for frogs, salamanders, and aquatic reptiles.

5. Fish

The Corps sampled the fish community of the park's North Cove in August and September 2003. At total of 257 fish representing 15 species were collected during the beach seine hauls and trap net surveys. Bay anchovy (*Anchoa mitchilli*) and Atlantic menhaden (*Brevoortia tyrannus*) were the most common species collected, by number, during the seine survey. White perch (*Morone americana*) and striped bass (*Morone saxatilis*) were the most common species collected in the trap nets, followed closely by winter flounder (*Pseudopleuronectes americanus*). Six species (alewife, [*Alosa pseudoharengus*]; hogchocker, [*Trinectes maculates*]; oyster toadfish, [*Opsanus tau*]; scup, [*Stenotomus chrysops*]; summer flounder, [*Paralichthys dentatus*]; and tautog, [*Tautoga onitis*]) were each represented by only one fish caught (U.S. Army Corps of Engineers, 2004).

Several species were collected primarily as adults, notably white perch, summer flounder, and American eel (*Anguilla rostrata*). Only one yearling striped bass was collected; the remainder of the striped bass were larger. However, the majority of the fish collected in the North Cove, based on total length, represent juveniles of their respective species; these were fish spawned in 2003. These results are not surprising, as early life stages of fish often use protected, low-energy, shallow-water habitats such as those in coves and backwaters, especially in coastal estuaries where many species spawn (U.S. Army Corps of Engineers, 2004).

The species collected in the North Cove are all common species in estuaries of the Middle Atlantic Bight and NY-NJ Harbor. The species composition is represented by a mix of resident and migratory species that likely use cove habitats in different ways depending on life stage, season, and time of day. The occurrence of juvenile bay anchovy and Atlantic menhaden suggests that the North Cove is currently providing foraging habitat for these pelagic species, as well as providing protection from predators (U.S. Army Corps of Engineers, 2004).

6. Benthos

The Corps sampled sediments and the benthic invertebrate community at seven stations in the North Cove in August 2003. The sediment grain size and benthic community characteristics varied greatly among the seven stations in the North Cove. A summary of the sediment characteristics and the abundance, diversity, and biomass of major groups is presented in Table 6. The variability of sediment characteristics and wave energy within the North Cove has created a patchy distribution of organisms based on differing habitat requirements. The mean density of organisms from all samples taken in the cove was 737 organisms per square meter. Samples containing fine-grained sediment tended to contain a more diverse assemblage of organisms than those from coarse-grain substrates (U.S. Army Corps of Engineers, 2004).

The samples were dominated by polychaete worms, which were collected at all seven sampling sites. Polychaetes are bioindicators of environmental stress due to their ability to tolerate poor conditions, such as low dissolved oxygen and high turbidity. Amphipods, an important food source for fish were present in two of the seven stations. The amphipod species that were collected feed on detritus and inhabit muddy and sandy substrates. Certain amphipod species sensitive to pollutants were not found. Horseshoe crabs (*Limulus polyphemus*) were collected at one station in the shallow water along the western edge of North Cove. Species diversity and relative abundance for the North Cove are consistent with data from other Upper New York Bay locations with similar environmental conditions (U.S. Army Corps of Engineers, 2004).

Table 6. Summary Data for Benthic Grab samples at the North Cove of Liberty State Park (U.S. Army Corps of Engineers, 2004)

Station	Density (animals/m^2)	Biomass (g/m^2)	Richness (# taxa)	Diversity	Dominant Group (by biomass)	Dominant Group (by density)	Particle Size Distribution[1]		Organic Content (by Weight)
							Coarse	Fine	
1	320	0.59	3	1.01	Arthropoda	Arthropoda	98.0%	2.0%	10.2%
2	520	26.58	1	0.00	Arthropoda	Arthropoda	99.8%	0.2%	5.1%
3	340	177.59	6	2.42	Annelida	Arthropoda	25.9%	74.1%	8.6%
4	1300	38.08	6	0.87	Annelida	Annelida	11.0%	89.0%	6.8%
5	620	12.53	5	1.34	Annelida	Annelida	89.0%	11.0%	9.8%
6	740	133.17	10	2.58	Mollusca	Annelida	23.9%	76.1%	8.8%
7	1320	21.73	10	2.44	Annelida	Annelida	16.0%	84.1%	7.3%

[1] - "Coarse" includes Gravel and Sand particles; "Fine" includes Silt and Clay particles

D. ENVIRONMENTAL CONTAMINANTS

1. Background

Liberty State Park is a New Jersey State-listed Known Contaminated Site (List No. NJD980505390), but is not listed as a federal Superfund Site. Liberty State Park contained a large rail yard that was used until 1967 for coal transport, stockyards, and a main freight switching yard. Railroad ties and cinders can still be observed on the surface of the park. The rail yard was created between 1860 and 1919 with fill material consisting of trash, cinders, ash, chromate waste, and excavation and dredge spoils. The rail yard area of Liberty State Park is comprised of approximately 205 acres in the center of the park and includes the majority of the proposed Restoration Area. Approximately, 335,000 to 348,000 cubic yards of dredged material from the eastern edge of Liberty State Park were placed in the 2,300-foot-long by 82-foot-wide rectangular dredge disposal area near the center of the Restoration Area, the "impoundment," between 1981 and 1987.

In 1993, the NJDEP implemented an interim remedial measure that entailed excavating the 8-foot-high earthen berms that formed the impoundment for the dredge spoils and placing the excavated material over the dredged spoils as a cap to prevent redistribution of the dredged spoil. The berms consisted of the original fill material excavated to create the impoundment. By requirement of a consent decree, the dredged spoils and their cap are now being removed from the impoundment and placed in a soil stockpile area at the southwestern corner of Liberty State Park. The material at the soil stockpile area will be capped with 2 to 3 feet of clean soil and maintained as a grassland, as noted above.

The various fill materials placed throughout Liberty State Park provide the majority of contaminants of concern. However, oil deposits associated with past industrial uses and from spills also occur along the eastern boundary of the park.

2. Sampling

The Service is aware of three efforts, since 1995, to sample the sediments and soils throughout the 1,122-acre park. Soil samples collected in 1995 included 11 samples removed from the soil staging area (at less than 7 feet in depth or the depth of groundwater), 52 samples removed from the central Restoration Area (depth of less than 7 feet with most samples removed from the uppermost 6 inches), 46 samples removed from the impoundment (all at a depth of approximately 6 feet), and 27 samples (only analyzed for chromium) were removed from the sewer line area (depth of 10 to 12 feet) at the northern end of the park. Table 7 summarizes the results of the analyses for certain of these samples and Table 8 provides toxicity guidelines for comparison. The 1995 dataset reviewed by the Service did not include data on the dredge spoils area, sewer line area, or soil staging area. The data reviewed by the Service primarily consisted of raw analytical data on samples TP1 through TP81 from the central, southern, and eastern portions of the Restoration Area. The data suggest a number of concerns that are outlined below under specific contaminant headings.

In August and September of 2003, samples from 38 cores were collected at 28.5 to 30 feet in depth from throughout the Restoration Area. Table 9 summarizes the results of the analyses. Although taken below the depth of fill and below the depth of the proposed restoration, these samples did suggest elevated levels of contaminants that are addressed in sections below under specific contaminants. The third sampling effort took place in February 2004. Seventeen samples were removed from cores of the surface to 15 feet in depth. Cores were removed from the impoundment and from the North Cove. These samples indicated contamination, but the 2004 data were primarily from samples of material that will be removed and permanently isolated in a berm at the soil staging area. The Service understands (Will, pers. comm., 2004) that all of the previous dredged material stored in the impoundment will be removed; therefore, the Service does not have extensive concerns regarding contaminants in the dredged material. Furthermore, the 2 to 3-foot cap proposed for covering the berm should adequately isolate any residual contamination in the dredged material.

3. Metal Contaminants

The 1995 data indicate several metals above various ecological effects levels. Heavy metal contaminants of concern discussed below include antimony, arsenic, cadmium, copper, lead, mercury, and zinc. Overall these metals are at levels associated with adverse impacts to fish and wildlife resources and are of concern for restoration. Although these metals, are of concern, their presence does not preclude restoration, but would influence how restoration proceeds.

Antimony concentrations as high as 714 mg/kg (sample TP-80 from the western edge of the park) were observed, although most concentrations were approximately an order of magnitude less with considerable variation (mean = 39.5 ± 112.5). This maximum concentration detected suggests a hazard quotient (existing concentration / protective guideline) based on terrestrial exposure and the Ecological Soil Screening Levels (Eco-SSLs) (Table 8) of 2,462 for mammals

Table 7: Summary of selected sampling points from the 1995 data. Sampling points marked with an "*" are proposed for restoration to aquatic habitat or are adjacent to such an area. Sampling points marked with an "**" are already aquatic habitat. The location of sampling points marked with a "?" is not clear relative to aquatic habitat. All concentrations are in mg/kg dw.

Inorganics

	Sample															
	TP-80?	**TP-25**	**TP-66***	**TP-17***	**TP-41**	**TP-24**	**TP-7**	**TP-21**	**TP-2***	**TP-28**	**TP-10**	**TP-27**	**TP-3**	**TP-8**	**TP-61***	**TP-38?**
Antimony	714	357	293	30.2	7.3	7.5	53.3	7.5	6.4	11.8	17.8	14.8	7.1	25.9	30.6	6.7
Arsenic	232	545	321	29.8	27.7	31.2	29.8	9.6	120	16	72.7	30.7	14.7	24.8	19.6	309
Cadmium	8.7	2.3	3.9	17.5	0.47	4.3	0.38	2.8	2.6	0.95	0.63	1.2	1.1	0.82	2.8	0.63
Chromium	94.2	55.1	190	122	20.1	78	157	47.9	44.1	13.8	56	48.5	34.9	48.4	81.3	32.6
Copper	5400	3790	3060	2900	57	778	778	415	900	53.2	190	206	99.9	238	133	153
Lead	8190	11800	4200	2440	556	511	789	724	421	3240	512	474	753	436	176	172
Mercury	0.18	1	0.27	0.65	0.47	0.5	0.75	0.62	0.37	0.33	0.74	0.5	0.92	0.61	0.34	0.35
Selenium	9.1	5.2	0.96	0.88	0.86	0.77	3.5	1.2	0.97	2.2	3.1	2.4	1.2	2.1	1.8	2
Zinc	31700	16000	13800	7660	2180	1180	1060	786	731	622	601	564	523	520	447	362

Semivolatiles

	Sample															
	TP-31	**TP-44?**	**TP-40**	**TP-3 DL**	**TP-3**	**TP-80?**	**TP-2***	**TP-5**	**TP-21**	**TP-27**	**TP-25**	**TP-7**	**TP-26**	**TP-24**	**TP-10**	**TP-28**
Pentachlorophenol	5.1	27	4.4	5.4	1.1	1.8	0.97	0.99	1.1	1.1	1.3	0.91	1	1.1	1	0.98
Phenanthrene	1.3	6.7	1.8	3.2	2.8	0.39	0.56	1.3	1.3	1.2	0.36	0.52	0.38	0.79	0.47	0.88
Anthracene	0.84	1.6	0.77	0.59	0.57	0.61	0.51	0.28	0.28	0.23	0.55	0.15	0.77	0.25	0.72	0.6
Flouranthene	5	10	3	4.3	3.6	2.4	1.5	1.7	0.89	1.1	0.6	0.58	0.68	0.59	0.55	0.65
Pyrene	6.4	7.7	2.9	6.5	6.8	2.9	2.5	1.6	1.7	1.6	0.97	0.62	0.92	1.7	0.88	0.84
Benzo-a-anthracene	4.4	4.4	1	2.5	2.4	0.95	0.86	0.76	0.45	0.56	0.4	0.2	0.28	0.34	0.28	0.26
Chrysene	6.6	4.6	2.7	2.6	2.1	1.7	1.3	0.82	0.81	0.76	0.64	0.57	0.56	0.49	0.47	0.38
Benzo-b-flouranthene	11	6.7	5.4	5.2	5.7	2.6	2.9	1.7	1.4	1	1.2	1.2	0.62	0.77	0.6	0.51
Benzo-a-pyrene	4.3	3.8	0.52	2.3	2.3	0.4	0.6	0.62	0.36	0.49	0.46	0.12	0.19	0.36	0.25	0.23

Pesticides

	Sample (all listed are outside of the proposed restoration area)					
	TP-53 B	**TP-54 B**	**TP-69**	**TP-69 DL**	**TP-72**	**TP-72 DL**
Dieldrin	0.0039	0.0053	0.18	0.17	0.0044	0.0044
4, 4'-DDE	0.0039	0.0053	0.08	0.067	0.055	0.056
4,4'- DDD	0.0039	0.0053	0.13	0.12	0.2	0.21
4,4'- DDT	0.0039	0.0053	0.23	0.23	0.45	0.49
total DDT	0.0117	0.0159	0.44	0.417	0.705	0.756
Toxaphene	0.2	0.27	0.19	1.9	0.22	2.2
Total PCBs	0.313	0.428	0.311	3.11	3.008	7.28

Table 7 continued

Inorganics

	TP-35	TP-43	TP-1*	TP-5*	TP-81?	TP-45**	TP-40	TP-18	TP-42	TP-16	TP-47**	TP-26	TP-14	TP-31	TP-48	TP-31A
Antimony	6.3	19.8	6.5	6.4	41.2	15	25.6	9.1	6.6	6.7	10.9	6.5	6.5	6.6	6.5	6.4
Arsenic	14	5.8	4	5.8	17.5	9.8	21.6	27	14.5	15.6	4.3	26.1	9.1	15.1	8.6	18.2
Cadmium	0.78	0.39	1.3	1.3	0.43	1.5	0.37	0.41	0.42	0.43	0.66	0.42	0.42	0.42	0.69	0.41
Chromium	39.4	34.8	43.1	47.1	46.8	25.6	60.7	57.1	11.7	30.3	15.9	28.2	11.1	29.1	26.4	21.9
Copper	147	145	117	138	252	64.2	239	171	80.4	78.8	31.3	65.6	30.1	117	72.9	94.3
Lead	218	106	493	325	607	143	687	338	80	202	46.5	195	37	163	76.7	140
Mercury	0.09	0.26	0.53	0.44	1.3	0.19	0.73	0.72	0.06	0.34	0.09	0.43	0.97	0.33	0.17	0.23
Selenium	0.37	0.36	0.38	0.4	0.39	0.38	2.1	1.7	0.78	1.1	0.35	2.6	0.6	1.2	1.4	1.6
Zinc	358	345	322	299	132	125	119	82	60.9	59.4	41.8	34.4	27.4	24	19.9	17.8

Semivolatiles

	TP-81?	TP-45**	TP-35	TP-8	TP-18*	TP-38?	TP-41	TP-43	TP-16	TP-14	TP-42	TP-17*	TP-48	TP-47**
Pentachlorophenol	1	0.99	0.95	0.99	0.97	1	1.1	0.94	1	0.98	0.99	1.2	0.99	0.9
Phenanthrene	0.69	0.24	0.33	0.63	0.31	0.48	0.31	0.16	0.29	0.3	0.25	0.02	0.13	0.051
Anthracene	0.069	0.073	0.09	0.086	0.047	0.06	0.053	0.036	0.06	0.043	0.082	0.028	0.4	0.36
Flouranthene	0.48	0.47	0.44	0.41	0.39	0.32	0.18	0.24	0.3	0.086	0.22	0.15	0.12	0.12
Pyrene	0.52	0.48	0.55	0.42	0.46	0.33	0.69	0.36	0.32	0.24	0.24	0.32	0.092	0.11
Benzo (a) anthracene	0.41	0.2	0.02	0.15	0.14	0.14	0.17	0.18	0.14	0.078	0.096	0.088	0.052	0.057
Chrysene	0.36	0.33	0.33	0.32	0.32	0.28	0.25	0.23	0.2	0.18	0.16	0.15	0.12	0.079
Benzo (b) flouranthene	0.55	0.52	0.48	0.37	0.44	0.48	0.38	0.41	0.31	0.15	0.23	0.27	0.17	0.13
Benzo (a) pyrene	0.19	0.18	0.26	0.093	0.11	0.11	0.15	0.17	0.11	0.064	0.072	0.14	0.045	0.055

Table 8: Examples of Guidelines for Soil and Sediment Concentrations. All concentrations are in mg/kg dw. Categories with an OC are based on organic carbon normalized values.

	Soil					Freshwater sediment		Marine sediment		Freshwater and marine sediment		
Inorganics	NRDCSCC	Eco SSL plants	Eco SSL inverts	Eco SSL birds	Eco SSL mammals	SEL	PEC	ERM	AET	NYSDECc OC	NYSDECa OC	NYSDECw OC
Antimony	340	NA	78	NA	0.29	NA	NA	NA	9.3	NA	NA	NA
Arsenic	20	NA	NA	NA	NA	33	33	70	35	NA	NA	NA
Cadmium	100	32	140	1	0.38	10	4.98	9.6	9.6	NA	NA	NA
Chromium	NA	NA	NA	NA	NA	110	111	370	370	NA	NA	NA
Copper	600	NA	NA	NA	NA	110	149	270	270	NA	NA	NA
Lead	600	110	1700	16	59	250	128	218	400	NA	NA	NA
Mercury	270	NA	NA	NA	NA	2	1.06	0.71	0.41	NA	NA	NA
Selenium	3100	NA	NA	NA	NA	NA	NA	NA	1	NA	NA	NA
Zinc	1500	NA	NA	NA	NA	820	459	410	410	NA	NA	NA
Semivolatiles	NRDCSCC	Eco SSL plants	Eco SSL inverts	Eco SSL birds	Eco SSL mammals	SEL OC	PEC	ERM	AET	NYSDECc OC	NYSDECa OC	NYSDECw OC
Pentachlorophenol	24	NA	NA	NA	NA	NA	NA	NA	0.017	40	100	NA
Phenanthrene	NA	NA	NA	NA	NA	950	1.17	1.5	0.66	120 (FW) 160 (SW)	NA	NA
Anthracene	10000	NA	NA	NA	NA	370	0.845	1.1	0.28	107	986	NA
Flouranthene	10000	NA	NA	NA	NA	1020	NA	5.1	1.3	1020 (FW) 1340 (SW)	NA	NA
Pyrene	10000	NA	NA	NA	NA	850	1.52	2.6	2.4	961	8775	NA
Benzo-a-anthracene	4	NA	NA	NA	NA	1480	1.05	1.6	0.96	12	94	NA
Chrysene	40	NA	NA	NA	NA	460	1.29	2.8	0.95	NA	NA	NA
Benzo-b-flouranthene	4	NA	NA	NA	NA	NA	NA	NA	1.8	NA	NA	NA
Benzo-a-pyrene	0.66	NA	NA	NA	NA	1440	1.45	1.6	1.1	NA	NA	NA
Pesticides and PCBs	NRDCSCC	Eco SSL plants	Eco SSL inverts	Eco SSL birds	Eco SSL mammals	SEL	PEC	ERM	AET	NYSDECc OC	NYSDECa OC	NYSDECw OC
Dieldrin	0.18	NA	NA	1.6	0.28	NA	0.0618	NA	0.0019	9 (FW) 17 (SW)	NA	0.77
DDE	NA	NA	NA	NA	NA	NA	0.0313	NA	NA	NA	NA	NA
4, 4'-DDE	9	NA	NA	NA	NA	NA	NA	0.027	0.009	NA	NA	NA
DDD	NA	NA	NA	NA	NA	NA	0.028	NA	NA	NA	NA	NA
4,4'- DDD	12	NA	NA	NA	NA	NA	NA	NA	0.016	NA	NA	NA
DDT	NA	NA	NA	NA	NA	NA	0.0629	NA	NA	1	1100 (FW) 130 (SW)	NA
4,4'- DDT	9	NA	NA	NA	NA	NA	NA	NA	0.012	NA	NA	NA
total DDT	NA	NA	NA	NA	NA	NA	0.572	0.0461	0.011	NA	NA	1
Toxaphene	0.2	NA	NA	NA	NA	NA	NA	NA	NA	0.01	3.2 (FW) 0.14 (SW)	NA
Total PCBs	2	NA	NA	NA	NA	NA	0.676	0.18	0.13	19.3 (FW) 41.4 (SW)	2761 (FW) 13804 (SW)	1.4

NRDCSCC: New Jersey Department of Environmental Protection. 1999. Soil cleanup criteria: Nonresidential direct contact soil cleanup criteria. New Jersey Department of Environmental Protection, Trenton, New Jersey. 5 pp.

Eco SSL: U.S. Environmental Protection Agency. 2003. Ecological Soil Screening Level guidance. U.S. Environmental Protection Agency, Washington, D.C.

SEL: Persaud, D., R. Jaagumagi, and A. Hayton. 1993. Guidelines for the protection and management of aquatic sediment quality in Ontario: Severe Effect Levels. Ontario Ministry of the Environment, Ottawa, Ontario. 23 pp.

PEC: MacDonald, D., C.G. Ingersoll and T.A. Berger. 2000. Development and Evaluation of Consensus-Based sediment quality guidelines for freshwater ecosystems: Probable Effect Concentrations. Archives of Environmental Contamination and Toxicology 39:20-31.

ERM: Long, E.R., D.D. MacDonald, S.L. Smith, and F.D. Calder. 1995. Incidence of adverse biological effects within ranges of chemical concentrations in marine and estuarine sediments: Effects Range Median. Environmental Management 19(1):81-97.

AET: National Oceanic and Atmospheric Administration. 1999. NOAA Screening Quick Reference Tables (SQuiRT). Apparent Effect Thresholds for marine sediments. National Oceanic and Atmospheric Administration, Coastal Protection and Restoration Division, Washington, D.C. 12 pp.

NYSDECc: New York State Deparment of Environmental Conservation. 1999. Sediment criteria for non-polar organic contaminants: Sediment critiera for benthic aquatic life, chronic toxicity. New York State Department of Environmental Conservation, Albany, New York. 7 pp.

NYSDECa: New York State Deparment of Environmental Conservation. 1999. Sediment criteria for non-polar organic contaminants: Sediment critiera for benthic aquatic life, acute toxicity. New York State Department of Environmental Conservation, Albany, New York. 7 pp.

NYSDECw: New York State Department of Environmental Conservation. 1999. Sediment criteria for non-polar organic contaminants: Sediment criteria, wildlife bioaccumulation. New York State Department of Environmental Conservation, Albany, New York. 7 pp.

Table 9. Select Sampling Points and Data for the 28.5 to 30-foot 2003 Samples (all concentrations are in mg/kg dw). Sample locations marked with an "*" appear to be in or adjacent to areas being proposed for aquatic habitat.

Sample	Arsenic	Cadmium	Copper	Lead	Mercury	Nickel	Chromium(VI)	Dieldrin	Phenanthrene	Flouranthrene	Pyrene	Chrysene
LSP-03-01*							0.49					
LSP-03-03*					0.193	25.3						
LSP-03-04		1.32				25.8	9.4					
LSP-03-05*		1.31				29.9						
LSP-03-12*						27.3						
LSP-03-14*							1.1					
LSP-03-17		1.27				25.2						
LSP-03-18*	8.35		41.4			26.3						
LSP-03-19	8.33	1.31				26.5	3					
LSP-03-20*	10	1.74		74.3	3.22	31.9	2.9		2.1	3.5	3.3	1.8
LSP-03-24*		1.35				24.5	6.3					
LSP-03-25								1.6				
LSP-03-26*						40.2						
LSP-03-28		1.36				26.7						
LSP-03-31*	8.45					26						
LSP-03-37		1.39				26.6	4.8					
PEC (FW)	33	4.98	149	128	1.06	48.6	NA	0.0618	1.17	NA	1.52	1.29
ERM (SW)	70	9.6	270	218	0.71	51.6	NA	NA	1.5	5.1	2.6	2.8
NRDCSCC	20	100	600	600	270	2,400	10	0.18	NA	10,000	10,000	40

PEC (FW): MacDonald, D., C.G. Ingersoll and T.A. Berger. 2000. Development and Evaluation of Consensus-Based sediment quality guidelines for freshwater ecosystems: Probable Effect Concentrations. Archives of Environmental Contamination and Toxicology 39:20-31.

ERM (SW): Long, E.R., D.D. MacDonald, S.L. Smith, and F.D. Calder. 1995. Incidence of adverse biological effects within ranges of chemical concentrations in marine and estuarine sediments: Effects Range Median. Environmental Management 19(1):81-97.

NRDCSCC: NRDCSCC: New Jersey Department of Environmental Protection. 1999. Soil cleanup criteria: Nonresidential direct contact soil cleanup criteria. New Jersey Department of Environmental Protection, Trenton, New Jersey. 5 pp.

and 9.2 for soil invertebrates. For aquatic invertebrates, based on an exposure in the sediment and the Apparent Effects Threshold (AET) in Table 8, the hazard quotient is 77 (*i.e.*, the concentration is 77 times too high to be considered protective). The guidelines in Table 8 must be used with caution because they are not designed to be protective of all fish and wildlife resources, especially upper trophic level species. In addition, the restored areas will contain a mixture of fresh and saltwater that causes variable bioavailability and toxicity. The guidelines must also be used with caution because they do not take into account the elevated background concentrations of most contaminants in the upland and aquatic substrates throughout the HRE. Major sources of antimony that may have contributed to the concentrations detected in the samples include smelters, coal combustion, incineration of waste and sewage sludge (U.S. Environmental Protection Agency, 2003a), burning of other fossil fuels, and wastes from steel plants (Takayanagi, 2001). The Eco-SSL for mammals is primarily based on rodents and therefore is appropriate for use at this site. Eco-SSLs are developed by the U.S. Environmental Protection Agency (EPA) to represent concentrations of contaminants in soil that are sufficiently low to be protective of ecological receptors that commonly come into contact with soil or ingest biota that live in or on the soil. Eco-SSLs values are presumed to provide adequate protection to terrestrial ecosystems. Guidelines, such as the Eco-SSLs, are generally simplified in that they do not consider the exact form (*e.g.*, organic or elemental) and species (*e.g.*, valence state) of the contaminants of concern, which have different toxicity and can vary greatly depending on a complex suite of site conditions such as pH and redox potential (Gambrell *et al.*, 1991). The Service has not thoroughly assessed the applicability of the Eco-SSLs or the other guidelines listed in Table 8 to the level of a complete Ecological Risk Assessment and for this report is only suggesting the values provide a range of concentrations that might be considered protective relative to the unique site conditions.

The EPA considers antimony a priority pollutant. Antimony has been positively associated with the prevalence of fish tumors in bottom dwelling fish (Chang *et al.*, 1998). Antimony can also bioaccumulate efficiently in plants (Hozhina *et al.*, 2001), but only if mobile forms are present in high concentrations in the sediment (Hammel *et al.*, 2000). Antimony can be clastogenic, carcinogenic (Gebel, 1997), genotoxic (Cavallo *et al.*, 2002), and estrogenic (Choe *et al.*, 2003), but still relatively little is known about its toxicity (Gebel, 1997). Further, antimony's toxicity is dependent on its chemical form (Takayanagi, 2001, Filella *et al.*, 2002). Antimony bioaccumulation in terrestrial invertebrates and small mammals has been observed; however, evidence of significant biomagnification does not exist (Ainsworth *et al.*, 1990; Long *et al.*, 1999). Sample TP-66 had an antimony concentration of 293 mg/kg at the surface. This sample is from the area where the inlet channel is proposed. If the concentration of 293 mg/kg is representative of potential sediment concentrations in that area, then the hazard quotient is 32 when compared to the AET and well in excess of concentrations considered safe for fish and wildlife resources.

<u>Arsenic</u> concentrations up to 545 mg/kg (sample TP-25 from the northern portion of the Restoration Area) were found in the 1995 samples, although most concentrations were approximately an order of magnitude less with extensive variation (mean = 48.0 ± 96.0). This maximum concentration suggests a hazard quotient of 27 based on terrestrial exposure and the Nonresidential Direct Contact Soil Cleanup Criteria (NRDCSCC) value (Table 8). Exposure to

aquatic invertebrates suggests a hazard quotient of 7.8 based on an Effects Range Median (ERM) guideline (Table 8). Sample TP-2 had an arsenic concentration of 120 mg/kg and is in an area where emergent marsh is proposed, suggesting a hazard quotient of less than 2. The 2003 data from 28.5 to 30 feet in depth also revealed some elevated arsenic concentrations; however, none were above the referenced soil and sediment guidelines (Table 9).

Arsenic occurs on the site from a variety of likely sources such as wood preservative, smelters, historical pesticide use or manufacture, batteries, and electronics (Chou *et al.*, 2000). Arsenic can cause varied effects in fish and wildlife such as reduced survival and growth (Hoffman *et al.*, 1992) and abnormal behavior (Eisler, 1988), and is highly toxic to fish, causing liver tumors and other problems (Sorensen, 1991). Arsenic bioaccumulates but generally does not biomagnify past lower trophic level species (Hamilton and Hoffman, 2003). Some forms of arsenic can bioaccumulate efficiently in plants under certain conditions (Carbonell *et al.*, 1998; Hozhina *et al.*, 2001). The Service found the arsenic concentrations at Liberty State Park may cause adverse impacts to fish and wildlife resources without corrective measures.

Cadmium concentrations up to 17.5 mg/kg (sample TP-17 from the middle of the Restoration Area) were observed in the 1995 samples, although most concentrations were approximately an order of magnitude less with extensive variation (mean = 1.7 ± 2.7). This maximum concentration was observed in a sample from the surface and close to where deep emergent marsh is proposed. This cadmium concentration suggests a hazard quotient based on terrestrial exposure and the Eco-SSLs (Table 8) of 46 for mammals and 17.5 for birds and a freshwater sediment hazard quotient of 3.5 based on the Probable Effect Concentration (PEC) (Table 8). The 2003 data from 28.5 to 30 feet in depth also revealed some elevated cadmium concentrations; however, none were above the referenced soil and sediment guidelines (Table 9).

Cadmium may enter the environment during the use of zinc and lead ores; the recovery of metals by processing scrap; the casting of alloys for coating products (telephone cables, electrodes, sprinkling systems, fire alarms, switches, relays, circuit breakers, solder, and jewelry); the combustion of coal and fossil fuels; paint, pigment, and battery manufacture and use; and the production and use of fertilizers (Hutton, 1983; Van Enk, 1983; and Shore and Douben, 1994). Cadmium can cause a variety of adverse effects in fish and wildlife such as suppressed egg production, embryonic malformations, gonadal degeneration (Gross *et al.*, 2003), kidney degeneration (Prasada Rao *et al.*, 1989), depressed growth of fish (Peterson *et al.*, 1983; Miliou *et al.*, 1998), and molt inhibition of crustacea (Gentile *et al.*, 1982). Although cadmium does not biomagnify in fish, dietary exposure may still provide doses associated with adverse effects (Hamilton and Hoffman, 2003). Cadmium concentrations in the tissues of bivalves and crustaceans in Upper New York Bay exceed 500 ng/g and are indicative of contaminated conditions (Skinner *et al.*, 1997a). Cadmium is found in the soils and sediments at Liberty State Park at concentrations associated with adverse impacts to fish and wildlife resources.

Copper concentrations up to 5,400 mg/kg (sample TP-80 from the western edge of the park) were found in the 1995 samples, although most concentrations were approximately an order of magnitude less and varied extensively (mean = 474.7 ± 1,019.0). This maximum concentration suggests a hazard quotient of 9 based on terrestrial exposure and on the NRDCSCC value (Table

8). Elevated copper concentrations occur in areas proposed for wetland restoration. For example, sample TP-17 from the surface was from the middle of the Restoration Area close to where deep emergent marsh is proposed. Sample TP-17 had a copper concentration of 2,900 mg/kg suggesting a hazard quotient of 26 based on the Severe Effect Level (SEL) for freshwater sediment (Table 8).

Copper enters the environment through release from copper ore, industrial processes using copper or copper compounds, combustion of fossil fuels, fungicides, insecticides, wood preservatives, and natural sources (Dorsey *et al.*, 2002). Copper is among the most toxic heavy metals in freshwater and marine biota (Betzer and Yevich, 1975), and often bioaccumulates and causes irreversible harm to some species at concentrations just above levels required for growth and reproduction (Hall *et al.* 1988). Copper bioaccumulates in terrestrial systems and passes from plants to mammals (Torres and Johnson, 2001). Copper causes egg and larval mortality, reproductive abnormalities (Gross *et al.*, 2003), and is toxic to invertebrates (Imlay and Winger, 1983), fish (Gardner and LaRoche, 1973), mammals, and sensitive plants (Eisler, 2000a). Effects to upper trophic level organisms from copper are not well documented but generally do not occur at most environmentally relevant concentrations (Eisler, 1998). For example, Kozie and Kubiak (1991) found herring gulls foraging in a Michigan lake heavily polluted with copper to have an egg concentration of 0.69 ug/g, well below an adverse affect concentration of 5 to 40 ug/g suggested by Rest (1976). Using water from the same lake, Ellenberger *et al.* (1994) found similar results of no to minimal adverse affects on the reproduction of yellow perch (*Perca flavescens*). Observed copper concentrations at Liberty State Park are sufficiently high to warrant consideration in restoration design, planning, construction, and monitoring.

Lead concentrations of up to 11,800 mg/kg (sample TP-25 from the northern portion of the Restoration Area) were observed in the 1995 samples, although most lead concentrations were approximately one or two orders of magnitude less with extensive variation (mean = 872.8 ± 2,003.1). This maximum concentration suggests a hazard quotient based on terrestrial exposure and the Eco-SSLs (Table 8) of 107 for plants, 7 for invertebrates, 737.5 for birds, and 200 for mammals. A lead concentration of 2,440 mg/kg was observed in sample TP-17, from an area proposed for wetland restoration, suggesting a hazard quotient of 19 based on the PEC (Table 8). The 2003 data (Table 9) did not suggest that lead concentrations are over the referenced soil and sediment guidelines at the depth sampled (28.5 to 30 feet).

Lead is released to the environment from coal-fired power plants, ceramic manufacturing, mining, ore processing, smelting of lead ores, refining, the production and use of lead alloys and compounds, recycling, combustion processes, disposal (U.S. Environmental Protection Agency, 2003b), batteries, ammunition, historical use of paints and fuels, and electronics (Abadin and Llados, 1999). Lead can cause a variety of adverse impacts to reproduction, development, growth, neural functioning, and behavior in fish and wildlife (Burger and Gochfeld, 1988; Burger, 1995; Burger *et al.*, 1998; Burger and Gochfeld, 2000; Gross *et al.*, 2003). For example, laboratory mice (*Mus musculus*) fed an absorbed 0.05 to 0.1 mg/kg bw daily dose of lead have long term inhibition of hemoglobin production (Schlick *et al.*, 1983). Perez-Coll *et al.* (1988) examined toad eggs and found an LC50 (Lethal Concentration of 50 percent of a population) after 48 hours with surviving embryos having a high frequency of malformations at a concentration of 470 to 950 ug/l in water. Lead bioaccumulates to concentrations in bivalves and crustaceans in Upper New York Bay in excess of 250 ng/g and as much as 5,000 ng/g indicating contaminated conditions are already present for this metal (Skinner *et al.*, 1997a). Lead at Liberty State Park may cause adverse impacts to fish and wildlife resources if no remedial measures are taken.

Mercury concentrations of up to 1.6 mg/kg (sample TP-57 from the eastern edge of the Restoration Area) were observed in the 1995 data with extensive variation (mean = 0.51 ± 0.38). The concentrations detected are not of toxicological significance if they remain in an upland environment. Mercury concentrations in areas proposed for wetland restoration, such as 0.44 mg/kg in sample TP-5, are only marginally above the most conservative ecological effects levels and not of significance considering the ubiquity of mercury in the environment surrounding Liberty State Park. The 2003 data (Table 9) suggested maximum mercury concentrations at 28.5 to 30 feet in depth exceed sediment guidelines by a factor of approximately 3. Mercury concentrations at the depths proposed for restoration are not well documented.

Mercury occurs in the environment due to a variety of industrial processes and other sources such as barometers, thermometers, batteries, electrical switches, dental amalgams, fungicides, antibacterials, pigments, fluorescent lights, catalysts, recycling (Risher and DeWoskin, 1999), burning of fossil fuels, landfills, contaminated sites, and wastewater (New Jersey Mercury Task Force, 2002; de Cerreno *et al.*, 2002). Mercury causes a wide variety of adverse effects in most terrestrial and aquatic fauna including neurotoxicity and behavioral abnormalities, incoordination and an inability to feed or avoid predators, low hatching success, low adult survival, decreased reproductive success, failed embryonic development, and abnormal cell development (Wolfe *et al.*, 1998; Wiener *et al.*, 2003). Plants, especially aquatic species, may also bioaccumulate mercury and can contribute to mercury entering the food web (Zillioux *et al.*, 1993). Similar to mercury, selenium was found up to 9.1 mg/kg (mean = 1.44 ± 1.49), below concentrations likely to be toxicologically significant in an upland environment and close to sediment effects concentrations, but generally insignificant.

Zinc concentrations were observed in the 1995 data of up to 31,700 mg/kg (Sample TP-80), although most zinc concentrations were approximately one, two, or three orders of magnitude less with extensive variation (mean = 1,641.9 ± 5,155.2). A concentration of 31,700 suggests a hazard quotient of 21 based on the NRDCSCC. Sample TP-17, from an area proposed for wetland restoration, had a concentration of 7,660 mg/kg suggesting a hazard quotient of 16.7 and potential adverse effects to aquatic organisms based on the PEC (Table 8).

Zinc occurs in the environment due to extensive use in metallurgic operations such as the creation of alloys and electroplating; numerous commercial products such as batteries, paints, wood preservatives, dyes, and pharmaceuticals; and presence in smelter wastes, coal and bottom fly ash, and fertilizers (Socha and Amata, 2003). Zinc concentrations of 100 mg/kg can be lethal to red maple (*Acer rubrum*) and oak (*Quercus* sp.) seedlings (Buchauer, 1971). An earthworm LC50 for a 2-week period was observed at 662 mg/kg (Neuhauser *et al.*, 1985). Elevated aquatic zinc concentrations adversely affect hatching success and development in salamanders and fish (Gross *et al.*, 2003). The LC50 for American oyster (*Crassostrea virginica*) embryos over 96 hours was observed at 230 ug/l (U.S. Environmental Protection Agency, 1987). Zinc concentrations, as low as 10 ug/l, cause 50 percent lethality and/or deformations in toad embryos after 7 days (U.S. Environmental Protection Agency, 1987). The zinc concentrations at Liberty State Park are of concern for restoration and potential adverse impacts to fish and wildlife resources.

4. Polycyclic Aromatic Hydrocarbons

As shown in Table 7, the 1995 data include concentrations for many semivolatile organics such as the polycyclic aromatic hydrocarbons (PAH) anthracene, fluoranthene, pyrene, and chrysene that are elevated but below the NRDCSCC (Table 8). The concentrations detected should be acceptable for an upland environment, particularly given the high background concentrations of these compounds in the project area and throughout the metropolitan New York area. However, the 1995 data indicate concentrations of the PAHs benzo-*a*-anthracene, benzo-*b*-fluoranthene, and benzo-*a*-pyrene that may be as high as 12,000 mg/kg, in excess of the NRDCSCC (Table 8). The 2003 data collected from 28.5 to 30 feet suggested only slightly elevated concentrations of PAHs (Table 9).

These various PAH compounds enter the environment primarily from fossil fuels and incomplete combustion of organic compounds (Gross *et al.*, 2003). Birds can be exposed to PAH compounds through their skin or diet (Gross *et al.*, 2003). Bioaccumulation of PAHs occurs in all marine organisms with variable tissue concentrations occurring from different lengths of exposure (Meador *et al.*, 1995), size of the PAHs, and species' varied ability to metabolize these compounds (Wood *et al.*, 1997). PAHs, such as fluoranthene, bioaccumulate in meiofauna rapidly to sublethal and lethal concentrations (Lotufo, 1998). PAHs especially bioaccumulate in taxa that have a low ability to biotransform and excrete them, such as bivalves (Tanacredl and Cardenas, 1991), and less so in other taxa, such as fish, that more efficiently biotransform and excrete PAHs (Varanasi, *et al.*, 1989; Meador *et al.*, 1995). Despite evidence that these compounds do not biomagnify extensively and can biodegrade, PAHs do bioaccumulate and are associated with adverse impacts to fish and wildlife resources. For example, PAHs can impair reproduction, disrupt the endocrine system, cause abnormal behavior (Gross *et al.*, 2003), fish tumors (Chang *et al.*, 1998), DNA adduct formation (McElroy *et al.*, 1991), decreased egg viability (Hose *et al.*, 1981), and suppressed immunity (Arkoosh *et al.*, 1994). Additionally, PAHs and their natural metabolites have adverse affects on development including thyroid and neurochemical disruption (Brouwer *et al.*, 1998).

Overall, the Service finds that PAHs, like metals, are at levels associated with adverse impacts to fish and wildlife resources, are of concern for restoration, and require attention. The presence of high PAH concentrations does not preclude restoration, but should influence how restoration proceeds.

5. Pesticides

The Liberty State Park contaminant data include elevated concentrations of certain pesticides. The ranges of pesticide concentrations found in the sediments and soils of the Restoration Area are sufficiently high to be associated with adverse impacts to fish and wildlife resources and require further attention during planning, design, and construction. The concentrations of pesticides observed are not high enough to prevent restoration.

Dieldrin, a pesticide as well as a metabolite of the pesticide aldrin, was observed at concentrations as high as 0.180 mg/kg (Sample TP-69 from immediately east of the Restoration Area) in the 1995 data, equal to the NRDCSCC. In the 2003 data, dieldrin was found to be 1.6 mg/kg in the 28.5 to 30-foot sample LSP-03-25, removed approximately from the area where freshwater biofilter wetlands are proposed. This concentration in sediment suggests a hazard quotient of 25.9 based on the PEC guideline (Table 8).

Most use of dieldrin was banned in 1970; however, dieldrin still persists in the environment (Jorgenson, 2001). Dieldrin causes behavioral abnormalities in invertebrates (Klein and Lincer, 1974); bioaccumulates (Henderson *et al.*, 1971); interferes with fertilization and development of marine invertebrates (Pesando *et al.*, 2004); has acute and chronic toxic affects on marine invertebrates (Robinson *et al.*, 2002); has estrogenic affects (Soto *et al.*, 1994); and causes neurochemical and behavioral alterations in waterfowl (Sharma *et al.*, 1976).

Dichlorodiphenyltrichloroethane (DDT) and its metabolites (total DDT) were found at elevated concentrations in the data from the 1995 sampling. Concentrations were as high as 0.756 mg/kg (sample TP-72DL). Although this concentration is well below soil guidelines, such as the NRDCSCC (Table 8), it has the potential to be of ecological concern if it occurs in a sediment or in an area where it can contribute DDT to surface water via runoff. The sampling point TP-72DL is just east of the Restoration Area; however, this point may be representative of the area being restored and exceeds the PEC of 0.572 mg/kg.

DDT is persistent in the environment (Blus *et al.*, 1987); causes eggshell thinning, and thus poor hatching success in birds (Anderson *et al.*, 1975); efficiently bioaccumulates and biomagnifies (Braune and Norstrom, 1989); disrupts the endocrine system (Rotchell and Ostrander, 2003); causes abnormal behavior in fish (Javaid, 1972); and results in direct toxicity to invertebrates (Swartz *et al.*, 1994). DDT is found throughout the HRE (Gillis *et al.*, 1995).

Toxaphene was observed at concentrations as high as 2.2 mg/kg in samples bordering the Restoration Area to the east. This concentration suggests a hazard quotient of 11 based on terrestrial exposure and the NRDCSCC (Table 8). If such a high concentration occurs in an area proposed for wetland restoration, the hazard quotient would be significantly higher. For example, the New York State Department of Environmental Conservation (NYSDEC) chronic sediment criterion (Table 8) is 0.01 mg/kg OC (Organic Carbon). Assuming an OC concentration of 5 percent suggests a hazard quotient of 4,400 (2.2 / 0.05 = 44 then /0.01 = 4,400).

Toxaphene was widely used as a broad spectrum insecticide until 1990 when it was banned for all uses. However, toxaphene is persistent in soil and water. Eisler and Jacknow (1985) explain toxaphene is especially hazardous to aquatic organisms, with death recorded at ambient water concentrations substantially below 10 ug/l, and adverse affects observed on growth, reproduction, and metabolism at water concentrations between 0.05 and 0.3 ug/l. In water, the concentration of toxaphene considered safe for protection of freshwater life is conservatively estimated to lie between 0.008 and 0.013 ug/l; for marine life, the safe concentration is 0.07 ug/l. Aquatic organisms readily bioaccumulate toxaphene from the ambient medium and diet, retain it for lengthy periods, and biomagnify the chemical through food chains. Toxaphene has been associated with both fish and bird kills in areas where extensive applications have occurred.

Pentachlorophenol (PCP) at elevated concentrations is also suggested by the 1995 data. For example, sample TP-18, from an area proposed for deep emergent marsh in the middle of the Restoration Area, had a PCP concentration of 0.970 mg/kg. This concentration is below levels of concern for the terrestrial environment but well above levels associated with adverse impacts to wetland species.

PCP is a moderately persistent compound (Pierce *et al.*, 1977) used as a biocide and wood preservative until its use was restricted in 1984 (Miller and Ingerman, 2001). PCP can be highly toxic to many types of fish; for example a 96-hour LC50 value for bluegill sunfish is 32 ug/L (Johnson and Finley, 1980). PCP can bioconcentrate by a factor of over one thousand into aquatic species from the surrounding waters (Smith *et al.*, 1990; Makela *et al.*, 1991); however, dependent on pH and salinity (Tachikawa, 1991), PCP can be rapidly excreted or broken down, preventing significant biomagnification to upper trophic level species (Stehly *et al.*, 1989). PCP can rapidly break down in a flooded anaerobic sediment with high amounts of organic matter (Augustijn-Beckers *et al.*, 1994) that potentially would occur in a restored wetland. The major contaminant in PCP is octachlorodibenzo-*p*-dioxin, which may be present at concentrations between 500 and 1,500 mg/kg. However, PCP may include other heavily chlorinated dioxin congeners as well (Pohl *et al.*, 1998). Various congeners of dioxin can be degraded to the more toxic dioxin congener 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD), such as through photolysis, at a rate of 0.5 to 1 percent (Miller *et al.*, 1989). However, the concentration of PCP at Liberty State Park does not suggest the associated dioxin concentration would be of concern relative to the elevated dioxin concentrations already present in the HRE.

6. Polychlorinated Biphenyls

Total PCBs, based on a sum of Aroclors, from the 1995 data suggest concentrations as high as 7.28 mg/kg (sample TP-72 DL from the eastern portion of the park). If this concentration were to occur in an area to be converted to a wetland, the hazard quotient would be 56 based on the AET (Table 8).

PCBs were commonly used in the U.S. from the late 1920's to the late 1970's for a wide range of industrial and commercial uses such as dielectric fluids; waxes; heat transfer agents; plasticizers in paints and coatings; ink solvents in carbonless copy paper; cutting oils; sealants and caulking compounds; and pesticide extenders (Eisler, 2000b) and are common in the water, sediment, and biota of the HRE (Stainken, 1984; Achman *et al.*, 1996; Skinner *et al.*, 1997b; Durell *et al.*, 1998; Feng *et al.*, 1998; Litten, 2003; and Monosson *et al.*, 2003). PCBs are still in use today but are not produced except as inadvertent byproducts, and new or uncontained uses are prohibited. Death, reproductive failure, immunosuppression, liver damage, and wasting syndrome have been attributed to PCB exposure in fish and wildlife (see reviews in Hoffman *et al.*, 1996 and Rice *et al.*, 2003).

The data collected do not provide sufficient information for the Service to conclude that PCBs pose no potential threat to fish and wildlife resources in the Restoration Area. Circumstantial evidence suggests PCBs may be at elevated concentrations relative to the guidelines referenced in Table 8 and may be a matter of concern for the restoration. The Service noted that PCBs were not analyzed other than with an Aroclor analysis. The EPA Draft Method 1668A (U.S. Environmental Protection Agency, 1999; Rushneck *et al.*, 2004) would provide for more conclusive results for detecting PCBs and assessing ecological risk. For example, the 1668A method allows detection of specific congeners that are dioxin-like in their shape and in their adverse affects to fish and wildlife (Van den Berg *et al.*, 1998). Dioxin-like PCBs have been shown to cause embryo mortality in wildlife species such as mallard (*Anas platyrhynchos*), goldeneye (*Bucephala clangula*), and black-headed gull (*Larus ridibundus*) (Brunstrom and Reutergardh, 1986; Brunstrom, 1988). Congeners 105, 114, 118, 123, 156, 157, and especially 77 and 126, are the most likely to produce dioxin-like effects in wildlife. These congeners likely all occur in sediments throughout the HRE.

7. Petroleum Hydrocarbons

Petroleum hydrocarbons are present at Liberty State Park and particularly in the area of North Cove. For example, 2004 data from sediment samples collected in the North Cove had concentrations from nondetected to 2,881.14 mg/kg total petroleum hydrocarbons. The Service is unaware of any sediment total petroleum guideline for ecological health. However, petroleum hydrocarbons can produce a variety of adverse effects to fish and wildlife resources such as invertebrate community changes (Suchanek, 1993) and immunosupression, impaired reproduction, abnormal behavior, death of embryos and larvae, and DNA adduct formation in fish (Albers, 2003). Petroleum hydrocarbons bioaccumulate especially in those organisms with little ability to metabolize these contaminants, such as mollusks, and/or organisms with high concentrations of lipids (Albers, 2003).

Some oil would likely seep through any cap placed in the North Cove or become redistributed if the cap erodes. However, considering the unique circumstances of restoration in the HRE, the ecological risk associated with oil should be relatively minimal. Additionally, petroleum hydrocarbons can rapidly degrade by exposure to air, water, sunlight (Atlas and Bartha, 1973), and some microorganisms (Mueller, *et al.*, 1999). The State of New Jersey uses a total organic compound soil cleanup criterion of 10,000 mg/kg for oil spill cleanup (http://www.state.nj.us/dep/srp/index.htm). Although this value has limited application for determining ecological risk in a marine sediment, it at least suggests the concentrations are below State remediation levels.

8. Additional Contaminant Considerations

The significance of the environmental contaminant levels discussed above must be considered in the context of four additional factors. First, data are not available for tissue concentrations or tissue biomarkers from the Restoration Area. Without such data, we cannot conclude whether the biota at Liberty State Park actually contain high body burdens of contaminants or whether they suffer (*e.g.*, impaired endocrine and immune systems) to a degree that would preclude restoration without extensive remediation. Second, Liberty State Park contains a wide variety of contaminants, none of which would impact an organism in isolation of other contaminants. The effects of contaminants are often synergistic (Kanciruk *et al.*, 1982) and can occur in a variety of ways at the population, individual, tissue, or cell level. For example, evidence suggests exposure to mercury can have a synergistic effect with PCBs, enhancing both of their toxicities (Bemis and Seegal, 1999). Third, the particular characteristics of the park further the concern for contaminants. For example, low pHs are found throughout much of the park (Gallagher pers. comm., 2004). Low pH generally causes an increase in soluble forms of metals and may increase bioavailability (Gambrel *et al.*, 1991). Fourth, very little sampling has been performed that is useful for assessing contaminants at the proposed restoration depths. Therefore, contaminant concentrations above those recorded to date may be present and in areas likely to be disturbed during wetland restoration.

V. PROJECT EFFECTS AND SPECIFIC RECOMMENDATIONS

The Service's views and recommendations on this project are guided by its Mitigation Policy (Federal Register, Vol. 46, No. 15, January 23, 1981), which reflects the goal that the most important fish and wildlife resources should receive priority consideration in planning. The following Service recommendations focus on birds, as the most diverse and abundant wildlife group in Liberty State Park, but are likely to benefit other wildlife species as well. Specific recommendations for three Wildlife Management Areas (based on tidal marsh, forest / freshwater wetland, and grassland cover types) are provided in Section A below. Environmental contaminant concerns and potential impacts are presented in Section B. Specific recommendations are summarized at the end of each contaminant discussion.

With adequate efforts to avoid and minimize exposure of wildlife to environmental contaminants, the Service supports the creation and enhancement of habitats for fish and wildlife in the Liberty State Park Restoration Area as proposed by the Corps and the DPF (Figure 2). The proposed project will create a 200 to 250-acre mosaic of tidal marsh, upland forest, freshwater wetland, and grassland. This restoration project is expected to benefit a variety of wildlife species in the NY-NJ Harbor including wading and other marsh birds, waterfowl, raptors, grassland and forest birds, and marine fish. The project may also benefit reptiles, including diamondback terrapins, snakes, and turtles, as well as freshwater amphibians that may eventually colonize the site.

A. MANAGEMENT AREAS

The Service's primary recommendation is to approach the creation and management of habitats in the Restoration Area from a perspective of large habitat blocks. As discussed above, wooded and grassland portions of the Restoration Area may be near the minimum acreage necessary to support area-sensitive nesting birds. Even absent nesting activity by area-sensitive species, consolidation of habitat patches and management as large blocks is likely to improve overall habitat conditions for a variety of birds and other wildlife within the park. For example, some studies have shown that bats and small mammals may also experience adverse effects associated with edges, small patch size, and habitat fragmentation (Hobson, 1995; Ontario Ministry of Natural Resources, 2001; Robbins, 1988). With sufficiently large blocks, "interior" marsh, forest, and grassland areas can be created to provide wildlife habitats that are buffered from noise, disturbance, invasive vegetation, nest parasites, and predation and competition from generalist or non-native species.

Figure 4 presents the Service's recommended perimeters for marsh, forest/freshwater wetland, and grassland "Management Areas" within the Restoration Area, shown overlain with existing conditions and the Conceptual Plan. Round or square habitat patches maximize the ratio of interior to edge habitats, and are therefore generally preferable (Diamond, 1975; Ontario Ministry of Natural Resources, 2001; Robbins *et al.*, 1989; Dettmers and Rosenberg, 2000; Maryland Partners in Flight, 1998; Rosenberg *et al.*, 1999; Cornell Lab of Ornithology, 2004). However, in delineating the suggested Management Areas shown in Figure 4, the Service recognizes that the Corps and the DPF are constrained in the location, size, and design of the marsh, and that the DPF desires to maintain most of the existing forest cover that has developed naturally through succession. These constraints have produced somewhat elongated and irregular-shaped Management Areas, with low interior-to-edge ratios. Even with these suboptimal shapes, consolidation and management of cover types within the park as large blocks would create approximately 56 acres of marsh, 100 acres of forest/freshwater wetlands (32 acres interior) (not including the 8 acres across Phillip Drive), and 67 acres of grasslands (3 acres interior). These large blocks would substantially benefit the wildlife of Liberty State Park and the NY-NJ Harbor region, especially migratory birds.

The Service's overriding recommendations are to create and manage habitats from the Management Area perspective, and to strive for further gains in <u>interior</u> habitat acreage during the PED, Construction, and Operations and Management (O&M) phases of the project.

1. Tidal Marsh

a. Design the marsh to become self-sustaining and avoid artificial structures requiring long-term maintenance (see guidance in National Research Council, 2001).

b. Complete a contingency plan that would provide for further Corps action during the post-construction monitoring period if necessary, as part of an adaptive management strategy to be carried out in concert with the DPF (which will be responsible for O&M, as the local project sponsor). Necessary Corps interventions may include regrading, replanting, or other actions to correct for unexpected conditions, including deposition, erosion, failure of marsh vegetation to become established, and/or invasion of *Phragmites* beyond pre-defined acceptable limits.

c. Ensure adequate organic content of sediments at the target marsh elevation. If sediments have lower organic content than other nearby marshes (*i.e.* South Cove), organically amend the sediments or lay down an organic base (see management guidelines in Maryland Partners in Flight, 1998).

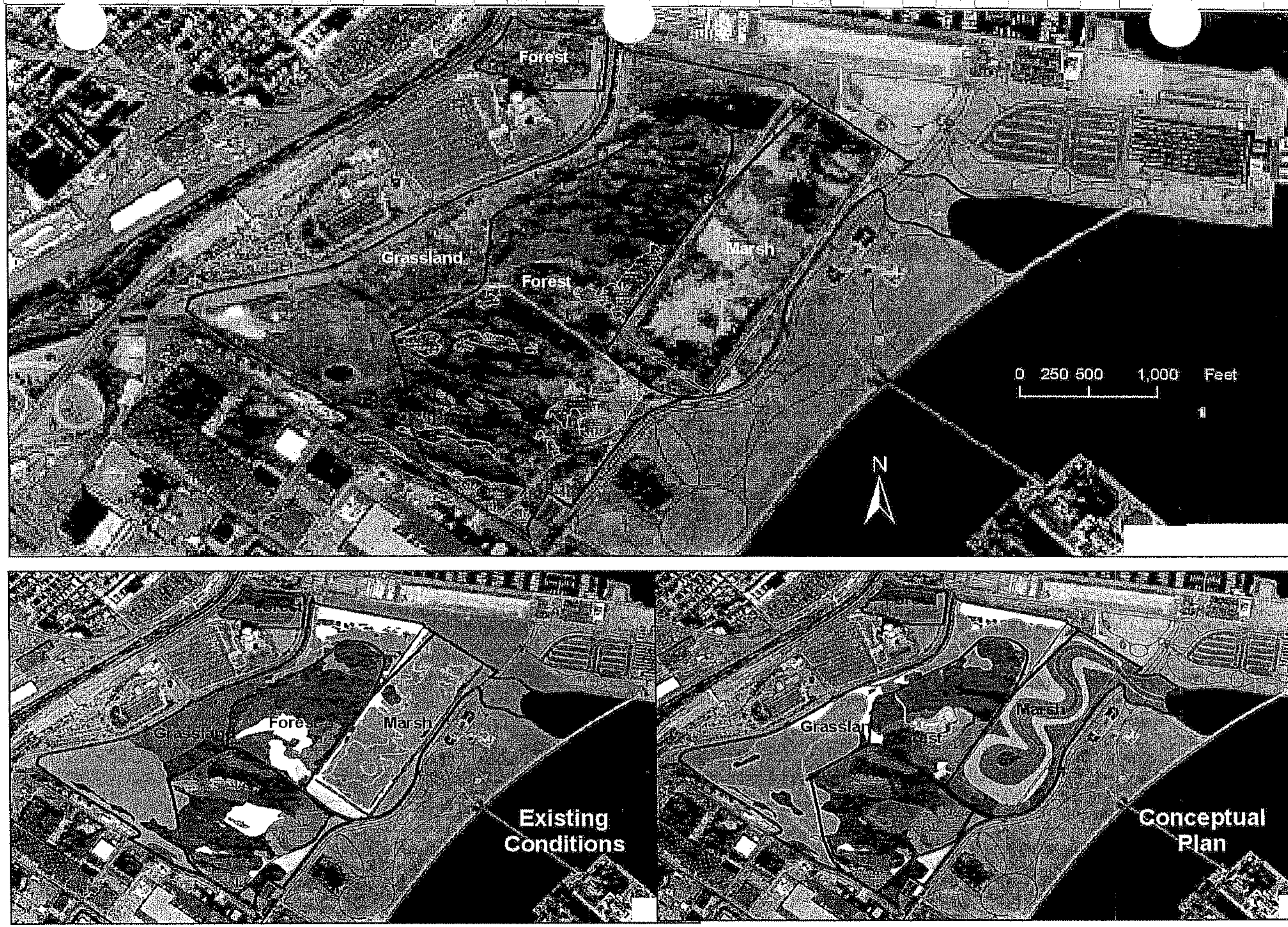

Figure 4. Recommended Management Areas within the Restoration Area

d. Provide appropriately heterogeneous topography of the marsh surface. Coordinate closely with the construction contractors and conduct post-grading on-site meetings and inspections to ensure consistency with construction plans (National Research Council, 2001; Balzano *et al.*, 2002).

e. Consult the scientific literature and use the best available information regarding planting elevation, depth, soil type, and seasonal timing, and subsurface conditions to include soil and sediment geochemistry and physics, groundwater quantity and quality, and infaunal communities (National Research Council, 2001).

f. Consider planting *Spartina* plugs rather than seed; higher success has been achieved with plugs in the Hackensack Meadowlands (Spendiff, pers. comm., 2003).

g. Protect newly planted *Spartina* from Canada goose herbivory through fencing, monitoring, and goose harassment as needed; these methods have been effective in the Meadowlands (Spendiff, pers. comm., 2003). Fencing should consist of 4-foot-high deer exclusion fencing mounted on hardwood posts, spaced 10 feet on center. Geese should be exclosed from the top of the fencing using avian netting, or a grid of nylon twine marked with mylar strips to create a visual and auditory deterrence. The top of the fence should not be inundated at high tides. The fence will require frequent maintenance, and should be kept in place for the first two growing seasons. If monitoring reveals that fencing is insufficient to allow *Spartina* establishment, implement goose harassment techniques (*e.g.*, lasers, noise, dogs).

h. Work with contractors to minimize burial and/or spread of *Phragmites* rhizomes from construction activities, particularly during operations to transport, stockpile, or regrade soils and sediments. Measures should include care to avoid transport and burial of rhizomes on construction equipment, and post-construction monitoring and treatment as needed. Work by Bart and Hartman (2003) shows that rhizome burial promotes *Phragmites* establishment.

i. Redesign the proposed areas of Maritime Forest as a zone or band between the northwestern edge of the marsh and the forest/freshwater wetland Management Area, rather than as fingers of habitat protruding into the Successional Northern Hardwood cover type (as shown on the current Conceptual Plan). Select native tree species that will afford roosting and nesting opportunities to wading birds and raptors.

j. Evaluate the potential to create a zone of softened shoreline (*i.e.*, stabilized with bioengineering structures and/or vegetation instead of rip rap) at the mouth of the new tidal channel, and along adjacent areas of the North Cove shore.

k. Protect the existing *Spiraea* and moss mat communities, and the occurrence of Torrey's rush, during construction.

l. Avoid construction during the Northern harrier nesting season, if nesting activity resumes in the vicinity prior to the start of work.

m. Provide osprey and peregrine nesting structures; the Service will work with the ENSP to provide more detailed recommendations during the PED phase of the project.

n. Consult the NMFS and the NJDEP to determine if any seasonal restrictions are necessary to protect particular fish species during dredging and construction in the North Cove.

o. Monitor the marsh for 5 years to ensure successful establishment of target vegetation, and colonization of appropriate benthic invertebrate, fish, and small mammal communities (forage for other wildlife species). Include early monitoring (during and immediately following construction) as part of the adaptive management strategy ("b" above) to correct for any unsuccessful establishment of desired species. Maintain contacts within the larger Hudson-Raritan Estuary restoration planning effort and keep planning team members informed of progress on the Liberty State Park restoration. Report results to contribute to the science of wetland restoration, particularly in urban settings.

p. Develop an avian monitoring and management plan with the Service and the ENSP during the PED phase. The plan should address nesting colonial waterbirds, sensitive marsh species (State-listed species, rails, marsh wren, nesting waterfowl), osprey, peregrine falcon, and Northern harrier. Avian management may include surveys, monitoring of reproductive success, banding, environmental contaminants testing, and active management and protection of nest sites. Indefinite continuation of these activities by DPF, and close coordination with ENSP, are recommended.

2. Forest / Freshwater Wetland

a. Allow the entire forest/freshwater wetland Management Area to continue succeeding naturally, except for rare plant communities that warrant management to maintain more open conditions (*i.e.*, *Spiraea* community, moss mat community, Torrey's rush occurrence, any orchids requiring open conditions).

Within this Management Area, the Service recommends promoting succession of both existing and proposed freshwater wetlands to a forested condition (except the margins of the deepwater wetland), for the following reasons. First, a contiguous block of forest (upland and wetland) will provide a less fragmented landscape for interior wildlife species. Second, recent studies have shown that Neotropical songbirds preferentially utilize forested wetlands over other habitat types as stopover sites during migration (Mizrahi and Elia, 2002, Gauthreaux and Belser, 2003). Considering the high value of this urban forest to these migrating birds, it is appropriate to provide habitat enhancements targeted for this avian guild. Finally, tree cover may help control invasive species such as *Phragmites* and purple loosestrife, as these invaders are intolerant of shade.

b. Continue work with Rutgers University to complete a Forest Management Plan that includes a tree planting strategy, invasive vegetation control, predator control, long-term monitoring and management of vegetation and key wildlife groups, and public access.

c. Promote succession in shrub and field communities within the Forest/Freshwater Wetland Management Area. Plant trees in the small patches of the old field cover type to accelerate succession and prevent establishment of invasive vegetation. These existing old field patches are too small to support grassland bird species and their presence fragments the developing forest (refer again to Maryland Partners in Flight, 1998; Dettmers and Rosenberg, 2000; Ontario Ministry of Natural Resources, 2001).

d. Consider providing bird perches in areas where expedited succession is desired but tree planting may be impractical. McClanahan and Wolfe (1993) found that snags and perches to attract birds can increase the probability of reforesting later-successional species, increasing plant diversity, and accelerating succession, especially in highly fragmented landscapes where forest patches are small and distances to seedbanks are great. These authors caution, however, that this approach may not necessarily result in establishment of desired plant communities; the Service recommends close monitoring if perches are employed to accelerate vegetational succession.

e. Create "gradual" edges (edges with successional species) between forest and grassland Management Areas by encouraging shrubs, saplings, and some understory trees along the boundary. Abrupt, high-contrast edges between forest and grassland generally have more negative edge effects on forest songbirds than gradual edges (Rodewald, 2001). Brown-headed cowbirds and many predators tend to follow straight lines along habitat discontinuities. Dense shrub thickets and a row of native conifers along exposed edges may also help buffer forest interior habitats (Ontario Ministry of Natural Resources, 2001). Incorporating successional species will increase the edge width; however, the edge width should be less than 25 feet to avoid creating extensive (low-priority) shrub habitats.

f. Retain snags (dead trees) to provide perches, nesting cavities, and foraging habitat for insectivorous birds (see Maryland Partners in Flight [1998] and Rodewald [2001]).

g. Control invasive vegetation (Maryland Partners in Flight, 1998; Rosenberg *et al.*, 1999). Active abatement programs may be necessary where dense stands of *Phragmites*, purple loosestrife, or Japanese knotweed have become established; tree planting in such areas may help prevent re-invasion. Where tree-of-heaven has become a dominant woody species, girdle these trees and leave the snags to benefit cavity nesting birds. Implement routine invasive species survey and control activities as part of the Forest Management Plan.

h. Monitor for white-tailed deer (*Odocoileus virginianus*) activity. Although deer colonization is unlikely due to the surrounding urban landscape, deer in the Restoration Area could severely damage the forest understory through overgrazing, and deer control may be necessary to protect this key forest component (Rosenberg *et al.*, 1999).

i. Minimize adverse effects of trails through the interior of this Management Area. Miller *et al.* (1998) found that composition and abundance of birds, as well as reproductive success, was altered by trails in forest and grassland, with effects extending 250 to 330 feet.

(1) Do not create new trails. Convert existing roads to trails as necessary to meet DPF's public access and education goals.

(2) Keep trails under 50 feet wide, preferably under 25 feet wide, to reduce edge effects (Rich *et al.*, 1994).

(3) Do not create trails of mowed lawn as this cover type is associated with high cowbird abundance (Rich *et al.*, 1994; Maryland Partners in Flight, 1998); dirt, boardwalk, or even gravel or paved trails are preferable.

(4) Promote a closed canopy over trails, including tree planting where necessary to minimize fragmentation and help control invasive vegetation (Maryland Partners in Flight, 1998).

(5) Close sensitive areas (unusual plant communities, noted above; nesting bird areas) to public access seasonally or year-round as needed.

j. Test salinity and pH of groundwater and freshwater wetlands as possible limiting factors in amphibian abundance. Consider improvements or amendments to these aquatic systems (lime, clay liners, stormwater treatment) if water quality is poor.

k. Consult with the ENSP to determine if introduction of additional reptile and amphibian species is appropriate and beneficial. If so, design and implement a reintroduction plan.

l. Consult with the New Jersey Natural Heritage Program to determine if introduction of Torrey's rush to the margins of the proposed deepwater wetland would benefit this species, and to determine if restoration or enhancement of the moss mat community is appropriate. Undertake such efforts as recommended.

m. Revive the conifer grove through management, as well as planting native trees, to benefit Cooper's hawks, long-eared owls, and other species (Beans and Niles, 2003). Avoid monocultures, especially of non-native species (Maryland Partners in Flight, 1998; Rosenberg *et al.*, 1999).

n. Work with the Service and the ENSP during the PED phase of the project to develop an avian monitoring and management plan, including surveys for wintering owls and other raptors, breeding Cooper's hawks (Beans and Niles, 2003), and nesting forest interior birds (Dettmers and Rosenberg, 2000). Avian management may include surveys, monitoring of reproductive success, banding, environmental contaminants testing, and active management and protection of nest sites. Continued management by DPF, and close coordination with ENSP, are recommended.

3. Grassland

a. Convert this entire Management Area to the Maritime Grass cover type. The Successional Old Field and Mugwort cover types should be eliminated as they are dominated by non-native species, and the Mugwort cover type supports low bird usage (U.S. Army Corps of Engineers, 2004). Inclusion of the proposed treatment wetlands in this Management Area is compatible with the grassland, and may attract shorebirds and other species.

b. Plant a diverse mixture of native warm season grasses with a variety of heights and growth forms, including species such as big bluestem (*Andropogon geradii*), little bluestem (*Schizachyrium scoparium*), switchgrass (*Panicum virgatum*), Atlantic coastal panic grass (*Panicum amarum*), and Indian grass (*Sorghastrum nutans*). Select specific grass species adapted to soil conditions on the site. Prepare the areas before planting; eliminate woody vegetation and dense sod or stands of non-native vegetation by mowing short and applying a glyphosate-based herbicide. Light disking to break sod and/or application of a pre-emergent herbicide to block germination of cool season grasses and non-native species may be necessary. In the area to be capped with clean fill, apply the cap before planting to avoid colonization by non-target species. Plant in spring or fall, depending on site-specific factors, using a grass drill. The Service can assist in arranging rental of a grass drill. Seed at a rate of approximately 10 to 12 pounds per acre (Cornell Lab of Ornithology, 2004; Jones and Vickery, 1997; Massachusetts Audubon Society, 2004; Smith, pers. comm., 2004; Dettmers and Rosenberg, 2000; Maryland Partners in Flight, 1998). The Service is available to assist in developing a revegetation plan during the PED phase of the project.

c. Once target grasses are established, implement a rotational mowing regime on a 2 to 3 year basis to control natural succession, provide a mosaic of different grass heights, and maintain some undisturbed areas each year. Mowing should be conducted in late February or March to avoid disturbance of nesting birds, and to provide winter foraging habitat for raptors, woodcock, and meadowlarks. Mow to a height of 6 to 10 inches (Maryland Partners in Flight, 1998; Vickery *et al.*, 1999; Dettmers and Rosenberg, 2000; Beans and Niles, 2003; Massachusetts Audubon Society, 2004; Smith, pers. comm., 2004).

d. Monitor and control invasive vegetation that may colonize the area.

e. Create gradual edges between forest and grassland Management Areas by encouraging shrubs, saplings, and a few understory trees along the boundary, as discussed above, to protect forest species as well as provide perches for field-oriented species such as field sparrows and kestrels (Maryland Partners in Flight, 1998).

f. Do not create hedgerows or tree lines, except for a few trees at the top of the proposed berm to serve as a visual barrier and perches (Maryland Partners in Flight, 1998; Dettmers and Rosenberg, 2000).

g. Maintain patches of bare ground for horned larks and killdeer (Massachusetts Audubon Society, 2004).

h. Create a large "butterfly garden" of native wildflowers, including larval host plants and nectar-producing plants (Maryland Partners in Flight, 1998), located between the grassland and the proposed area of mowed lawn in the southwest corner of the Restoration Area. This garden would enhance insect diversity, serve as a buffer between a public recreation area and the grassland, and provide educational opportunities. Many parks employ volunteers to maintain such gardens. Informational resources regarding butterfly gardens are provided in Appendix F.

i. Locate trails as close as possible to the perimeter of the grassland to avoid fragmentation and disturbance of wildlife (Miller *et al.*, 1998; Maryland Partners in Flight, 1998). Close areas to public access as needed if bird nesting is documented.

j. Once target grasses are established, monitor grass height and density for compatibility with habitat requirements of priority bird species. Some studies have shown shorter, sparser grasslands provide better habitat where the goal is a diversity of non-game bird species (Dettmers and Rosenberg, 2000).

k. Provide nest boxes for bluebirds, swallows, and purple martins (Maryland Partners in Flight, 1998). Informational resources regarding nest box design and management are provided in Appendix F.

l. Coordinate with the Service and the ENSP during the PED phase to develop an avian monitoring and management plan, including all species listed in Table 5, as well as American woodcock. Avian management may include surveys, monitoring of reproductive success, banding, environmental contaminants testing, and active management and protection of nest sites, especially nest boxes. Continued management by DPF, and close coordination with ENSP, are recommended.

m. Monitor small mammal communities as small mammals represent an important prey base for raptors.

B. ENVIRONMENTAL CONTAMINANTS

1. Soil and Sediment Differences

The restoration design will include grade changes and creation of tidal marsh and freshwater wetlands. As a result, existing soils will be partially excavated and mixed into an aquatic environment as sediments. Tables 7 and 9 indicate which soil and sediment samples are in areas that are dominated by existing wetlands or would become wetlands with the proposed restoration. The contaminant concentrations in these samples are compared more appropriately to the sediment guidelines presented in Table 8 rather than soil screening levels, such as the NRDCSCC. The guidelines in Table 8 are more useful because bioavailability, pathways, and exposures of contaminants are generally greater in a sediment/aquatic environment than in a soil/upland environment. In addition, contaminants are more bioavailable to organisms at the base of the food chain in an aquatic environment. Bioavailable contaminants can cause toxic effects in invertebrates at low trophic levels or bioaccumulate in low trophic-level invertebrates with subsequent biomagnification to higher concentrations in upper trophic-level species. Using a potentially contaminated upland to create salt marsh is, therefore, typically inadvisable unless extensive testing indicates that significant adverse effects are unlikely.

Due to the differences between soil and sediment (*e.g.*, oxidized *vs.* reduced environment) and the types of contaminant exposures/pathways in terrestrial *vs.* aquatic environments (*e.g.*, skin *vs.* gills), sediment guidelines are generally more stringent. A comparison to sediment guidelines is therefore required to determine whether the contaminant concentrations observed in soils within an area proposed for wetland creation are acceptable relative to ecological impacts. As discussed above, a screening-level comparison to sediment guidelines for the Liberty State Park site indicates contamination of ecological significance.

> **Recommendation:** Use sediment guidelines and criteria to determine whether soil concentrations observed in areas proposed for wetland creation are acceptable relative to ecological impacts.

2. Sampling Depth

The 15 and 28.5 to 30-foot samples from 2004 and 2003, respectively, were removed below restoration grade and below depths likely to be biotically active in most areas of Liberty State Park. Thus, biologically relevant data, applicable to a screening-level review of contaminants, could not be obtained. The 1995 data are more revealing; however, most of the 1995 samples were removed from the surface and may be more representative of material that has accumulated since use of the rail yard ended in the 1960's. Thus, the samples obtained may be representative of material that is less contaminated than material at the depths actually proposed for restoration. For any additional characterization of contaminants at Liberty State Park that may occur, the Service recommends taking samples at depths corresponding to proposed restoration grades (and thus potential exposure and risk to fish and wildlife). Without data on contaminant concentrations at all depths that will contain biotically active zones during and after restoration, potential adverse effects on fish and wildlife resources cannot be adequately predicted.

> **Recommendation:** Perform any additional sampling and chemical analyses on samples removed from depths that correspond to the proposed elevation of the restoration sites.

3. Caps and Liners

Upon development of the Restoration Area, early plans called for a 1-foot cap of clean material to limit direct exposure of wildlife to contaminated soils. The Service understands capping is no longer part of the current restoration design (Will, pers. comm., 2004). The current restoration plan for Liberty State Park calls for much of the area to remain unremediated because the current ecological and aesthetic values are assumed to be greater than the potential for bioaccumulation and adverse effects from contaminants (Gallagher, pers. comm., 2004).

The rail yard area is now covered with dense vegetation, including upland forests and palustrine wetlands. Although the contaminant concentrations present in the soils are elevated and above protective concentrations, re-exposing or disturbing the soils during capping operations may not be prudent as this may allow more contaminants to be redistributed and increase wildlife exposure. The most significant exposure to certain surficial contaminants, particularly metals, would likely be through dust. Exposure from air borne dust is currently mitigated by existing vegetation, as long as the surface remains undisturbed. The Service concurs that vegetated upland areas, that are vegetated with successional native woody vegetation, do not require capping. However, during the restoration, all open areas and areas disturbed during removal of exotic vegetation should be capped with clean fill.

When contaminated soils are buried at 1 foot in depth, they are still susceptible to disturbance from erosion or biota. Wildlife degrade shallow soil caps through feeding or burrowing over time leading to erosion, water infiltration, and mixing of fill and soils (Smith *et al.*, 1997). For example, woodchucks (*Marmota monax*) dig burrow systems with up to 5 entrances that may extend down several feet and outward for approximately 50 feet. The mass of soil moved for one woodchuck burrow can be as much as 715 pounds (Baker, 1983). Small mammals (*e.g.*, mice, rats, moles, and shrews) and rabbits (*Sylvilagus floridanus*), may burrow to a lesser depth, but may be more common in an urban area. In addition to the vertebrate animals that burrow, earthworms are vertical migrators that may go up to 8 feet underground and can effectively mix soil horizons (Edwards and Lofty, 1977). Plants also contribute to the redistribution of contaminants. Roots of deciduous trees may penetrate to a mean depth of 11 feet and a maximum of 100 feet. The roots of annual grasses have been shown to penetrate to a mean depth of 1.65 feet and a maximum of 4 feet (Smith *et al.*, 1997).

> **Recommendation**: All open areas and areas disturbed during exotic removal should be capped with at least 1 foot of clean soil.
>
> **Recommendation**: Perform additional testing at the restoration grade in any area where restoration is proposed in an open (grass or old field) upland, if capping is not planned. If concentrations of any contaminants are above the NRDCSCC, include a cap of at least 1 foot of clean soil.

Once the restoration is complete, the Service's greatest concern for contaminant release is from sediments. For example, the basin proposed at the center of the rail yard will not include an outlet for normal stormwater volumes; instead, the water will spread over an adjacent infiltration basin. Thus, the restoration design must incorporate measures that remove and/or isolate sediments that could cause exposure of fish and wildlife to contaminants. Due to the increased bioavailability of many contaminants in an aquatic environment, the soils regraded at Liberty State Park to construct wetlands (estuarine or freshwater) should be lined with clean fill, such as 1 to 2 feet of clay covered with 1 foot of sand and/or growing medium. For wetlands designed for infiltration, the Service recommends 2 feet of clean sand as a liner.

Recommendation: Line restored wetlands with a minimum of 2 feet of clean material (1 to 2 feet of clay covered with 1 foot of sand or other growing medium). Line infiltration wetlands with at least 2 feet of clean sand.

Recommendation: Perform additional testing at the depth that will constitute the restoration grade in any area where wetland restoration is proposed, if capping/lining is not planned. If concentrations of any contaminants are above the ERM for estuarine wetlands or PEC for freshwater wetlands, include a cap as described above.

Due to the uncertainty of contaminant concentrations at restoration grade following excavation; the slopes of the wetlands and channels also require lining. If the channel slopes are unlined, contaminated material could wash into the wetlands and add concentrations of contaminants that could adversely affect fish and wildlife.

Recommendation: Place liners of clean fill along the slopes of restored wetlands and channels.

4. North Cove Water and Sediment Quality

The North Cove is the starting point of the proposed tidal inlet into the tidal marsh restoration. Surface and bottom water samples were collected bi-weekly from 5 stations in the North Cove for a period of 5 weeks, between August 7 and September 3, 2003. At stations where the depth exceeded 11 feet, samples were also collected from the middle of the water column. The samples were analyzed for temperature, dissolved oxygen, salinity, total suspended solids, biological oxygen demand, ammonia, nitrogen, nitrate/nitrite, and total phosphorus. Results of the 2003 water quality sampling did not include analyses of contaminants. The present water quality of the North Cove is representative of the water that will flow into the tidal marsh restoration site. The concentrations of contaminants in the water of the tidal marsh would not likely exceed concentrations observed throughout the rest of the HRE. Although the concentrations of contaminants in the waters of the HRE are generally of concern, remedial measures implemented over time, such as enacting TMDL standards, dredging, combined sewer overflow abatement, and landfill closure will help improve water quality. The existing water quality does not suggest an impediment to tidal marsh construction. Sediment contamination within the park, or in the existing soils that would become sediments after restoration, are of greater concern due to the potential increase in exposure of fish and wildlife to contaminants.

The Service also has concerns regarding sediments of the North Cove. The NJDEP completed a remedial investigation for the North Cove area in 1999 that revealed the presence of subsurface free oil product, believed to have resulted from the former McAllister Tug and Barge Area (http://www.state.nj.us/dep/srp/publications/site_status/2002/pdf/hudson.pdf). The North Cove appears to be a relatively low energy area that would allow fine materials to deposit and accumulate. Fine materials would be the most likely to contain any contaminants due to chemical bonding. Fine sediments were collected from the North Cove in 1999 that consisted of black soft muds containing a strong petroleum odor and oily globules suggestive of hydrocarbon contamination. The sediment fauna consisted primarily of polychaete worms, characteristic of contaminated areas. Organic content of the sediments from the North Cove ranged from 3.1 percent to 10.2 percent. North Cove sediments were not tested for contaminants. Considering the proximity to the Hudson River and Upper New York Bay, the contamination associated with this general area, and the cove's relatively low energy environment, North Cove sediments are likely to contain a variety of contaminants (*e.g.*, PCBs, dioxin and dioxin-like compounds, PAHs, and metals). To reduce contaminant risk, the Corps proposes to isolate material dredged from the North Cove at the soil staging area. Additionally, approximately 1 foot of clean sand is proposed to be placed over the entire surface of the North Cove below mean low water. This cap of clean fill may decrease wildlife exposure to petroleum and other contaminants to some degree and, as discussed above, degradation and other factors should reduce adverse ecological impacts of any oil that seeps through the cap. A remaining concern is the possibility that larger amounts of oil may have been undetected and could be released into the tidal marsh restoration. Maximizing the depth and minimizing the permeability of the cap would reduce the potential redistribution of petroleum hydrocarbons.

> **Recommendation**: Maximize the depth of the cap in the North Cove and use clay rather than sand as capping material.

5. Additional Samples

The hazard quotient of 2.9 for dieldrin for sample LSP-03-25 from the western edge of the park, discussed above, is not necessarily unacceptable in the HRE; however, the observed concentration was at a depth of approximately 30 feet. The concentration at this depth suggests that higher concentrations may exist closer to the surface that could become bioavailable during and after restoration. The dieldrin concentration where sample LSP-03-25 was removed or elsewhere in the Restoration Area should be investigated prior to further planning and construction. Dieldrin concentrations in excess of those previously observed would require removal or use of alternative portions of the Restoration Area for wetland creation.

> **Recommendation**: Investigate the concentration of dieldrin in the area proposed for wetland restoration along the western boundary of Liberty State Park. If concentrations exceed 1.6 mg/kg at the proposed restoration elevation, the material should be removed, the wetland design should be reconfigured, or an alternative location should be investigated.

Insufficient data on PCBs are available for the rail yard area; however, a rail yard used in the mid 1900's for locomotive maintenance is highly suggestive of PCB contaminated soils. PCBs were used as coolant in locomotive transformers and often were released both accidentally and intentionally during engine maintenance. Parts of the old rail yard correspond to the areas proposed for the tidal inlet or for other wetland restoration. Review of the 15 and 30-foot soil sampling data did not detect PCBs using the MDLs employed. "Non-detects" at 30 feet for PCBs does not necessarily indicate insignificant PCB concentrations at the restoration depth. PCBs adsorb to soil particles and generally do not migrate extensively vertically or horizontally, other than by erosion. The 1995 data included only six samples. How PCBs were sampled is unknown, as is the quality of the 1995 data.

> **Recommendation**: Include PCB analysis on samples collected throughout Liberty State Park at the surface and at the proposed restoration elevations for any area proposed for wetland creation if a liner of clean material is not included in the restoration design. If PCB concentrations exceed the ERM for estuarine wetlands or PEC for freshwater wetlands, redesign the area to include a cap, remove the material, or redesign the wetland to avoid the contaminated area.

As discussed above, PCB analyses were performed using an Aroclor-specific method. Although Aroclor methodology is less costly than congener-specific methods, the later provides data that are far more useful for assessing ecological risk.

> **Recommendation**: For any additional sampling and PCB analyses performed for the Liberty State Park restoration, use a congener-specific analytical method such as EPA Draft Method 1668A (U.S. Environmental Protection Agency, 1999; Rushneck *et al.*, 2004).

The Service noted dioxin and dioxin-like contaminants were not examined in any of the sampling events. The industrial history of this area and the dioxin-impaired state of HRE waters (New Jersey Department of Environmental Protection, 2002) suggest dioxin-like compounds may be present and should be included in any future analyses. The presence of PCP as a contaminant of concern at Liberty State Park also suggests sampling for dioxin is warranted, as discussed above.

> **Recommendation**: Include dioxin and dioxin-like compounds in any future analyses of sediment samples for any area not proposed to be capped or lined with clean material.

6. Stormwater Runoff

Stormwater runoff from parking lots to the west of the Liberty State Park will be diverted into biofilter wetlands and freshwater wetlands in the Restoration Area and will provide a major source of freshwater for maintaining the wetlands. To the Service's knowledge, the runoff from these parking lots has not been characterized. The parking lot runoff likely contains hydrocarbon pollutants associated with automobiles and other contaminants from urban and industrial activity. However, contaminant concentrations are not likely to be higher than those commonly seen throughout an urban area. Additionally, the created wetlands would help reduce the amount of unremediated stormwater runoff entering Upper New York Bay. Stormwater runoff will pass through biofiltering wetlands of low habitat value before entering freshwater wetlands specifically designed to provide high habitat values. Nevertheless, due to the potential for contaminants in runoff to impair the wetland functions, additional sampling is recommended. Sample TP-80, from the 1995 data, was taken near a facility (possibly used in waste recovery) along the western boundary of the park. The TP-80 sample displayed some of the highest concentrations of several environmental contaminants. If runoff from this facility is proposed to enter the biofilter wetlands, the runoff should be characterized for contaminants that could impair wetland functions.

> **Recommendation**: Characterize the contaminant concentrations in the stormwater runoff that will enter Liberty State Park, particularly in runoff coming from the facility near the TP-80 sample site.

7. Monitoring Plan

The Corps plans to partner with Rutgers University to use Liberty State Park as a model project for investigating urban ecology and natural attenuation of a degraded and contaminated site (Will pers. comm., 2004).

> **Recommendation**: Include monitoring of contaminants in all matrices (sediment, soil, water, and tissues of flora and fauna) in the Rutgers University project at Liberty State Park.

VI. CONCLUSIONS AND GENERAL RECOMMENDATIONS

With adequate measures to avoid and minimize undue exposure of fish and wildlife to environmental contaminants, the Service supports the Corps proposed habitat enhancements at Liberty State Park. The project will create a 200 to 250-acre mosaic of tidal marsh, upland forest, freshwater wetland, and grasslands. Habitat enhancements are expected to benefit a variety of fish and wildlife species in the NY-NJ Harbor, including wading and other marsh birds, waterfowl, raptors, grassland and forest birds, and marine fish. Reptiles and amphibians that may eventually colonize the site would also benefit.

The Service's primary recommendation for the project is to approach the creation and management of habitats in the Restoration Area from a perspective of large blocks of marsh, forest/freshwater wetland, and grassland habitats. To this end, the Service has delineated recommended Management Areas, based on existing vegetative conditions as well as the Corps Conceptual Plan for the Restoration Area. Other general recommendations include: preparing an eagle management contingency plan and completing consultation on the plan during the PED phase, pursuant to Section 7 of the ESA; maintaining a program to control feral dog and cat populations; following the State's general conservation recommendations for avian species; and avoiding the creation of fragmented forest and grassland habitats that would be unsuitable (and potentially function as population sinks) for forest interior nesting birds and grassland nesting birds, respectively. The Service especially prefers maximizing the habitat for interior forest species.

Comparisons of environmental contaminant concentrations present at the Restoration Area to the guidelines discussed above clearly indicate that contaminants at Liberty State Park are of ecological consequence and require remedial measures. Recognizing that Liberty State Park is part of a highly industrialized and urban area and has been an area of waste disposal, the Service realizes that the most stringent of environmental standards cannot be fully achieved for all restoration projects and some minimal amount of ecological risk to fish and wildlife resources may occur and continue after restoration. Contaminants are ubiquitous and will continue to be so, at least to some degree, in the urban, industrial environment surrounding the park. The Service understands that much needed restoration projects cannot be postponed indefinitely until all remedial measures, such as implementing TMDLs, have come to fruition. Therefore, the Service's concern is that the quality of habitats in Liberty State Park improve while not acting as an attractive nuisance to fish and wildlife. Restoration goals can be achieved by removing the most contaminated soils to the soil staging area, as the Corps proposes; by capping, as described above; and by incorporating the other Service recommendations provided above to further minimize fish and wildlife exposure. The ecological value of the Liberty State Park Restroration Area can be improved substantially, if contaminant exposure is decreased over the short and long-term as other habitat attributes are restored by the project.

VII. REFERENCES

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B. PERSONAL COMMUNICATIONS

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