RECORD OF DECISION

Gowanus Canal Superfund Site
Brooklyn, Kings County, New York

United States Environmental Protection Agency
Region II
New York, New York

September 2013

DECLARATION FOR THE RECORD OF DECISION

SITE NAME AND LOCATION

Gowanus Canal Superfund Site
Brooklyn, Kings County, New York

Superfund Site Identification Number: NYN000206222
Operable Unit: 01

STATEMENT OF BASIS AND PURPOSE

This Record of Decision (ROD) documents the U.S. Environmental Protection Agency's (EPA's) selection of a remedy for the contaminated sediments and source controls at the Gowanus Canal Superfund site (the "Site"), chosen in accordance with the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended (CERCLA), 42 U.S.C. §§ 9601-9675, and the National Oil and Hazardous Substances Pollution Contingency Plan, 40 CFR Part 300. This decision document explains the factual and legal basis for selecting a remedy to address the contaminated sediments at the Site. The attached Administrative Record Index (see Appendix III) identifies the items that comprise the Administrative Record upon which the selected remedy is based.

The New York State Department of Environmental Conservation (NYSDEC) was consulted on the proposed remedy in accordance with CERCLA Section 121(f), 42 U.S.C. § 9621(f), and it concurs with the selected remedy (see Appendix IV).

ASSESSMENT OF THE SITE

Actual or threatened releases of hazardous substances from the Site, if not addressed by implementing the response action selected in this ROD, may present an imminent and substantial endangerment to public health, welfare or the environment.

DESCRIPTION OF THE SELECTED REMEDY

The selected remedy, which addresses contaminated sediment, includes the following components:

- Dredging of the entire column of hazardous substance-contaminated sediments which have accumulated above the native sediments in the upper and mid-reaches of the canal (referred to as "soft sediments").
- In-situ stabilization (ISS)[1] of those native sediments in select areas in the upper

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[1] Mixing of materials, such as Portland cement, into the sediments to bind the contaminants

and mid-reaches of the canal contaminated with high levels of nonaqueous phase liquid (NAPL).[2]

- Construction of a multilayered cap in the upper and mid-reaches of the canal to isolate and prevent the migration of polycyclic aromatic hydrocarbons (PAHs) and residual NAPL from native sediments.
- Dredging of the entire soft sediment column in the lower reach of the canal.
- Construction of a multilayer cap to isolate and prevent the migration of PAHs from native sediments in the lower reach of the canal.
- Off-Site treatment of the NAPL-impacted sediments dredged from the upper and mid-reaches of the canal with thermal desorption,[3] followed by beneficial reuse off-Site (*e.g.,* landfill daily cover) if possible.
- Off-Site stabilization of the less contaminated sediments dredged from the lower reach of the canal and the sediments in the other reaches not impacted by NAPL, followed by beneficial reuse off-Site.
- Excavation and restoration of approximately 475 feet of the filled-in former 1st Street turning basin.
- Excavation and restoration of the portion of the 5th Street turning basin beginning underneath the 3rd Avenue bridge and extending approximately 25 feet to the east and the installation of a barrier or interception system at the eastern boundary of the excavation.
- Implementation of institutional controls incorporating the existing fish consumption advisories (modified, as needed), as well as other controls to protect the integrity of the cap.
- Periodic maintenance of the cap and long-term monitoring to insure that the remedy continues to function effectively.
- Combined sewer overflow (CSO)[4] controls as discussed below.

To prevent recontamination of the canal following the implementation of the above-described remedial actions, the upland sources of hazardous substances, including discharges from three former manufactured gas plants (MGPs), CSOs, other contaminated upland areas and unpermitted pipes along the canal, must be addressed prior to the commencement of, or in phased coordination with, the implementation of the selected remedy.

The former MGP facilities are being addressed by National Grid, a potentially responsible party (PRP) for these facilities and the Site, under NYSDEC oversight. Based upon the first NYSDEC-selected remedy at one of these former MGP facilities and NYSDEC guidance for presumptive remedies at former MGP facilities, it is assumed that a range of actions will be implemented at the facilities (that may include

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physically/chemically.

[2] Concentrated liquid contamination, typically oil-like, that forms a separate phase and is not miscible with water.

[3] Utilization of heat to increase the volatility of organic contaminants so that they can be removed and destroyed.

[4] Combined sewers receive both sewage and stormwater flows and discharge to the canal when the sewer system's capacity is exceeded.

removal of mobile sources, construction of cut-off walls along the canal, and active recovery of NAPL near the cut-off walls for each of the former MGP facilities) which will prevent the migration of contamination from the former MGP facilities into the canal. The cleanup of the former MGP facilities will be completed in accordance with schedules agreed upon between the EPA and NYSDEC. In the unlikely event that timely and effective state-selected remedial actions are not implemented at a given former MGP facility, the EPA may implement actions pursuant to CERCLA to ensure the protectiveness of the selected remedy.

NYSDEC is currently overseeing work being performed by New York City (NYC) to reduce CSOs to the canal by approximately 34 percent in middle and lower canal outfalls. To significantly reduce overall contaminated solid discharges to the canal, the selected remedy also includes the following CSO control measures for the upper reach of the canal:

- Construction of in-line sewage/stormwater retention tanks to retain stormwater which currently discharges through outfalls RH-034 and OH-007. It is estimated that an 8-million gallon tank and a 4-million gallon tank will be required to address CSOs from outfalls RH-034 and OH-007, respectively. In addition, outfalls located in the vicinity of outfalls RH-034 and OH-007 that contribute smaller CSOs will be connected to the retention tanks. The location of the retention tanks will be determined during the remedial design. While the sizes of the tanks will be determined during the remedial design, they are expected to conform with the requirements of the Clean Water Act (CWA) and to accommodate projected additional loads to the combined sewer system that result from current and future residential development, as well as periods of high rainfall, including future rainfall increases that may result from climate change.
- In the event that the permanent measures described above are not implemented in a timely manner, interim controls, such as temporary solids capture and removal, will be implemented to mitigate sediment from the CSO discharges until the permanent measures have been implemented.[5]
- Implementation of appropriate engineering controls to ensure that hazardous substances and solids from separated stormwater, including from future upland development projects, are not discharged to the canal.

Current and future high density residential redevelopment along the banks of the canal and within the sewershed shall adhere to NYC rules for sewer connections (Chapter 31 of Title 15 of the Rules of the City of New York) and shall be consistent with current NYC Department of Environmental Protection (NYCDEP) criteria (NYCDEP, 2012) and guidelines to ensure that hazardous substances and solids from additional sewage loads do not compromise the effectiveness of the permanent CSO control measures by exceeding their design capacity.

Since the EPA is incorporating contaminated CSO solids control in the remedy

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[5] It is unlikely that permanent measures to control the CSO discharges will be in place before the commencement of the remediation of the canal sediments.

selection, siting, remedial design and remedial action pursuant to the authority of CERCLA, certain CERCLA statutory authorities including, but not limited to, permit exemption and environmental impact statement functional equivalency apply. The EPA seeks to coordinate the CERCLA and CWA processes to the extent practicable, to ensure that the selected CERCLA remedy is implemented in an effective and timely manner.

The selected remedy also includes the following measures for discharges from upland sites (other than the former MGP facilities) and for unpermitted pipes along the canal:

- The EPA and NYSDEC will coordinate measures to control discharges from upland contaminated areas adjacent to the canal that have already been referred to NYSDEC for action. The schedule for these measures will conform to the schedules for the cleanup of the canal.
- Unpermitted pipe outfalls will be either controlled or eliminated.

The environmental benefits of the selected remedy may be enhanced by consideration, during the design, of technologies and practices that are sustainable in accordance with the EPA Region 2's Clean and Green Energy Policy and NYSDEC's Green Remediation Policy.[6] This will include consideration of green remediation technologies and practices.

The estimated present-worth cost of the selected remedy is $506 million.

The selected remedy will address source materials constituting principal threats by thermally treating the NAPL-impacted sediments dredged from the upper and mid-reaches of the canal, thereby satisfying the CERCLA preference for treatment.

DECLARATION OF STATUTORY DETERMINATIONS

The selected remedy meets the requirements for remedial actions set forth in CERCLA Section 121, 42 U.S.C. § 9621, because it: 1) is protective of human health and the environment; 2) meets a level or standard of control of the hazardous substances, pollutants and contaminants which at least attains the legally applicable or relevant and appropriate requirements under federal and state laws; 3) is cost-effective and 4) utilizes permanent solutions and alternative treatment (or resource recovery) technologies to the maximum extent practicable. In keeping with the statutory preference for treatment that reduces toxicity, mobility or volume of contaminated media as a principal element of the remedy, all of the contaminated sediments that are removed from the canal, as well as some contaminated sediments that remain in the canal, will be treated by implementing the selected remedy.

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[6] See http://epa.gov/region2/superfund/green_remediation and http://www.dec.ny.gov/docs/remediation_hudson__pdf/der31.pdf.

Because this remedy will result in hazardous substances, pollutants or contaminants remaining on-Site above levels that allow for unlimited use and unrestricted exposure, a statutory review will be conducted within five years after initiation of remedial action to ensure that the remedy is, or will be, protective of human health and the environment.

ROD DATA CERTIFICATION CHECKLIST

The ROD contains the remedy selection information noted below. More details may be found in the attached Decision Summary and the Administrative Record file for this Site.

- Contaminants of concern and their respective concentrations (see ROD, Appendix II, Tables 3 and 4);
- Baseline risk represented by the contaminants of concern (see ROD, pages 31-34 and Appendix II, Tables 6-15);
- Cleanup levels established for contaminants of concern and the basis for these levels (see ROD, Appendix II, Table 15);
- Manner of addressing source materials constituting principal threats (see ROD, pages iv and pages 74-75);
- Current and reasonably-anticipated future land use assumptions and current and potential future beneficial uses of groundwater used in the baseline risk assessment and ROD (see ROD, pages 29-30);
- Potential land and groundwater use that will be available at the Site as a result of the selected remedy (see ROD, pages 83-84);
- Estimated capital, annual operation and maintenance and present-worth costs; discount rate; and the number of years over which the remedy cost estimates are projected (see ROD, page 82 and Appendix II, Tables 16 and 17); and
- Key factors used in selecting the remedy (*i.e.*, how the selected remedy provides the best balance of tradeoffs with respect to the balancing and modifying criteria, highlighting criteria key to the decision)(see ROD, page 89).

AUTHORIZING SIGNATURE

Walter E. Mugdan, Director
Emergency and Remedial Response Division

September 27, 2013
Date

RECORD OF DECISION FACT SHEET
EPA REGION II

Site

Site name: Gowanus Canal Site

Site location: Brooklyn, Kings County, New York

HRS score: 50

Listed on the NPL: March 2, 2010

Record of Decision

Date signed: September 27, 2013

Selected remedy: Dredging of accumulated sediments, capping, off-Site thermal treatment of dredged nonaqueous phase liquid (NAPL)-impacted sediments in the canal and existing turning basins, in-situ stabilization of native sediments with high levels of NAPL, excavation and restoration of a portion of the filled-in former 1st Street and a portion of the 5th Street turning basin beginning underneath the 3rd Avenue bridge, stabilization of sediments not impacted by NAPL and reuse off-Site, institutional controls and combined sewer overflow controls.

Capital cost: $285,700,000

Treatment and Disposal cost: $216,000,000

Annual operation, maintenance, and monitoring cost: $4,400,000

Present-worth cost: $506,100,000

Lead EPA

Primary Contact: Christos Tsiamis, Remedial Project Manager, (212) 637-4257

Secondary Contact: Joel Singerman, Chief, Central New York Remediation Section, (212) 637-4258

Main PRPs National Grid and New York City

Waste

Waste type: PAHs, PCBs and heavy metals, including mercury, lead and copper

Waste origin: Spills/disposal

Contaminated media: Sediments

DECISION SUMMARY

Gowanus Canal Superfund Site
Brooklyn, Kings County, New York

United States Environmental Protection Agency
Region II
New York, New York
September 2013

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SITE NAME, LOCATION and DESCRIPTION

The Gowanus Canal[1] is a 1.8-mile-long, man-made canal in the Borough of Brooklyn in New York City (NYC), Kings County, New York (see Figure 1) (see Appendix I for figures).

To facilitate the assessment and management of the canal, it was divided into three Remediation Target Areas (RTAs) that correspond to the upper reach (RTA 1), middle reach (RTA 2) and lower reach (RTA 3) (see Figure 2).

There are five east–west bridge crossings over the canal, at Union Street, Carroll Street, 3rd Street, 9th Street and Hamilton Avenue. The Gowanus Expressway and a viaduct for NYC subway trains pass over head. North of Hamilton Avenue, the canal is approximately 5,600 feet long and 100 feet wide, with a maximum water depth of approximately 15 feet in the main channel at low tide. There are four short turning basins that branch to the east of the main channel at 4th Street, 6th Street, 7th Street and 11th Street. A former turning basin at 1st Street and an extension of the 4th Street turning basin that had been referred to as the 5th Street turning basin were filled in between 1953 and 1965 (Hunter Research *et al.*, 2004). An extension of the 7th Street turning basin has also been filled. South of Hamilton Avenue, the canal widens to a maximum of approximately 2,200 feet and ranges in depth from -15 to -35 feet mean lower low water (MLLW).[2] The Gowanus Canal has no remaining natural wetlands (various small, unconnected areas of vegetation and intertidal habitat exist) or natural shoreline. The vast majority of the shoreline of the canal is lined with retaining structures or bulkheads.

The canal is located in a mixed residential-commercial-industrial area. It borders several residential neighborhoods, including Gowanus, Park Slope, Cobble Hill, Carroll Gardens and Red Hook, with housing located within one block of the canal. The waterfront properties abutting the canal are primarily commercial and industrial. Re-zoning of canal-front parcels to high density residential began in 2009 and further such re-zoning is anticipated. During major storm events, canal flooding affects broad areas which are industrial, residential and commercial in nature.

A number of businesses use the canal for maritime commerce. All but two of the businesses are located south of 9th Street and none are located north of 4th Street. The canal is also regularly used by recreational boaters (primarily, canoers and kayakers). A limited number of people reside in houseboats on the canal.

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[1] The Site's Superfund Site Identification Number is NYN000206222. The U.S. Environmental Protection Agency (EPA) is the lead agency; the New York State Department of Environmental Conservation (NYSDEC) is the support agency.

[2] As a tidally-influenced water body, the canal has two high tides and two low tides of unequal height each tidal day. MLLW is the lower low water height of the two low tides.

Despite a New York State Department of Health fish advisory covering the entire Gowanus Canal, posted warnings and public outreach efforts, the canal is regularly used for fishing, particularly subsistence fishing by communities with environmental justice concerns surrounding the canal.

SITE HISTORY AND ENFORCEMENT ACTIVITIES

Prior to being developed, the area around the Gowanus Canal was occupied by Gowanus Creek, its tributaries and lowland marshes. Before the mid-1840s, the creek and its tributaries were dammed and used primarily to power tide mills (Hunter Research *et al.*, 2004). By the mid-1840s, Brooklyn was rapidly growing and the Gowanus marshes were considered to be a detriment to local development. In 1848, the State of New York authorized construction of the Gowanus Canal to open the area to barge traffic, flush away sewage, receive stormwater and fill the adjacent lowlands for development. The canal was constructed in the mid-1800s by bulkheading and dredging.

The former 1st Street turning basin[3] was originally utilized to deliver coal via barges to the former Brooklyn Rapid Transit Power House. The Power House consumed large quantities of coal. During its operating era, large coal piles surrounded the building until the plant became obsolete and was removed from service. As was noted above, the 1st Street turning basin was filled in. Portions of the building were also torn down over time. By 1969, the 125-foot tall smokestack and dynamo sections of the Power House had been demolished and the currently extant section of the Power House was the only part of the original building still standing.

The 4th Street turning basin extends from the main channel east to the 3rd Avenue bridge; the 5th Street turning basin originally continued east from there nearly to 4th Avenue. Both basins were completed in the early 1870s, contemporaneously with the main channel of the canal. As was noted above, the 5th Street turning basin was filled in between 1953 and 1965. A portion of that fill extends underneath the 3rd Avenue bridge into the 4th Street turning basin. Sediment has further accumulated throughout much of the 4th Street turning basin.

Following its construction, the canal quickly became one of the nation's busiest industrial waterways, servicing heavy industries that included manufactured gas plants (MGPs), coal yards, cement manufacturers, tanneries, paint and ink factories, machine shops, chemical plants and oil refineries. The Gowanus Canal served as an open sewer when it was initially constructed in the late 1860s. As a result of the poor environmental practices typical of the era, large quantities of wastes from many of these operations were discharged directly into the canal. By the late 1870s, sewers

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[3] The 1st and 4th Street turning basins are described in detail since they will be addressed under the selected remedy.

entering the canal carried a combination of household waste, industrial effluent from the MGPs and other industries and stormwater runoff (Hunter Research *et al.*, 2004). These discharges, which contained hazardous substances such as polycyclic aromatic hydrocarbons (PAHs) (a semi-volatile organic compound [SVOC]), polychlorinated biphenyls (PCBs), pesticides, metals and volatile organic compounds (VOCs), caused the canal to become one of New York's most polluted waterways.

The initial canal design recognized the likelihood of stagnant pollution problems and proposed various flushing solutions. These were not, however, implemented. Studies and commissions have repeatedly examined methods of addressing the contamination. A series of unsuccessful solutions were implemented, including directing additional sewage discharges to the canal in order to improve flow. In 1911, NYC began operating the Gowanus Canal flushing tunnel to address the canal's serious water quality issues. The flushing tunnel connects the head of the canal with Buttermilk Channel in Upper New York Bay. It was designed to improve circulation and flush pollutants from the canal by pumping water in either direction. The flushing tunnel starts at Degraw Street on Buttermilk Channel and ends on the west side of the canal at Douglass Street. The flushing tunnel operated until the mid-1960s, when it fell into disrepair.

The flushing tunnel was rehabilitated and reactivated in 1999 by the NYC Department of Environmental Protection (NYCDEP), pumping cleaner harbor water from Buttermilk Channel to the canal using a rebuilt version of the 1911 propeller-based pump system. Thereafter, NYCDEP determined that the 1990s flushing tunnel repairs were inadequate, because the pumping system was poorly designed, difficult to maintain and unable to function properly at low tide.

Direct discharges to the canal from industrial activities were substantially reduced or controlled over time because of declining industrial activity and the implementation of the Clean Water Act (CWA) in the early 1970s. Discharges from present-day industrial operations are regulated and permitted under the CWA's National Pollutant Discharge Elimination System (NPDES) and its state counterpart, the State Pollutant Discharge Elimination System (SPDES).

Although the level of industrial activity along the canal declined over the years as industry shifted away from the canal, high levels of hazardous substances remain in the sediments and upland sources. Discharges from upland contaminated areas adjacent to the canal, CSOs, storm sewers and unpermitted pipe outfalls continue to contribute contaminants to the canal. The history of these sources is summarized below.

Discharges from Upland Contaminated Areas Adjacent to the Canal

Contaminated areas adjacent to the Gowanus Canal are being investigated and remediated under the direction of NYSDEC. The EPA is coordinating with NYSDEC on these matters. Environmental investigations or cleanups are underway at the former Fulton Municipal Works Manufactured Gas Plant, Carroll Gardens/Public Place (formerly known as "Citizens Gas Works") (hereinafter, "Public Place")[4] and Metropolitan former MGP facilities along the canal. Until these sites are remediated, contaminants from them will continue to be transported into the Gowanus Canal primarily by the migration of nonaqueous phase liquid (NAPL)[5] through subsurface soils and groundwater discharge of dissolved-phase contaminants. PAHs are the primary contaminants of concern (COCs) from these sources.

The former MGP facilities are being addressed under the State Superfund and Brownfield Cleanup programs by National Grid, a potentially responsible party (PRP) for both these facilities and the canal. NYC owns a large portion of Public Place and Thomas Greene Park, a portion of the site where the former Fulton MGP facility operated. Together with National Grid, NYC is a signatory to the NYSDEC Brownfields cleanup order for Public Place. As the owner of these parcels, NYC may be considered a PRP for these facilities.

The EPA and NYSDEC have agreed to a coordinated schedule for the former MGP facilities and canal sediment cleanup efforts based on the anticipated timing of the dredging in the canal (which will commence at the head of the canal). In January 2012, NYSDEC directed National Grid to begin the expedited remedial design of a cutoff wall as an interim remedial measure for the former Fulton MGP facility, near the head of the canal. The purpose of this wall is to prevent subsurface migration of NAPL from the former Fulton MGP facility into the sediments at the bottom of the canal. For the Public Place former MGP facility, centrally situated near the curve in the canal (see Figure 2), the remedy includes a combination of excavation and a subsurface barrier wall and tar extraction wells. An investigation and partial source control cleanup was implemented at the former Metropolitan MGP facility, the third and most southerly former MGP facility, in 2003 under the State's Voluntary Cleanup program. Since there are potential source areas at this site that were not addressed by the actions taken in 2003, a remedial investigation (RI)[6] for this site is currently underway.

Based on the results of the EPA's RI, additional upland areas were found to have the potential to contribute contaminated groundwater and NAPL to the canal and were

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[4] A remedy was selected for the Public Place former MGP in 2007. The design of the selected remedy is approximately 50% complete.

[5] Concentrated liquid contamination, typically oil-like, that forms a separate phase and does not dissolve in water.

[6] The purpose of an RI is to determine the nature and extent of contamination at a site.

referred to NYSDEC for investigation and, if necessary, remediation under the State Superfund or other remedial program. Remediation schedules will be coordinated with the schedule for the canal remedy. Relative to the former MGP facilities, these areas are much smaller potential sources and are, thus, expected to require only a fraction of the time and cost to address.

Discharges from Combined Sewer Overflows and Stormwater

Combined sewers (sewers that receive both sewage and stormwater flows) serve 92 percent of the Gowanus Canal watershed, storm sewers serve only 2 percent and direct runoff drains 6 percent (NYCDEP, 2008a). The Owls Head and Red Hook wastewater treatment plants (WWTPs) serve the area. When an appreciable amount of rainfall occurs, runoff enters the combined sewers and exceeds the capacity of the system and the Owls Head and Red Hook combined sewer systems overflow to the canal. There are ten active CSOs and three stormwater outfalls discharging to the Gowanus Canal (see Figure 3 for the locations). Four of the CSO outfalls account for 95 percent of the annual discharge. The greatest annual discharge volume is from outfall RH-034, located at the head of the canal (121 million gallons; NYCDEP, 2008a). The CSO discharges result in point source loading of high-organic-content solids and associated hazardous substances to the canal.

In 2008, NYCDEP prepared a *Gowanus Canal Waterbody/Watershed Facility Plan Report* (WB/WS Plan) as part of its City-Wide Long-Term CSO Control Planning Project (NYCDEP, 2008a). This work is being performed under an Administrative Order on Consent (AOC) between NYCDEP and NYSDEC.[7] The goal of that project is to implement a series of improvements to achieve compliance with water quality standards under the CWA. Specific objectives of the plan include eliminating odors, reducing floatables and improving dissolved oxygen concentrations to meet surface-water-quality standards. NYCDEP's planned improvements for the Gowanus Canal include continued implementation of programmatic controls, modernization of the Gowanus Canal Flushing Tunnel, reconstruction of the Gowanus Wastewater Pump Station, cleaning/inspection of the outfall OH-007 floatables/solids trap, repairs to the Bond-Lorraine Street sewer main, periodic water body floatables skimming and CSO sediment mound dredging.

In July 2010, the flushing tunnel was shut down by NYCDEP to perform facility improvements. This effort includes the installation of more efficient pumping systems, which will increase the volume of water by approximately 40 percent under a peak design flow. The reconstruction of the Gowanus Wastewater Pump Station, which began in February 2010, will increase the pumping capacity to deliver sewage to the Red Hook WWTP. All of these ongoing improvements are projected to decrease the

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[7] NYSDEC Case No. CO2-20000107-8 dated January 14, 2005 and updated on April 14, 2008, September 3, 2009 and March 8, 2012.

overall discharge to the entire canal by approximately 34 percent.

However, the greatest changes in annual CSO discharge are concentrated in the middle and lower portions of the canal. Although outfall RH-034 at the head of the canal has been projected to experience fewer discharge events per year, its total annual flow is projected to increase approximately 5 percent. Annual CSO discharges from RH-034 and OH-007 will still contribute approximately 97 percent of the total annual CSO flow into the canal.

The completion of the flushing tunnel and pump station improvements is anticipated by September 2014. The cumulative impact of these projected flow reductions and flushing improvements on sediment transport and deposition throughout the canal cannot currently be predicted with a high degree of confidence, although preliminary modeling by National Grid indicates that contaminated CSO solids will still be trapped in the canal even with enhanced flushing tunnel flow. Following the upgrades to the flushing tunnel and pump station, NYCDEP will conduct post-construction monitoring and then will begin the planning and public participation related to a CWA Long-Term Control Plan (LTCP)[8] which will analyze the next stage of CSO-related improvements for the canal. The LTCP is to be submitted to NYSDEC in June 2015.

NYCDEP also plans a sewer separation project in a 96-acre area around Carroll Street for flood control purposes. It is projected that this effort will result in an additional overall CSO reduction of 5 percent when it is completed in 2022. However, the PAHs in the stormwater component of the CSO will still discharge to the canal.

NYCDEP is also undertaking a green infrastructure effort[9] that will result in an estimated 10 percent CSO reduction in stormwater discharges to the entire canal over an extended period of time (20-30 years) (NYCDEP, 2012). Two pilot projects for the control of street runoff along the Gowanus Canal (the DL and Studio's Sponge Park at 2nd Street, on the Carroll Gardens side of the canal and the Gowanus Conservancy green infrastructure at 2nd Avenue on the Park Slope side) are being supported by federal and NYC grants.

It should be noted that NYC's sewer system operations include the treatment and disposal of hazardous substances consistent with the categorical pretreatment

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[8] An LTCP is a phased approach for control of CSOs that requires a permittee to develop and submit an approvable plan that will ultimately result in compliance with CWA requirements and New York State water quality standards.

[9] Green infrastructure is a network of open spaces and natural areas, such as rooftop gardens and vegetated swales, which naturally manage stormwater, thereby reducing storm runoff into the storm sewers.

standards promulgated under 40 CFR § 430.5, which limit the pollutant discharges to publically-owned treatment works from specific process wastewaters of particular industrial categories. Various industrial facilities within NYC, including those operating within the Gowanus Canal sewerage area, have historically discharged and continue to discharge hazardous substances to the NYC sewage system. As part of its water and sewer rates, NYC charges for such disposal through the sewers. NYC has operated an Industrial Pre-treatment Program (IPP), as required by federal regulations, since 1987 in order to help protect the sewers, the wastewater treatment plants and NYC's receiving waters. As part of the IPP, NYCDEP issues permits for and inspects IPP facilities. CSO events, however, may result in the discharge of sanitary sewage and hazardous substances disposed of by non-regulated users or picked up from captured stormwater. Some of these hazardous substances tend to bind to the organic solids present in the sewage.

The WB/WS Plan acknowledges that solids associated with CSO events will continue to be discharged to the canal following implementation of the current upgrades. In response, the WB/WS Plan includes an analysis which suggests that the upgraded flushing tunnel will disperse the solids more evenly throughout the canal and into the harbor than in the past (NYCDEP, 2007a). In conducting this analysis and describing future operations, the WB/WS Plan has effectively memorialized the canal’s historic role as an extension of NYC’s sewer system. The canal, particularly the upper canal, has and will continue to function as a sewage retention basin. Among other things, this historic and on-going usage has created CSO mounds located at the head of the canal. The WB/WS Plan again calls for dredging these mounds, a measure which has been authorized but not implemented since 1983 (NYCDEP, 2008a).

Unpermitted Pipe Outfalls

Nearly 250 outfalls were identified and inspected during the RI, most of which were pipes located on private property. In general, these are unused pipes associated with historic industrial activities. Twenty-five of these pipe outfalls were observed to be actively discharging during dry weather (about a third of these discharges may have been tidal backflow). The flow rate from all but one of the active outfalls was very small (the majority are estimated to be less than 1 liter/minute).

Permitted Pipe Outfalls

A review of NYSDEC and the EPA databases identified five active permitted discharges to the canal. During the RI, discharges were not observed in three of these permitted outfalls. Two of the permitted outfalls could not be clearly identified because of the large number of outfalls in their vicinity.

Prior Dredging of the Canal

The canal's narrow 100-foot width upstream of the Gowanus Expressway is the entire navigational channel, unlike many river and harbor sites where the shipping channel represents a fraction of the total area of the water body. In the upper two-thirds of the canal, NYC has primary responsibility for maintaining the navigational depths.

Limited recent dredging of the canal has been performed and documentation of historical dredging is sparse. There are no federal, state or local regulatory requirements related to the depth of the canal north of Hamilton Avenue. Below Hamilton Avenue, the U.S. Army Corp of Engineers (USACE) previously performed maintenance dredging.

While NYCDEP has obtained State approvals for successive water quality improvement-related dredging (1983, 1993 and 2008), no major dredging has been performed in the canal in three decades. The current plan for dredging the CSO mounds at the head of the canal is scheduled for completion in 2017.

Prior Studies

Since 1983, NYCDEP has compiled four separate major reports on water quality and CSOs controls for the canal, each of which was approved for implementation by NYSDEC. Since 2003, the USACE and National Grid have each issued about a dozen reports regarding the canal. National Grid has completed numerous reports regarding its former MGP facilities and studies and/or cleanups have been conducted at another dozen or more upland areas.

Listing on National Priorities List

In April 2009, the Gowanus Canal was proposed for inclusion on the National Priorities List (NPL) pursuant to the Superfund law at the request of NYSDEC. Following the proposal for inclusion on the NPL, the EPA commenced an RI. On March 2, 2010, the EPA placed the Gowanus Canal on the NPL.

In April 2010, the EPA entered into administrative consent orders with NYC and National Grid to perform work in support of the EPA's RI and feasibility study (FS).[10] The draft RI report was completed in January 2011 and the draft FS report was completed in December 2011. In connection with the release of these reports, the EPA conducted significant public outreach throughout 2011 and 2012. The outreach process included numerous public meetings with formal presentations, as well as informal question and answer sessions. An FS report addendum was completed in December 2012.

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[10] An FS identifies and evaluates remedial alternatives to address the contamination.

HIGHLIGHTS OF COMMUNITY PARTICIPATION

Due to the technically complex issues at the Site and the significant public interest, the EPA greatly augmented its interaction with the community beyond what is typical for the Superfund remedy selection process. Specifically, while the EPA typically releases RI/FS reports simultaneously with the Proposed Plan[11] and conducts a public meeting to discuss the results of the investigation and the basis for the preferred remedy, for the Gowanus Canal site, the RI and FS reports were released separately at the time of their respective completion in order to facilitate their review and understanding by the public. The RI report was made available on the EPA's website in January 2011 and the FS report was made available on the EPA's website in December 2011. Following the release of each of these documents, the EPA held separate public meetings in the Carroll Gardens and Red Hook neighborhoods to present the findings. These meetings were announced in the local press. Several follow-up meetings to further discuss the technical issues and the community's concerns were held at the invitation of the Gowanus Canal Community Advisory Group (CAG), the local Community Boards and other local organizations.

On December 27, 2012, a press release was issued (which generated a number of on-line articles) and a number of e-mails were sent to the Site's mailing list re-announcing the availability of the RI and FS reports and announcing the availability of an FS addendum report and Proposed Plan on the EPA's website. On December 28, 2012, the RI report, FS report, FS addendum report and Proposed Plan were made available to the public at information repositories maintained at the Community Free Library, located at the Carroll Gardens Library, the Joseph Miccio Community Center in Red Hook and the EPA Region II Office in NYC. A notice of availability for the above-referenced documents was published in the *Courier Life*, *Red Hook Star-Revue* and *The Brooklyn Paper* on January 4, 2013. Notices were published in these papers again on January 18, 2013 to announce a revised starting time for the January 23, 2013 public meeting. On January 23, 2013 and January 24, 2013, the EPA conducted public meetings at Public School 58 (the Carroll School) and the Joseph Miccio Community Center, respectively, to present the Proposed Plan for the Site, including the preferred remedy, and respond to questions and comments from the approximately 200 attendees at the January 23, 2012 meeting and 100 attendees at the January 24, 2012 meeting.

Although serious concerns were expressed about a proposed on-Site confined disposal facility (CDF)[12] for the stabilized, lesser contaminated sediments at the January 24

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[11] A Proposed Plan describes the remedial alternatives considered for a site and identifies the preferred remedy with the rationale for this preference.

[12] A secure structure designed to contain dredged sediments (in this case, after stabilization) within a waterway.

meeting, there was clear overall support for the major components of the proposed remedy, similar to the support expressed during the January 23 meeting..

Prior to the release of the Proposed Plan and the commencement of the public comment period, a member of the CAG expressed concern that a 30-day comment period would be too short to provide the CAG members and other stakeholders sufficient time to provide technically well-informed comments. Accordingly, a 90-day public comment period was announced at the time of the release of the Proposed Plan.

In response to a January 28, 2013 request from NYC that the public comment period be extended 30 days, the comment period was extended to April 27, 2013.

A notice announcing the extension of the public comment period to April 27, 2013 was published in the *Courier Life*, *Red Hook Star-Revue* and *The Brooklyn Paper* on March 22, 2013.

During the comment period, in addition to the two meetings discussed above, the EPA held informational meetings with the CAG in Carroll Gardens on February 11, 2013, and again with the Red Hook community on February 13, 2013, the residents of public housing located immediately north of the canal on March 27, 2013 and the Red Hook community on April 16, 2013, the CAG on April 23, 2013 and the residents of public housing again on April 25, 2013. The purpose of these meetings was to discuss, in more detail, the specifics of the Proposed Plan and to answer additional questions from the community.   With the exception of the April 25, 2013 meeting which was attended by 25 people, all of the other follow up meetings were well attended.

The public generally supports the dredging, capping and CSO abatement components of the remedy. The CAG, which is comprised of approximately 50 members representing over 30 organizations and 20 non-organizational members, passed resolutions in support of the overall remedy, including 100% CSO control. Community Board Six, a municipal entity which represents the neighborhoods surrounding the canal, submitted comments supporting the overall remedy.

While 15 businesses and approximately 700 Red Hook residents located in close proximity to the proposed location of the CDF expressed support for its construction, approximately 900 parties located in other sections of Red Hook, elsewhere in New York State and in other states expressed strong opposition to the CDF option. In addition, No Toxic Red Hook submitted two similar petitions to the EPA containing approximately 2,500 original names and signatures from business owners, residents, users of the recreation area and concerned citizens. The petitions express opposition to the processing of contaminated sediments in Red Hook and their placement in a CDF.

Although various development interests filed formal comments in opposition to nomination of the Site for the NPL in 2009, no comments were filed in opposition to the Proposed Plan by the developers who have acquired property along the canal for residential, commercial and other redevelopment purposes since the Site was placed on the NPL.

Friends of Douglass Greene Park presented the EPA with a petition with 765 parties expressing opposition to the placement of an in-line sewage/stormwater retention tank beneath the Douglass and Degraw community pool. The petition also sought an assurance from the EPA that should any disruption or displacement to the pool be necessary as a result of the remediation, the park's facilities and services would be provided at a nearby location.

NYCDEP submitted 124 pages of comments, with approximately 300 pages of attachments. When read in their entirety, NYCDEP's comments state that the CSOs do not contribute to unacceptable impacts to the canal, lengthy additional studies are needed prior to remedy selection, further NAPL controls are needed and various project complexities effectively prevent addressing the contamination in the canal. National Grid submitted 43 pages of comments and 600 pages of attachments. National Grid, in sum, agreed that a cleanup of the canal can be done, despite significant technical challenges, asserted that even greater CSO controls were warranted and advocated for less dredging than indicated in the Proposed Plan. Comments questioning various aspects of the remedy were also submitted by various other PRPs and industry-related parties. Notably, NYC was alone in stating that no further CSO controls are warranted. Industry and other PRP commenters suggested that additional CSO controls beyond those set forth in the Proposed Plan are needed for an effective cleanup.

Responses to the questions and comments received at the public meetings and in writing (letters, postcards and emails) during the public comment period are included in the Responsiveness Summary (see Appendix V).

The areas adjacent to the canal historically have been residential, commercial and industrial. It is well known that significant redevelopment is anticipated around the canal, including high density residential redevelopment along the banks of the canal that has already been approved. Therefore, it was not necessary for the EPA to solicit the public's views on reasonably-anticipated future land use. Since the area is served by municipal water and the aquifer is already designated as a drinking water source (although it is not likely that the groundwater in the vicinity of the canal will be used for potable purposes in the foreseeable future), it was not necessary for the EPA to solicit the public's views on potential future beneficial groundwater uses.

The EPA has conducted extensive community outreach during the development of the

RI/FS and Proposed Plan and is committed to maintaining a transparent, proactive community interaction process during each cleanup phase, with informal comment opportunities on all key elements of the design and implementation. The EPA is committed to working with the community to minimize short-term impacts, including any temporary disruptions to public amenities.

SCOPE AND ROLE OF THE OPERABLE UNIT

The National Oil and Hazardous Substances Pollution Contingency Plan (NCP), at 40 CFR Section 300.5, defines an operable unit as a discrete action that comprises an incremental step toward comprehensively addressing site problems. A discrete portion of a remedial response eliminates or mitigates a release, threat of a release or pathway of exposure. The cleanup of a site can be divided into a number of operable units, depending on the complexity of the problems associated with the site.

The Site is being addressed as a single operable unit.

The EPA has the primary responsibility under CERCLA for investigating and remediating the canal sediments. By agreement between the EPA and NYSDEC, NYSDEC has the primary responsibility for the investigation and response actions related to the upland properties adjacent to the canal and the CSOs under the CWA. Addressing ongoing contaminant contributions to the canal from active sources is a prerequisite to a sustainable remedy for canal sediments.

The primary objectives of the response action are to remediate the contaminated sediments in the Gowanus Canal in order to reduce or eliminate unacceptable human health and ecological risks from exposure to the contaminated sediments, and to prevent recontamination of canal sediments after the remedy is implemented.

Contaminated groundwater that is migrating to the canal from the upland sources is being addressed by a combination of federal and state response actions. Groundwater and NAPL source areas associated with the former MGP facilities are being addressed by NYSDEC, in coordination with the EPA, under existing and anticipated MGP program response action decisions.

The EPA screened other upland source areas to identify locations where NAPL may have the potential to migrate through the subsurface into the canal. Of the areas identified through this process, the EPA currently plans to address a portion of the 1st Street turning basin and the portion of the 4th Street turning basin located underneath the 3rd Avenue bridge through this response action decision, while 400 Carroll Street[13] will be addressed through a non-time-critical removal action consistent with this response action decision.

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[13] A former oil terminal facility and location of a suspected coal tar hotspot.

Additional source areas (*e.g.,* Chemtura Corp.[14] and 627 Smith Street[15]) are already being addressed under various NYSDEC cleanup programs, such as the Resource Conservation and Recovery Act (RCRA) and state Brownfields redevelopment. The remainder of the EPA-identified upland groundwater source areas have been referred to NYSDEC for further investigation. These parcels will be addressed, as necessary, in separate response action decisions under NYSDEC authority, in coordination with the EPA. If any additional groundwater contamination source areas which threaten the effectiveness of the selected remedy are later identified, the EPA or NYSDEC will address such locations, as appropriate.

The cost of response actions, such as the former MGP facilities, Chemtura and Brownfields, which are being or will be addressed through separate decision documents, are not included in this decision document.

SUMMARY OF SITE CHARACTERISTICS

Site Hydrology

The Gowanus Canal is a tidally influenced, dead-end channel that opens to Gowanus Bay and Upper New York Bay (see Figure 1). The canal experiences a semidiurnal tidal cycle (*i.e.*, two high tides and two low tides of unequal height each tidal day), with a vertical tidal range from 4.7 to 5.7 feet. The only fresh surface water inflows to the canal are wet-weather CSO and stormwater discharges. Because of its narrow width, limited freshwater input and enclosed upper end, the canal has low current speeds and limited tidal exchange with Gowanus Bay. Circulation is enhanced by the addition of water from the flushing tunnel located at the head of the canal, when it is operating (NYCDEP, 2008a).

The canal upstream of the Gowanus Expressway has been designated “Use Class SD,” which indicates that the surface waters should be suitable for fish survival, as described in Title 6 NYCRR Part 701. The area downstream of the Gowanus Expressway is designated “Use Class I,” which indicates that the waters should be suitable for finfish propagation and survival as described in Title 6 NYCRR Part 701.

Site Hydrogeology

Four geologic units (in order of increasing depth and age) lie beneath the area surrounding the Gowanus Canal:

- Fill

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[14] A former laboratory and chemical manufacturing facility located at 633 and 688 Court Street.

[15] The former Barrett Manufacturing Co. asphalt roofing facility.

- Alluvial/marsh deposits
- Glacial sands and silts
- Bedrock

Fill materials are associated with canal construction and subsequent industrialization and regrading of the area, much of which was originally marshland. The fill consists of silts, sands and gravels mixed with ash and fragments of brick, metal, glass, concrete, wood and other debris.

The alluvial/marsh deposits lie below the fill and are composed of sands (alluvial deposits from flowing water bodies), peat organic silts and clays (marsh deposits). These alluvial/marsh deposits are associated with the original wetlands complex (*i.e.,* native sediment) that was present when the area was settled.

A thick sequence of glacial deposits occurs below the alluvial/marsh deposits. The full thickness of the glacial deposits was not penetrated in the RI, but the observed glacial deposits were composed mostly of coarser grain sediments (sands and gravel) and occasional beds of silt. These glacial sands, silts and gravel were deposited as glacial ice melted during the retreat of the last ice age. At the base of the glacial sequence lies a layer of dense clay, deposited by the glacier or prior to glaciation.

Weathered and competent bedrock underlies the glacial deposits. The bedrock consists of a medium- to coarse-grained metamorphic rock known as the Fordham Gneiss (GEI, 2005).

The primary aquifer beneath the Gowanus Canal and surrounding uplands is identified as the Upper Glacial Aquifer, which generally occurs in the thick sequence of glacial deposits but may include sandy units in the alluvial/marsh sediments. The Upper Glacial Aquifer appears to be generally unconfined, although local beds of silt and clay may confine underlying sand beds. In the Upper Glacial Aquifer, regional groundwater flows to the west/southwest toward Gowanus Bay. Groundwater-bearing zones in the fill and alluvial/marsh deposits discharge to the canal.

The canal is located within the area designated for the Brooklyn Queens Sole Source Aquifer. Groundwater is not, however, used as a potable water supply in this part of Brooklyn.

Multiple lines of evidence were developed in the RI to characterize the hydraulic relationships between local groundwater and the canal. Potentiometric surfaces developed from the synoptic (instantaneous points in time) measurement events suggest that, at the water table, groundwater flows toward the canal. Potentiometric data from intermediate wells screened in the glacial deposits depict a more complex pattern, with groundwater generally flowing upward toward the canal, which is typical of a discharge area. Data from a five-day tidal evaluation indicate that at specific locations adjacent to the canal, canal elevations at high tide consistently exceeded groundwater elevations in the shallow fill/alluvium, creating hydraulic conditions for surface water to intermittently flow into shallow aquifer sediments.

Sediment Characteristics

The sediments in the canal consist of two distinct layers. The upper layer is referred to as "soft sediment." The soft sediment has accumulated in the canal over time since the canal was last dredged. The soft sediment layer ranges in thickness from approximately 1 foot to greater than 20 feet, with an average thickness of about 10 feet. The thickest deposits are found at the head of the canal and within the turning basins. The soft sediment consists, generally, of a dark gray to black sand/silt/clay mixture that contains variable amounts of gravel, organic matter (*e.g.,* leaves, twigs, vegetative debris)[16] and trash. Odors described as "organic," "septic-like," "sulfur-like," and "hydrocarbon-like" were commonly detected in the soft sediment during the RI, as were visible sheens. The soft sediments are underlain by the alluvial and marsh deposits of the Gowanus Creek complex that were present prior to the canal's construction. These deposits are referred to as "native" sediments and consist of brown, tan and light-gray sands, silts, silty sand, sandy clay, clay and peat.

Sediment coring data produced by the EPA and National Grid document the presence of high-organic content sediments that adsorb and retain contaminants, including PAHs. Many of these sediments also contain visible sheens, indicating the presence of undissolved petroleum hydrocarbons or coal tar. Specifically, the total organic carbon (TOC) content is substantially higher in Gowanus Canal surface sediments than in the Gowanus Bay and Upper New York Bay reference area sediments, with averages of 6.4 and 2.8 percent, respectively. The high TOC content of the surface of the soft sediment reflects the impact of CSO discharges to the canal. NYCDEP has estimated the loading of biochemical oxygen demand (BOD) to the canal and noted that CSOs dominate these loadings relative to stormwater runoff (NYCDEP, 2008a). BOD is another measure of organic matter in a sample. High concentrations of organic contaminants (*i.e.,* PAHs associated with NAPL) appear to have increased the TOC measurements in some samples. Other physical characteristics of each sediment type in the Gowanus Canal and Upper New York Bay reference area (*i.e.*, grain size distribution, percent solids, sulfide concentration and bulk density) are described in the FS report.

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[16] While the soft sediments are comprised of mineral grains, naturally-occurring organic material and sewage, as is noted in the "Nature and Extent of Contamination" section, below, these sediments are heavily contaminated with PAHs, PCBs, metals and VOCs.

Shoreline and Bulkhead Characteristics

NYCDEP (NYCDEP, 2008b) has documented that the shorelines of the Gowanus Canal are entirely altered. While there are areas where the shoreline consists of riprap and piers, the shorelines are dominated by bulkheads (NYCDEP, 2008b).

A bulkhead inventory performed along the entire length of the canal by Brown Marine Consulting (2000) indicated that there are four primary types of bulkheads:

- Crib-type bulkheads, which are constructed of interlocking timbers or logs that are filled with backfill to form a type of gravity retaining structure.
- Gravity retaining walls, which are built so that the weight of the wall itself provides stability.
- Relieving platforms, which consist of a deck of timber or concrete supported on piles, typically timbers or logs, at an elevation high enough above the mean low water[17] line to not require underwater construction techniques but low enough to keep the pilings continuously submerged.
- Steel sheet-pile bulkheads, which are flexible walls constructed of steel sheets with interlocking joints. The steel is capped with concrete or masonry construction. Anchorage systems prevent outward movement and consist of tie-rods and anchors (*e.g.*, structures buried inshore of the bulkhead, such as massive concrete blocks or steel sheet-piles). The bulkheads north of Hamilton Avenue are generally constructed of wood or steel.

The survey concluded that the existing structures were sufficient only to support present loading conditions and that any type of dredging activity could threaten bulkhead stability due to the deteriorated condition of the structures. The survey was based only on visual examinations of structures without physical or laboratory testing and recommended that a more thorough investigation of bulkhead integrity be performed if dredging is planned. The report also noted that an estimated 42 percent of the bulkhead length was in fair condition or worse.

Hunter Research *et al.* (2004) quantified bulkhead conditions in 2003. In that survey, they evaluated bulkhead construction and determined that approximately 73 percent of the bulkheads along the main canal and turning basins were crib-type bulkheads with timber construction. Approximately 10 percent of the bulkheads consisted of concrete or bridge abutments and 17 percent were timber or steel sheet-piling-type barriers.

Limited environmental investigations of the shoreline were conducted immediately adjacent to the canal and beyond the limits of the upland source areas. These

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[17] The average of all the low water heights.

investigations revealed the presence of coal tar at certain locations in the canal bank at the same elevation as the tar in the canal. These findings suggest that tar might have migrated along the canal and re-infiltrated into the bank at locations away from the original source areas. These areas of bank-stored tar may act as secondary sources of contamination to the canal.

Areas of Archaeological or Historical Importance

In 2006, the Gowanus Canal Historic District was found eligible for the National and State Registers of Historic Places by the New York State Historic Preservation Office (SHPO).[18] The district was identified as a result of an eligibility study undertaken by Hunter Research in 2004 for the USACE. Additional contributing resources were identified by the SHPO in 2008 following a cultural resources study undertaken in response to a proposed Toll Brothers project at 363-365 Bond Street.

The EPA supplemented this information during the RI/FS. Documentary research and a high-resolution side-scan sonar survey performed for the RI identified known historic resources in the form of the canal bulkheads, as well as anomalies on the canal bottom, which will be the subject of further investigation. The variety of bulkheads reflects an evolution of technology, a varied use of materials and an effective means of maintaining the function of the canal, thus ensuring its role in the commercial development of Brooklyn.

A historical and archaeological study of the Gowanus Canal was carried out as part of the FS to assist the EPA in meeting its obligations under Section 106 of the National Historic Preservation Act and its implementing procedures (36 CFR Part 800). The study's objectives were to establish prehistoric and historic contexts for identifying and evaluating potential subsurface features of interest that may have been buried following the draining and filling of the Gowanus Creek marsh during the construction of the canal from *circa* 1853 to 1870. As part of this report, a Historic American Engineering Record (HAER) narrative history of the Gowanus Canal was prepared.

One conclusion of the study was that sites of potential archaeological interest exist within the Gowanus Canal project area. These include an area of prehistoric potential from the former 1st Street turning basin up to Degraw Street, the sites of three tide mill complexes, two corridors of battle action from the Battle of Brooklyn during the

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[18] The district is a linear corridor following the canal channel from a point opposite Percival and 17th Streets extending approximately 6,500 feet northeast to a point between Douglass and Butler Streets. It includes the canal channel and bulkheads and 13 related contributing buildings and structures, sharing a context within the industrial landscape that developed adjacent to the canal following its initial phase of construction and improvement from *circa* 1853 to 1870.

Revolutionary War and two potential sites of soldier burials.

A geotechnical evaluation of soil borings indicated that the likelihood for these sites to have survived intact is very low to low but not entirely without potential. Their state of integrity is unconfirmed, but if intact, they will be deeply buried at depths of at least 15 feet at the edges of the canal, with the greatest likelihood of intact survival existing just outside of the canal bulkheads (about 20 feet from the edge of the canal). Moving away from the canal, any surviving cultural stratigraphy generally will be buried less deeply (based on documented patterns of filling in the former tidal marshes) and have a much higher likelihood of having been disturbed by more than 150 years of intensive urban development.

Of greater certainty are the survival of archaeological resources associated with the Gowanus Canal itself and the industries that grew beside it in the mid- to late 19th century. The canal and its turning basins include more than two miles of timber cribwork bulkheads that have been identified as part of the canal's historic fabric and are likely to contain important information about the canal's design and construction. Within the canal itself are the remains of at least four shipwrecks and a high likelihood that several other ship hulls have survived within the fill of the former 1st Street turning basin. Canal-side industrial archaeology sites also have the potential to yield information related to specific industries and research questions about those industries' activities and their impact on the natural and human environment.

The study also identified recommendations for further archaeological studies and considerations to be included in the remedial design in order to avoid or mitigate remedy impacts on potential archaeological resources. Recommendations for additional cultural resources work during the remedial design phase include the refinement of the archaeological "Area of Potential Effect;" targeted research on canal-related, mid- to late-19th-century industrial sites that may be impacted by ground disturbances; additional, targeted geotechnical investigation; and archaeological monitoring of the removal/stabilization of timber cribwork bulkheads with documentation of sample bulkheads. Specifically related to the recommended monitoring, the additional effort will document the design and construction of the canal's timber cribwork and include the preparation of drawings as appropriate for inclusion in a supplemental HAER documentation package. Other resources identified for monitoring include any identified potential industrial archaeological resources, maritime resources identified by side-scan sonar in 2010, and the buried ships reportedly located in the former 1st Street turning basin. Further archeological studies may be required to avoid or mitigate potential remedy impacts related to siting of CSO controls and any temporary water treatment or staging facilities.

Should the bulkheads be subject to adverse effects as a result of cleanup actions, a wide range of mitigating measures could be implemented as part of the remedy. As noted above, the appropriate measures will likely include additional documentation of bulkhead characteristics and the incorporation of archaeological and architectural investigations. Where new bulkhead construction is required, bulkhead configurations that are in keeping with the historic character of the setting will be considered.

Further examination of anomalies on and within the sediments will need to be performed as remediation proceeds. This investigation will likely encompass further remote sensing and/or direct examination of items in the canal bottom.

RESULTS OF THE REMEDIAL INVESTIGATION

Based upon an analysis of the extensive prior studies and reports that were prepared for the canal and upland areas, the following additional work was performed as part of the RI: bathymetric survey; survey of outfall features, including identifying outfall features, collecting and analyzing outfall water samples and tracing outfall features to their origin; cultural resources survey, including a bulkhead study; sediment coring; surface sediment sample collection and analysis; surface water sample collection and analysis; fish and shellfish tissue sample collection and analysis; air sample collection and analysis; CSO sediment and water sample collection and analysis; and hydrogeological investigation, which included groundwater monitoring well installation and development, soil sampling, groundwater sampling, groundwater/surface water interaction sampling, synoptic measurements of water levels and tidal evaluation.

Geophysical Surveys

The bathymetry of the canal was measured by the USACE in a January 2010 survey using the same methodology as was used in the 2003 USACE bathymetry study performed in a joint investigation with NYCDEP. The measured bottom depth elevations ranged from approximately -0.13 feet to -38 feet North American Vertical Datum 1988 (NAVD88). The bottom depth elevations measured within the canal north of Hamilton Avenue were typically between -0.13 feet and approximately -18 feet NAVD88; much lower sediment surface elevations were measured south of Hamilton Avenue. The sediment surface at the head of the canal and in the eastern ends of many of the turning basins is exposed at low tide. Evidence of propeller scour in the form of a deeper sediment surface was noted in the southern portion of the canal; this area is subject to frequent tugboat activity to move and position oil and gravel barges at the various commercial terminals near the mouth of the canal.

Debris, such as tires, sunken barges, concrete rubble, timbers, gravel and general trash, is widespread throughout the canal. A debris survey was performed in late 2005 by National Grid using magnetometer, sub-bottom profiling and side-scan sonar technologies.

The combined observations from the 2003 and 2005 geophysical surveys, 2010 side-scan sonar survey and 2010 RI field observations were used to characterize the distribution of debris and obstructions in the canal. Detailed observations are provided in the RI/FS reports.

Extent of Contamination

<u>Sediment</u>

The horizontal and vertical distribution of contamination in surface sediment (0-to-6-inch depth interval), soft sediment (from a depth of 6 inches below the sediment surface to the contact with the native Gowanus Creek sediments) and native sediment (*i.e.*, original Gowanus Creek alluvial and marsh deposits) were characterized on the basis of field observations and chemical analysis of sediment samples.

The canal, especially the upper reach, is a water body contained in a constructed confined space of relatively regular geometry and relatively shallow depth. Water and suspended sediments from New York Harbor enter the canal through tidal exchanges from the south end and flushing tunnel flow at the northern end. Small amounts of direct stormwater runoff from areas adjacent to the canal also drain directly into the canal. Deposition of solids in the canal from these sources constitute the "background" level of contamination *(i.e*., regional contamination with no contribution from Gowanus Canal point sources of contamination), which should be within or slightly above the range of contaminant concentrations at the reference area sampling stations in the harbor. For the harbor reference stations sampled during the RI, PAH concentrations ranged from 1 mg/kg to 14 mg/kg. See Table 1 for a summary of the range and average concentrations for harbor reference data for PAHs, PCBs, copper and lead (see Appendix II for tables). Previous studies have shown that for the entire New York/New Jersey harbor system, total PAH[19] concentrations in the sediment ranged from 0.7 mg/kg to 22.1 mg/kg (EPA, 1998). Data recently collected from candidate reference areas for the Newtown Creek Superfund site RI indicate that PAH concentrations in enclosed and semi-enclosed industrial embayments without CSOs are comparable to the reference area concentrations measured in the Gowanus Canal RI.

All other major ongoing inputs of chemical contamination to the canal are from upland point sources of contamination to the canal, including the three former MGP facilities and the CSO and stormwater outfalls.

Canal sediments are affected by contaminants that are adsorbed to sediment particles and by the upwelling and horizontal transport of NAPL, which contains PAHs. In surface sediments (0-to-6-inch depth interval), PAHs, PCBs and seven metals (barium,

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[19] Total PAH is defined as the sum of detected Priority Pollutant PAHs and 2-methylnaphthalene.

cadmium, copper, lead, mercury, nickel and silver) were found to be contributing to unacceptable ecological and human health risks. Concentrations of these constituents in surface sediment were statistically significantly higher in the canal than at reference locations in Gowanus Bay and Upper New York Bay. The average total PAH concentration in surface sediment from the canal is two orders of magnitude higher than the average concentration in reference area surface sediment. Average total PAH concentrations in subsurface soft and native sediment are three orders of magnitude higher than samples from the reference area.

Subsurface sediment sampling data indicated that VOCs, particularly benzene, toluene, ethylbenzene and xylene (BTEX), and total PAHs were frequently detected at high concentrations, with PAHs detected up to 48,000 mg/kg in both the soft and native sediment units. The highest PAH concentrations were measured in samples that contained NAPL. PCBs and metals were all frequently detected in the soft sediment, but were infrequently detected or detected at lower concentrations in the native sediments. In the subsurface soft sediment, VOCs (primarily BTEX), PAHs, PCBs and metals were all detected at substantially higher concentrations than those found in the surface sediments.

Table 2 summarizes the physical characteristics of surface, soft and native sediments in the canal and surface sediment in the reference area. Table 3 shows the average concentrations of selected constituents in surface, soft and native sediments in the canal and surface sediment in the reference area. Table 4 shows the average concentrations of selected constituents in surface sediment in the upper, middle and lower reaches of the canal.

The sediment coring effort showed that NAPL contamination is present in native sediments underneath the canal and at certain locations in the banks of the canal between the head of the canal and the Gowanus Expressway, in portions of the upper reach of the canal and in the overlying soft sediment primarily in the middle reach of the canal.

The NAPL from the three former MGP facilities is, primarily, coal tar waste. Some of this waste was discharged directly into the canal during the periods when the MGPs were operating. This NAPL, being heavier than water, settled to the bottom of the canal, and a portion of it might have been transported within the canal as a result of tidal currents and the action of the flushing tunnel when it was operating. Native sediments along nearly the entire length of the canal above the Gowanus Expressway became contaminated with coal tar. In some areas, this NAPL has moved downward to substantial depths below the canal and laterally into the banks of the canal.

Additional coal tar NAPL can be found in the subsurface soils near the former MGP facilities. This is tar which escaped from the subsurface structures at the former MGP facilities and seeped into the surrounding soils. Very high levels of coal tar contamination have been found at all three of the former MGP facilities. In some locations, the pore spaces of the soils near the former MGP facilities are saturated with coal tar. It is clear that in some cases, this tar is either still mobile or could be mobilized in the future by relatively minor subsurface disturbances. PAH and BTEX compounds are major constituents of coal tar.

In most areas north of the Gowanus Expressway, NAPL and high-PAH concentrations were found in sediment to the maximum depth of the investigation activities, which was targeted to be six feet below the interface between the soft and native sediment layers. Deep borings installed in the canal adjacent to the Public Place former MGP facility by National Grid in 2010 indicate that NAPL contamination extends to a depth in excess of 50 feet below the sediment surface. Adjacent land-based borings on the former MGP facility contained visible NAPL at depths of more than 100 feet.

While the NAPL from historic MGP operations accounts for the majority of the PAH mass and the highest PAH concentrations in canal sediments, PAH concentrations in the top six inches of the sediments (the bioactive zone) in the upper reach of the canal are primarily associated with contaminants introduced through more recent CSO discharges. Existing sediments in the canal are covered by newer contaminated CSO sediments and, to some extent, solids transported from the harbor through tidal transport or through the flushing tunnel when it is in operation. Thus, generally, surface sediments are newer and deeper sediments are older.

Some ongoing movement of coal tar NAPL into shallow sediments has been documented. In the vicinity of the Public Place former MGP facility, tar droplets can occasionally be seen rising to the water surface in the canal during low tide. It appears that this tar is being transported upward through the sediments by the ebullition of gas bubbles generated by microbial decay of organic material in the sediments.

Combined Sewer Overflows

The results for wet weather CSO water samples (*i.e.*, samples collected from the sewer system during wet weather overflow events) indicate that CSOs containing VOCs, PAHs, PCBs, pesticides and metals are discharged to the canal during wet weather events. The wet weather CSO water samples represent actual discharges to the canal. Samples were collected from the combined sewer regulators, approximately one block from the discharge points, to eliminate potential backflow (tidal intrusion) from the canal. Sampling results for residual CSO sediments collected from within sewer pipes indicate that, if mobilized during wet weather events, these will discharge VOCs, PAHs, PCBs, pesticides and metals to the canal.

Unpermitted Pipe Outfalls

As noted above, more than 250 unpermitted pipe outfalls were identified and inspected during the RI; 25 of these pipe outfalls were observed to be actively discharging during dry weather. Effluent from 14 of the 25 active outfalls identified during the RI could not be attributed to tidal drainage (*i.e.*, drainage of seawater that entered the pipe at high tide). Samples from 12 of these 14 outfall discharges contained VOCs, PAHs and metals (two of the discharges were not sampled due to low flow rates). Pesticides and PCBs were not detected. Contaminant loading from unpermitted outfalls was estimated to be very low since observed pipe discharges were intermittent and at very low flow rates (estimated to be less than 1 liter per minute). Based on these estimates and measurements (according to NYCDEP's 2008 study), these loadings are insignificant by comparison to other sources, such as the CSOs and the flushing tunnel.

Surface Water

VOCs, SVOCs and metals were detected in surface water samples collected from the canal under wet-weather and dry-weather conditions for the RI. Pesticides and PCBs were not detected in any surface water sample. BTEX compounds were the most common VOCs detected and PAHs were the most common SVOCs detected. Concentrations of contaminants, including benzene and PAHs in the Gowanus Canal surface water samples were significantly higher than their concentrations at the Gowanus Bay and Upper New York Bay reference locations during both dry- and wet-weather conditions.

High levels of bacteria are also present in the canal as a result of periodic discharges from the combined sewer outfalls. Although not considered for CERCLA remedy selection purposes, risk to child and adult recreational users and workers from CSO-related pathogen exposure is a significant issue, as was outlined in the draft Gowanus Canal Public Health Assessment.

Ambient Air

The sampling results for air samples collected from canoe-level and street-level locations along the length of the canal and from three background locations (two blocks west of the canal) indicate that the types and concentrations of VOCs and PAHs detected in air samples were similar, regardless of sample location. The detected constituents were typical of those found in urban environments and the VOC and PAH concentrations were either within the same order of magnitude (sampling round 1) or the same as those found in urban environments (sampling round 2).

Groundwater

Groundwater samples were collected from 44 shallow and 46 intermediate monitoring wells. With the exception of PCBs, all classes of contaminants that were sampled for (VOCs, SVOCs, PCBs, pesticides and metals) were detected in samples from both the shallow and intermediate groundwater throughout the length of the canal (PCBs were not detected in any of the sampled monitoring wells). Chemical concentrations in the groundwater were higher in wells where NAPL saturation was observed in the soil borings. VOC concentrations were higher than screening values in approximately 33 percent of the shallow monitoring wells and 67 percent of the intermediate monitoring wells along the canal. Similarly, SVOC concentrations were higher than screening values in approximately 33 percent of the shallow monitoring wells and in half of the intermediate monitoring wells. Pesticides, however, were detected in only one shallow monitoring well and in one intermediate monitoring well and exceeded the screening value at the intermediate monitoring well location. With regard to metals, all of the shallow and intermediate monitoring wells contained at least one metal (arsenic, barium, lead, nickel or sodium) above its screening value.

For the shallow groundwater, a number of PAHs (2-methylnaphtalene, acenaphthene, acenaphtylene, anthracene, fluoranthene, fluorine, naphthalene, phenanthrene and pyrene) were found in more than half of the collected shallow groundwater samples and 93.2% of all samples contained at least one PAH. The compounds that showed the most excursions of various applicable standards were the VOCs benzene, ethylbenzene, isopropylbenzene and xylene. The same general pattern is true for the intermediate groundwater with 98% of all intermediate groundwater samples containing at least one PAH.

The EPA analyzed the groundwater data to determine whether contaminated groundwater discharge to the canal could potentially lead to continuing sediment contamination. This evaluation was performed by calculating Equilibrium-Partitioning Sediment Benchmark Toxic Units (TUs) for PAHs in each groundwater sample collected along the canal during the RI. Briefly, the TUs were calculated by comparing PAH concentrations in groundwater samples to their corresponding Final Chronic Values (FCV) based on the EPA’s National Water Quality Criteria (EPA, 2003). These FCVs represent the concentrations of the PAHs in water that are considered to be protective of the presence of aquatic life.

Estimates of total PAH mass flux were calculated. The analysis used both the median and mean concentrations for each RTA and the RTA-specific groundwater discharge rates and pore water concentrations provided by National Grid. The resulting estimates of total PAH flux to the canal, which are presented in Table 5, exhibit a wide variation in PAH discharge rates, ranging from 19 to 1,500 kilograms/year. The estimate developed using the mean groundwater concentration is significantly higher than the median groundwater concentration and both the median and mean pore water concentrations, but is not considered representative because it is biased by a few high values. The estimated mass discharge calculated using the median pore water concentration is considered the most representative of the four values. These concentrations represent the equilibrium PAH concentrations in near surface sediment associated pore water throughout the canal and are indicative of what may actually be fluxing into the surface water. Further, the data set includes a wide range of pore water concentrations, and has appropriate spatial coverage, including several samples in the central, most contaminated portion of the canal. Based on these data, the magnitude of the groundwater flux of total PAHs to the canal is relatively low compared to other sources.

Contaminant Fate and Transport

The conceptual site model (CSM)[20] for the Gowanus Canal summarizes and integrates the information presented above about historical and ongoing sources of contamination, the nature and extent of contamination, contaminant fate and transport mechanisms and risks to humans and wildlife from exposure to contaminated sediments in the Gowanus Canal. A schematic representation of the CSM for the Gowanus Canal is provided in Figure 4. This CSM is used as the basis for developing remedial action objectives (RAOs)[21] and remedial alternatives for canal sediments.

The EPA did not independently develop a hydrodynamic model as part of the RI/FS. Instead, the results of hydrodynamic modeling performed by the USACE for the Gowanus Bay and Canal Ecosystem Restoration Study (*i.e.,* maps showing velocities and shear stresses throughout the canal under existing conditions) were considered in the development of the CSM. The model results were used in conjunction with other data-based lines of evidence (*e.g.,* contaminant concentration gradients, bathymetric changes over time, sediment physical characteristics, radioisotope profiles, historical documentation about siltation in the canal) to develop the CSM. The results of three-dimensional hydrodynamic and sediment transport modeling recently performed by National Grid were also considered; these results are consistent with the data-based CSM developed for the RI/FS. While the CSM developed for the RI/FS is sufficient to establish the basis for a remedial action, additional data collection and modeling will be useful to confirm the CSM and prepare the remedial design.[22]

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[20] A conceptual site model illustrates contaminant sources, release mechanisms, exposure pathways, migration routes and potential human and ecological receptors.

[21] RAOs, which are developed after site characterization, are specific goals to protect human health and the environment.

[22] In connection with its CWA compliance, NYCDEP developed a three-dimensional, time-variable, coupled hydrodynamic/water-quality model. Since NYCDEP has declined requests to provide its model to the EPA, the EPA has not been able to assess it.

Sediment Transport and Deposition

Many of the contaminants detected in canal sediments (*e.g.*, SVOCs, PCBs, high molecular weight PAHs and metals) have a low solubility and an affinity for fine-grained sediment particles and organic matter. Contaminants with a higher solubility and volatility (*i.e.*, VOCs and some of the low-molecular-weight SVOCs) tend to disperse in the water column. Therefore, the accumulation of soft sediments in the canal over time has resulted in the accumulation of high levels of persistent contaminants. Because of low current velocities and limited tidal exchange with Gowanus Bay, the contaminated sediments have accumulated in the canal rather than being flushed out to the bay. Bathymetric survey data indicate that one to three feet of sediment was deposited in the upper canal between 3rd Street and Sackett Street between 2003 and 2010. The upper canal is the reach most affected by the deposition of solids from CSO discharges. Radioisotope analyses of sediment cores from other areas of the canal (*i.e.*, south of 3rd Street) indicate net sediment accumulation rates on the order of one to two inches/yr (GEI, 2007), although most of the cores that were dated showed evidence of disturbances that reduce the accuracy of the age-dating estimates.

Since many of the contaminants that are present at high levels in the Gowanus Canal soft sediments have an affinity for fine-grained sediment particles and organic matter, the fate and transport of these contaminants are largely controlled by the fate and transport of the sediments. Sediments deposited in Gowanus Canal may be re-suspended by currents, propeller wash, dredging and other disturbances. The canal is a low-velocity environment, with average current velocities less than 0.5 feet per second. These current speeds are insufficient to substantially erode sediment deposits. Currents generated by the flushing tunnel apparently erode sediments near the outlet of the tunnel, but the sediments are most likely to settle out where the current velocities decrease farther down the canal between Sackett and 3rd Streets.

Sediments in the Gowanus Canal appear to be frequently re-suspended and mixed by propeller wash from vessel traffic. The effects of propeller wash are particularly evident in the reach between the Gowanus Expressway and 3rd Street, where minimal net sediment accumulation was observed between 2003 and 2010. This reach experiences frequent tugboat and barge traffic associated with the concrete plant at the end of 5th Street. Evidence of propeller scour was also seen near the southern end of the Gowanus Canal (*i.e.,* north of Bryant and 22nd Streets) in the 2010 bathymetric survey. Substantial sediment disturbance also can result from vessel groundings. High resolution bathymetric surveys performed by National Grid in 2010 and 2011 indicated that a barge grounding near the mouth of the 4th Street basin in 2011 resulted in the displacement of up to 10 feet of sediment.

Given the low current velocities in the canal, most of the sediments re-suspended by propeller wash likely settle out in the same reach of the canal. Finer-grained sediment particles that remain suspended in the water column for a longer period of time may, however, be transported out of the canal by tidal currents and dispersion. The amount of sediment transported out of or into the canal in typical weather conditions or during storm events has not been measured. However, a substantial drop in contaminant concentrations in surface sediments from the middle reach of the canal to the lower reach and the additional drop from the lower reach of the canal to the Gowanus Bay and Upper New York Bay reference locations indicate that much of the contaminated sediment remains within the canal, north of the Gowanus Expressway. Contaminated sediments that are transported out of the canal are mixed with and diluted by suspended sediments from New York Harbor.

Contaminated Solids Impacts from Combined Sewer Overflows

Contaminated CSO solids impacts are most apparent in the upper reach of the canal because the outfall at the head of the canal (RH-034) is the single largest contributor to CSO discharges. Solids from CSO discharges are transported down the canal and deposited as the velocity from the CSOs dissipates with increasing distance from the head of the canal. Currents from the flushing tunnel, when operating, may facilitate transport, but also dissipate with increasing distance from the head of the canal. This is consistent with NYCDEP’s conclusions in its 2008 WB/WS Plan: “Historical discharges by CSOs and stormwater have impacted almost the entire canal bottom.” In that report, NYCDEP concluded that "CSOs dominate the loadings of . . . total suspended solids . . . to Gowanus Canal," and that discharges from the outfall at the head of the canal (RH-034) "dominate the CSO impacts throughout the entire Canal."

Hazardous substance levels in surface sediments in the upper reach are less influenced by releases from the former MGP facilities than surface sediments in the middle reach. The sediments in the upper reach are less susceptible to re-suspension by propeller wash from vessel traffic or vessel groundings, due to the low levels of such traffic in the upper reach. As noted previously, bathymetric studies from 2003 to 2010 indicate that one to three feet of sediment was deposited between 3rd and Sackett Streets. These shallow sediments were deposited after the period of greatest industrial activity in the canal and are, therefore, more predominantly influenced by CSO and stormwater discharges than by legacy contamination from historical industrial activity.

Other sources of solids to the upper reach of the Gowanus Canal include inflow from Buttermilk Channel through the flushing tunnel (when it is operating) and tidal advection/dispersion from Upper New York Bay through Gowanus Bay at the south end of the project area (when the flushing tunnel is not operating). A portion of the suspended sediments in these inflows settles in the canal as the current velocities decrease to slack tide.

The mass of solids delivered by each source (CSO/stormwater discharges and inflow from Upper New York Bay) was not quantified in the RI/FS or in the water quality model developed by NYCDEP for its CSO control planning, although NYCDEP included modeling of TSS and separated TSS into outfall and background (*i.e.,* Upper New York Bay) components to distinguish between the heavier, more-settleable solids discharged from sewers and the lighter, less-settleable solids suspended in receiving waters (NYCDEP, 2007).

The EPA has concluded that multiple lines of physical and chemical evidence demonstrate that CSO and stormwater solids have a significantly greater influence on the quality of sediments in the 0-2-foot depth interval in the upper reach of the canal than incoming sediments from Upper New York Bay. These lines of evidence include:

- Contaminated CSO solids[23] have high TOC content. The TOC content of the surface sediment is about 6 percent. The TOC levels in Upper New York Bay sediments are, on average, about 3 percent (EPA, 1998 and the RI report). Accordingly, if suspended sediments in tidal inflow or flushing tunnel flows from Upper New York Bay were contributing the majority of the deposited mass, the TOC of the surface sediment would be closer to 3 percent.
- The concentrations of PAHs, copper and lead in the surface sediment and in the CSO solids are similar. The concentrations of these chemicals are much lower in the reference sediments in the harbor; therefore, deposition of suspended sediments in harbor water (or from the flushing tunnel which brings in harbor water) could not be the predominant source of PAHs, copper and lead in the canal surface sediments.
- Sewage indicators, such as fecal coliform (GEI, 2011a, 2012a and 2012b) and steroids (Kruge *et al.*, 2007), are found consistently in the surface sediment in the canal. The highest concentrations are located in the upper portion of the canal where most of the CSOs are located.
- The EPA's bathymetric study shows that most of the accumulation of sediment coincides with the canal location (upper reach) where most of the CSOs are located and the highest CSO volumetric discharges take place. It has been reported and visually noted that CSOs discharge heavier mass solids. These heavier solids are typically expected to settle to the bottom of the canal within a short distance from the point of discharge unless high horizontal velocities disperse the solids downstream.
- Overall, the surface sediments in the upper canal have higher sand content and lower silt and clay content than the Harbor reference locations. The sediments in the lower canal, closer to the Harbor, have similar silt and clay content to the reference stations. This indicates that the upper canal surface sediment is more influenced by the deposition of contaminated CSO solids than the area near the

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[23] Contaminated CSO solids are the particles that are discharged to the canal during overflow events, whereas CSO sediment is the residual material found in the sewer pipes.

mouth of the canal. This is consistent with NYCDEP's conclusion that CSOs predominately contribute heavy grain sediments, while fine grain sediments are a mixture of CSO discharges and flushing tunnel and harbor tidal contributions.

The multiple lines of evidence summarized above strongly support the conclusion that surface sediment contaminant concentrations in the upper reach of the canal are significantly influenced by the accumulation of CSO solids. As a result, the EPA has concluded that the contaminated CSO solids are a source to the canal which must be controlled as part of this selected remedy. As discussed in further detail below, the estimated range of contaminated CSO solids control in the selected remedy incorporates an uncertainty factor which will be addressed during the remedial design. Further refinement of the sediment and contaminant mass balance is constrained by the constant variability in inputs, including the frequency, size and nature of storm events and infrastructure changes, such as the flushing tunnel and pump station upgrades, planned sewer separation project and on-going development. The EPA's CERCLA remedial design will be informed and refined by the results of additional sampling and modeling, as well as by coordination with NYSDEC and NYCDEP as they gather Post Construction Monitoring (PCM) data developed in accordance with EPA CSO guidance in advance of the LTCP submittal to address CWA compliance.

Nonaqueous Phase Liquid Fate and Transport

NAPL in the canal sediments can be transported upward through the sediments into the water column through several transport mechanisms, including ebullition, seep migration, sheen migration and groundwater advection. Ebullition is the production of gas due to anaerobic biological activity in sediment (Viana *et al.,* 2007a). Mineralization[24] of organic matter by bacteria in the sediment generates gases such as methane, nitrogen and carbon dioxide which cause ebullition (Reible, 2004). Ebullition is commonly observed in the soft sediments in the Gowanus Canal, which are rich in organic matter. The bubbles produced during ebullition tend to accumulate hydrophobic contaminants and colloids, such as NAPL sheen, on their surfaces (Viana *et al.*, 2007b). NAPL can then migrate through sediments and be adsorbed onto more newly deposited sediments or out of the sediment and upward through the water column and be deposited on the water surface as a sheen.

The EPA performed additional research on the potential for ebullition in the canal (EPA, 2013). The analysis concluded that ebullition is likely limited to the soft sediment, with RTA 1 and RTA 2 having the highest ebullition potential based on several factors:

- RTA 1 and RTA 2 had the highest TOC in the canal. Across all three reaches, the TOC in soft sediments was 4.2 to 15 times greater than the TOC in the native

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[24] Mineralization is the decomposition or oxidization of the chemical compounds in organic matter into plant-accessible forms.

sediment.

- Shallower water depths reduce the hydraulic pressure that sequesters ebullition.
- NAPL droplets have been observed attached to gas bubbles rising to the water surface at the Public Place former MGP facility on numerous occasions. This process appears to reach its maximum in late summer, when the decay of organic matter in the canal sediments would be expected to reach its maximum. Upon reaching the surface, some of the NAPL generates a sheen which rapidly spreads on the water surface. In one extreme case, the entire canal water surface between Public Place and the 9th Street bridge was covered.

A NAPL seep is defined as a NAPL discharge when one or more of the following occur:

- NAPL is moving under a sustained gradient.
- A source that provides the driving force is located at some distance from the seep.
- A recent or ongoing release is typically associated with the discharge.
- NAPL saturations are above residual levels.

Although NAPL seeps can migrate with groundwater through sediments that are not impacted by NAPL (*i.e.*, where NAPL is not coating the solid particle surfaces and occupies the smaller pore spaces), NAPL tends to migrate more readily through sediments previously impacted with NAPL (*i.e.,* NAPL is coating the solid particles). (Sale, 2011). Data from the former MGP facilities show that NAPL elevations are above the sediment elevation and that NAPL seep migration is occurring.

An analysis of NAPL impacts at the interface between native and soft sediments in the Gowanus Canal suggests that the hydrodynamic force from groundwater discharge is occurring at some locations. An analysis presented in the FS report indicates that upward groundwater velocities can potentially result in the upward NAPL migration under certain conditions.[25] This is essentially because the upward vertical groundwater velocity appears to be sufficient to overcome the downward density and capillary forces of the NAPL.

The EPA performed additional studies in early 2013 to determine if NAPL in native sediment could migrate upward from hydrodynamic force (EPA, 2013). It is concluded from the studies that low groundwater discharge velocities can mobilize NAPL upward in the more impacted areas of the canal.

“NAPL sheen” is defined as a NAPL discharge when one or more of the following

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[25] The general Site conditions were used to approximate the potential for NAPL migration. The actual conditions at specific locations can vary substantially. Additional data collection and evaluation will be necessary to verify NAPL mobility at specific locations for purposes of remedial design.

occur:

- A very limited amount of oil is discharged as a sheen on the water surface.
- Ephemeral sheen behavior may be observed.
- Former seeps have occurred.
- NAPL saturations are close to or below residual levels.

NAPL sheens migrate as a result of the difference in the surface tensions that result in a positive spreading coefficient. In the upland area, NAPL spreads on the surface of the groundwater in the same way as the surface water sheen. In this way, the NAPL sheen spontaneously enters water-coated, air-filled pores on the surface of the water table and the NAPL migrates. The sheens may migrate into the canal where the groundwater surface intersects the canal. Sheens can also be transported to the canal in street runoff, originating in areas where vehicle maintenance activities are taking place or near petroleum handling facilities where delivery trucks are cleaned.

Droplets of NAPL can also be transported along the length of the canal by tidal currents and redeposited in areas some distance from the points where they originally entered the canal. Some transport of discrete NAPL droplets occurs in the canal, particularly in the vicinity of the Public Place former MGP facility. These droplets can be seen on the canal bottom, and can be moved along the bottom and redeposited by the same transport processes that control movement of solid sediment particles.

Overall, NAPL seep migration is considered the primary mechanism through which NAPL enters the canal from the former MGP facilities. A secondary source of potential seeps is NAPL that has migrated into the canal and re-infiltrated into the bank at certain locations other than the original source areas. Once in the sediment, hydraulic forces can drive the NAPL from the native sediment upward to the soft sediments. In the soft sediments, the hydraulic force continues, but ebullition increases the mobility of NAPL upward into the surface water.

CURRENT AND POTENTIAL FUTURE LAND AND RESOURCE USES

Land Use

The canal is located in a mixed residential-commercial-industrial area. The waterfront properties abutting the canal are primarily commercial and industrial. Rezoning of several canal-front parcels in the upper canal to high density residential occurred in 2009. In March 2013, NYC approved the Lightstone Group’s development plans for 700 rental units on these parcels. Construction is anticipated to begin in fall 2013. NYC has also entered into a public-private partnership called Gowanus Green to construct 774 units of high density mixed income housing on NYC-owned portion of the Public Place former MGP facility. NYC postponed an area-wide rezoning effort as a result of the NPL nomination. However, further rezoning and land use changes have continued during the Superfund process. For example, a hardship rezoning was approved in February 2013 for a Whole Foods market on two canal-side parcels. Construction is under way, with an anticipated completion in fall 2013. In response to the on-going development pressures, Community Board Six formally requested that NYC restart the area-wide re-zoning process.

Through Community Board Six, the community has also received a grant from the New York State Department of State's (DOS's) Brownfield Opportunity Area (BOA) Program for a study to promote reuse and redevelopment of under-used properties in two large sections along the canal. Governmental participants in the ongoing BOA study include NYSDOS, NYSDEC, NYC Department of City Planning, the Mayor's Office of Environmental Remediation and the EPA.

As a result of development speculation, numerous parcels have been acquired along and near the canal for potential residential and commercial uses in anticipation of the cleanup and further rezoning. Public use along and on the canal is expected to increase significantly over time due to NYC waterfront zoning requirements which mandate public esplanades at redevelopment sites along the canal. Such esplanades are under construction or planned at the Whole Foods, Lightstone Group and Gowanus Green projects. In addition, moderate–to--large-scale commercial activities, such as outdoor nightclubs and flea markets, have operated or sought permits to operate at canal-side parcels.

The canal is regularly used by commercial barges at several facilities along the mid- and lower canal. Recreational boaters, primarily, canoers and kayakers, frequent the canal. A public boat launch where canoes are available is located at 2nd Street. This boat launch will be incorporated into the Lightstone Group project. The anticipated remediation and redevelopment will likely increase recreational boating use. A limited number of people reside in houseboats on the canal.

Despite posted warnings, the canal is regularly used for fishing, particularly subsistence fishing by several separate communities with environmental justice concerns surrounding the canal. A NYCDEP survey of residents indicated that fishing is the number one canal use by area residents (NYCDEP, 2008).

Groundwater Use

The area is served by municipal water. Local groundwater is not used in NYC as a source for potable public water, therefore, a completed exposure pathway does not exist. Additionally, the NYC Department of Mental Health and Hygiene has strict regulations regarding the installation of wells or the use of groundwater for any purpose.

SUMMARY OF SITE RISKS

The human health risk assessment (HHRA) for the Gowanus Canal evaluated potential current and future risks to recreational users, anglers, residents and industrial workers in and near the canal. The HHRA evaluated the potential human risks from exposure to surface water, sediment, ambient air and ingestion of fish and shellfish (crabs). The Gowanus Canal has no remaining natural wetlands (various small, unconnected areas of vegetation and intertidal habitat exist) or natural shoreline (the shoreline consists of bulkheads, riprap and piers). The community of potential ecological receptors using the canal includes fish-eating birds; dabbling ducks; invertebrates such as worms, amphipods and mollusks; and crabs and fish. The potential ecological risk to these receptors from exposure to surface water and sediment in the canal was evaluated in the ecological risk assessment (ERA).

Human Health Risk Assessment

A four-step human health risk assessment process was used for assessing Site-related cancer risks and noncancer health hazards. The four-step process is comprised of:

Hazard Identification: In this step, the chemicals of potential concern (COPCs) at the Site in the various media (sediment, surface water and air) are identified based on factors such as toxicity, fate and transport of the contaminants in the environment, concentrations of the contaminants in specific media and bioaccumulation. The contaminated media, concentrations detected and concentrations utilized to estimate potential risk and hazards for the chemicals of concern (COCs) at the Site are presented in Table 6.

Exposure Assessment: In this step, the different exposure pathways through which people might be exposed to the COPCs in the various media identified in the previous step are evaluated. Examples of exposure pathways include incidental ingestion of and dermal contact with contaminated surface water and sediment. The exposure pathways that were evaluated are presented in Table 7. Factors relating to the exposure assessment include, but are not limited to, the concentrations in specific media that people might be exposed to and the frequency and duration of that exposure. Using these factors, a “reasonable maximum exposure” scenario, which portrays the highest level of human exposure that could reasonably be expected to occur, is calculated.

Toxicity Assessment: In this step, the types of adverse health effects associated with chemical exposures and the relationship between magnitude of exposure and severity of adverse effects are determined. Potential health effects are chemical-specific and may include the risk of developing cancer over a lifetime or other noncancer health hazards, such as changes in the normal functions of organs within the body (e.g., changes in the effectiveness of the immune system). Some chemicals are capable of causing both cancer and noncancer health hazards. The toxicity values that were used to evaluate noncancer health hazards are presented in Table 8 and the toxicity values that were used to evaluate cancer risk are presented in Table 9.

Risk Characterization: This step summarizes and combines outputs of the exposure and toxicity assessments to provide a quantitative assessment of Site risks for all COPCs. Exposures are evaluated based on the potential risk of developing cancer and the potential for noncancer health hazards. The likelihood of an individual developing cancer is expressed as a probability. For example, a 10^{-4} cancer risk means a “one-in-ten-thousand excess lifetime cancer risk (ELCR)”; or one additional cancer may be seen in a population of 10,000 people as a result of exposure to Site contaminants under the conditions identified in the Exposure Assessment. Current Superfund regulations for exposures identify the range for determining whether remedial action is necessary as an ELCR of 10^{-4} to 10^{-6}, corresponding to a one-in-ten-thousand to a one-in-a-million excess cancer risk. For noncancer health effects, a “hazard index” (HI) is calculated. The key concept for a noncancer HI is that a threshold exists below which noncancer health hazards are not expected to occur (an HI less than 1 would indicate the threshold is not exceeded and a noncancer health hazard is not expected). These acceptable risk levels are defined in the NCP at 40 CFR 300.430(e)(2)(I)(A). Chemicals that contribute to a cancer risk that exceeds 10^{-4} or an HI to a specific target that exceeds 1 are typically those that will require remedial action at the Site.

The HHRA was conducted to evaluate the potential human health risks associated with direct contact (incidental ingestion and dermal contact) with surface sediment and surface water in the Gowanus Canal, ingestion of fish and crabs, direct contact (incidental ingestion and dermal contact) with sediment and surface water that overtop the canal during extreme tidal or storm surge conditions, and inhalation of volatile emissions from the canal into the ambient air near the canal.

For an adult, an adolescent and a child using the canal for recreational purposes, the risks associated with exposure to surface water and surface sediment (from exposed and near-shore locations) in the canal and from ambient air at canal level while swimming, boating, fishing or crabbing were evaluated. The HHRA assumed that recreational use/swimming in the canal would occur at frequencies, durations and exposures that are typical of most water bodies, even though the current actual use of the canal is likely lower given its current nature. The total reasonable maximum exposure (RME) noncarcinogenic hazard associated with exposure to surface water and sediment for all recreational users was within the EPA’s acceptable risk levels (Table 10). However, exposure to surface water and sediment by recreating adults (3×10^{-4}), adolescents (2×10^{-4}) and children (8×10^{-4}), and lifetime recreational users (recreational users throughout their life as child, adolescent and adult; 1 x 10^{-3}) may result in a carcinogenic risk above the EPA's target risk range (Table 11). These risks are associated primarily with exposure to carcinogenic PAHs in the surface water and the surface sediment.

The risks associated with exposure to surface water and surface sediment from canal overflow and ambient air at street level were evaluated for residential adults and children and for industrial workers. RME noncarcinogenic hazards and carcinogenic risks associated with exposure to these media by the industrial worker are within acceptable levels. Exposure to surface sediment from canal overflow was above the EPA's target risk range (2.0 x 10^{-4}) for the lifetime resident (resident exposed during full life during childhood, adolescence and adulthood).

Although not considered for CERCLA remedy selection purposes, a screening level risk assessment for CSO pathogens that was performed by National Grid found significant risk to child and adult recreational users and workers from CSO-related pathogen exposure.

Exposure to ambient air at street level was within acceptable levels. The RME carcinogenic risk for the adult/child resident exceeding acceptable levels is associated with carcinogenic PAHs in sediment (with a smaller contribution from surface water).

Risks associated with ingesting fish and crabs from the Gowanus Canal were evaluated for adult, adolescent and child subsistence and recreational anglers.[26] The RME total noncarcinogenic hazards and/or carcinogenic risks for all receptors exceeded the EPA's acceptable levels as shown in Tables 10 and 11. Table 12 compares the risks associated with fish ingestion for recreational anglers and subsistence fishermen. The noncarcinogenic hazards and carcinogenic risks are associated with PCBs in fish and crabs. Because PAHs normally metabolize quickly in fish, the fish tissue samples were not analyzed for PAHs. To assess whether the canal's high levels of PAHs pose a risk in a scenario where PAHs were not metabolized before consumption, PAHs in fish tissue were estimated assuming that fish tissue concentrations of PAHs are similar to the concentrations of PAHs in crab tissue. The resulting estimated carcinogenic risks from ingestion of PAHs in fish were below the EPA's acceptable risk range. The concentrations of PCBs in the canal fish and crab samples were higher than the PCB concentrations in the reference area samples collected from Gowanus Bay and Upper New York Bay. However, the PCB concentrations in the reference samples would also result in noncarcinogenic hazards and carcinogenic risks above the EPA acceptable risk range, although lower than in

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[26] The HHRA assumed fishing/crabbing and ingestion of the fish/crab from the canal at typical recreational angler fish/crab consumption rates. The FS report addendum provided a supplemental evaluation of subsistence fishing.

samples from the canal.

Ecological Risk Assessment

The overall ERA for the Site consisted of a combined screening level ecological risk assessment (SLERA) and baseline ecological risk assessment (BERA) performed in accordance with the EPA's (1997) *Ecological Risk Assessment Guidance for Superfund* and its updates. The survival and reproduction of the following receptor groups were selected for evaluation:

- Benthic (sediment)-dwelling macroinvertebrate communities.
- Water-column-dwelling aquatic life communities.
- Avian wildlife (aquatic herbivores, aquatic omnivores and aquatic piscivores).

The following summarizes the risk analysis and results for each receptor group based on data reported in the BERA.

Risks to benthic macroinvertebrate communities were evaluated primarily through the use of laboratory-based sediment bioassays (*i.e.*, toxicity tests), which were conducted with two sediment-dwelling invertebrates (amphipods and polychaetes) and through the comparison of sediment chemical concentrations to literature-based screening benchmarks. The analyses indicate the following:

- Sediment bioassays indicate a Site-related potential for adverse effects to benthic communities from chemicals in sediment, with the greatest potential for adverse effects occurring in the central portion of the canal, where contaminant levels are highest. The bioassay results also indicate the potential for less severe, but Site-related adverse effects to the benthic community at several other locations scattered throughout the canal.
- Chemical analysis indicates the presence of organic chemicals (primarily, PAHs and PCBs) and metals in sediment at concentrations that are likely to be causing the adverse effects observed in the sediment bioassays. The highest concentrations of those chemicals were detected primarily in the central portion of the canal, which coincides with the locations where the most severe effects to the sediment bioassay organisms were also observed.
- PAHs were consistently detected in sediment at the highest concentrations relative to their ecological screening benchmarks and are considered to represent the greatest Site-related risk to the benthic community. Other chemicals, most notably PCBs and seven metals (barium, cadmium, copper, lead, mercury, nickel and silver), were also detected at concentrations above their ecological screening benchmarks and at concentrations above those detected in reference area sediments and are also considered to represent a potential Site-related risk to the benthic community.

Risks to water-column-dwelling aquatic life communities were evaluated primarily through the comparison of surface water chemical concentrations to literature-based screening benchmarks. The surface water was sampled during both dry and wet (*i.e.,* while CSO outfalls were discharging) periods. Chemical concentrations in surface water indicate very little Site-related potential for adverse effects to water-column-dwelling aquatic life.

Risks to avian aquatic wildlife were evaluated by modeling the potential exposure of these receptors to chemicals ingested in food items including prey (*e.g.*, fish and crabs) and through the incidental ingestion of sediment. The analyses indicate the following:

- There is a potential risk to aquatic herbivores (represented by black duck) from exposure to PAHs. PAHs were detected on-Site (in sediments) at concentrations above those detected in reference area locations and represent a Site-related risk to aquatic herbivores.
- There is a potential risk to avian omnivores (represented by heron) from exposure to mercury and selenium. Mercury was the only metal that was frequently detected both in fish and crab tissues at elevated concentrations and that was also detected in canal sediments at a concentration above those detected in reference area locations. Although the BERA concluded that mercury poses a Site-related risk to omnivorous birds, additional analysis of the sediment and tissue data collected for the RI indicates that mercury levels in the Gowanus Canal are similar to those in the Gowanus Bay and Upper New York Bay reference areas. Therefore, risks to avian omnivores was dropped from further consideration.
- There is no potential unacceptable risk to avian piscivores, such as the double-crested cormorant, from the ingestion of fish in the canal.
- As indicated in the human health section, PAHs were not analyzed in fish tissue. Using an assumption that fish tissue concentrations of PAHs are similar to the concentrations of PAHs in crab tissue, food web modeling shows no unacceptable risk from PAHs to avian wildlife from the consumption of fish.

Uncertainties

The procedures and inputs used to assess risks in this evaluation, as in all such assessments, are subject to certain uncertainties for both the HHRA and the BERA.

Human Health Risk Assessment Uncertainties: The sampling conducted along the canal for use in the HHRA focused on areas where contact with the canal is most likely to occur (shallow and exposed sediment and surface water and air samples collected from similar locations) to estimate the most realistic exposure and risk to humans. Additional surface water and surface sediment samples were collected from locations where historic operations and discharges to the canal have most likely occurred. Only the surface sediment samples from the exposed and shallow areas were used to evaluate the recreational exposure risks, as this is the sediment that these receptors are most likely to contact. All of the surface water samples were included in the recreational scenario evaluations, since the receptors could be exposed to the water throughout the canal while boating. All of the surface water and surface sediment samples were used to evaluate risks to the residential and industrial worker receptors associated with exposure to canal overflow water and sediment. Therefore, the available data were evaluated in the HHRA in data groupings for each receptor group to estimate the more likely reasonable maximum exposures and risks for each receptor. The uncertainty associated with the data analysis is minimal. All of the data were validated prior to being used in the HHRA, and a data quality evaluation was performed on all analytical data evaluated in the HHRA.

A few constituents (mainly pesticides) were not detected in any of the fish or crab tissue samples but had detection limits above the human health risk-based screening level. This may result in slightly underestimating the risk associated with ingestion of fish and crab. However, it should be noted that risks above acceptable levels were identified for the fish and/or crab tissue and risks were primarily associated with the PCBs detected in the fish and crab tissue. The pesticides, when they were detected in the fish and crab tissue, did not contribute significantly to the risk. A comparison of data collected from the canal to data collected from the reference locations was not used to identify the COPCs for the canal media. This may result in including COPCs related to background conditions in the risk estimates. All of the canal data were screened against residential screening levels to select the COPCs. The use of residential screening levels is conservative, as not all the scenarios evaluated in the HHRA are residential (*i.e.,* the industrial worker scenario). This may result in including COPCs with small contributions to overall risk estimates.

The exposure factors used for quantifying exposure were conservative and reflect upperbound assumptions (RMEs). The reliability of the values chosen for the exposure factors also contributes substantially to the uncertainty of the resulting risk estimates. The most conservative recreational scenario (swimming) was used to evaluate potential exposure and risks for recreating adults, adolescents and children. Based on the current conditions of the canal, it is likely that this is an overestimate of actual exposure to recreational receptors. Although possible, it is not likely that a current recreational receptor would swim in the canal for 26 days per year for 2.6 hours per day. For the purposes of the risk assessment, the angler population was defined as those individuals who consume self-caught fish from the Gowanus Canal at least once per year, in the absence of a fishing ban or fish consumption advisories. While the risks associated with subsistence fishing would be expected to be higher than for a recreational angler, since actual consumption rates for subsistence fisherman were unknown, they had to be estimated. Sources of uncertainty in the PCB concentrations in fish used in the assessment include the fact that concentrations were averaged over location and weighted by species. The weighting of species intake in order to derive an average exposure point concentration in fish is a source of uncertainty because there are limited Site-specific data available to estimate the species ingestion preferences (*e.g.,* weighting factors). Cancer risks and noncancer health hazards were not specifically quantified for subsistence anglers or other subpopulations of anglers who may be highly exposed. There is some degree of uncertainty as to whether these subpopulations have been adequately addressed in the risk assessment. Reported cooking losses vary considerably among numerous studies. However, little information is available to quantify personal preferences among anglers for various preparation and cooking methods and other related habits (such as consumption of pan drippings). The assumption that there is no loss of PCBs during cooking or preparation, used in the RME cancer risk and noncarcinogenic hazard calculations is conservative and could overestimate cancer risks and noncarcinogenic hazards, depending on how the fish are prepared. The sediment/skin adherence factor represents the amount of sediment that adheres to skin and is available for dermal exposure. Because this value is likely to vary based on one's activity, the values used for this parameter, which are estimates from single activities, are somewhat uncertain.

For dermal contact with canal sediments, published adherence factors for adults gathering reeds and for children playing in wet soils were used as a surrogate for recreational children and adults and children. Although it is somewhat uncertain whether these scenarios are representative of contact with canal sediments, they appear to be a reasonable use of available data.

Commercial PCB mixtures tested in laboratory animals were not subject to prior selective retention of persistent congeners through the food chain, so there is a potential that carcinogenic risks and noncarcinogenic hazards have been underestimated. However, since the cancer slope factors (CSF) are based on animal exposures to a group of PCB mixtures (*i.e*., Aroclor 1260, 1254, 1242 and 1016) that contain overlapping groups of congeners spanning the range of congeners most often found in environmental mixtures, this source of potential uncertainty is unlikely to have a significant impact. The fact that any previous exposures (either background or past consumption of contaminated fish) may still be reflected in an individual's body burden today is an additional source of uncertainty, and may result in an underestimate of noncarcinogenic health hazards. The risk assessment assumed that people would consume both the combined muscle (edible portion) and hepatopancreas from blue crab. This may result in an overestimation of risk, as many crabbers do not consume the hepatopancreas, and some chemicals, such as PCBs and mercury, accumulate in the hepatopancreas. However, the hepatopancreas is small compared to the edible portion of the fish and, therefore, although concentrations may be higher in the hepatopancreas, it contributes a small amount of the total amount of crab consumed by the receptor. Therefore, it would not significantly change the total amount of contaminants consumed.

Dioxin-like PCB toxicity equivalent (TEQ) concentrations, non-dioxin-like PCB concentrations and total PCB concentrations were calculated for each sample using detected PCB congeners only. In general, if the nondetected dioxin congeners were included in the sample concentration calculations, the non-dioxin-like PCB concentrations and the total PCB concentrations would be similar to those used in the risk assessment and the resulting risks would not differ significantly. The dioxin-like PCB TEQ concentrations would not always be similar, since if the most toxic congener (3,3',4,4',5-pentachlorobipheny) was not detected in a sample, inclusion of this congener at the detection limit times the toxicity equivalency factor (TEF) would contribute significantly to the dioxin-like PCB TEQ, even if it was not detected. Therefore, this may result in an underestimation of actual risk if this congener was present in the sample at a concentration below the reporting limit. However, when this congener was detected in a sample, it was generally flagged as detected below the reporting limit, so it is unlikely that it would be present in the samples at concentrations similar to reporting limits, and it would likely be present at much lower concentrations and not contribute significantly to the dioxin-like PCB TEQ concentration for the sample. Additionally, congeners that were detected in a laboratory or field blank at a concentration similar to that in the sample were not included in the concentration calculation. There were a number of such samples, which may result in an underestimation of risk if these congeners are present in the samples at a concentration below the blank contamination level. However, the concentrations in these samples were generally below the reporting limits.

There are inherent limitations and uncertainties associated with estimating health risks on the basis of fish and crab consumption that should be considered when interpreting the results of the HHRA. Factors contributing to these uncertainties include game fish and blue crab ranges are not limited to the canal, but reflect cumulative uptake from all areas they traverse. Blue crab and some of the game fish species kept by anglers have relatively large home ranges, and those caught within the canal are likely, at least in part, to have inhabited areas outside the canal and therefore to have been potentially exposed to contaminants not related to the canal. However, differences between canal and reference concentrations of PCBs in fish and crab tissue and sediment were identified, with canal media having higher concentrations. Assumptions regarding fishing/crabbing frequency and fish/crab consumption rates are variable and affect the estimates of exposure and associated risk.

There is uncertainty associated with the noncarcinogenic toxicity factors. The EPA applies several uncertainty factors (UFs) to extrapolate doses from animal studies to humans. The UFs for the COPCs range from 1 to 3,000. Therefore, there is a high degree of uncertainty in the noncarcinogenic toxicity criteria based on the available scientific data. The noncarcinogenic toxicity factors used in the HHRA are expected to be overestimates of actual toxicity.

CSFs and inhalation unit risk factors developed by the EPA represent upper-bound estimates. Carcinogenic risks generated in this assessment should be regarded as an upper-bound estimate on the potential carcinogenic risks. The true excess lifetime cancer risk is likely to be less than the predicted value. Use of provisional or withdrawn toxicity factors increases the uncertainty of the quantitative hazard and risk estimates. Provisional toxicity values were used in the HHRA to provide a quantitative estimate rather than a merely qualitative risk discussion. The TEFs used to adjust the concentrations of the dioxin-like PCB congeners to TEQ of dioxin for the sediment and fish/crab also results in uncertainty in the risk assessment. In particular, although the TEF scheme and TEQ methodology is intended primarily for estimating exposure and risk through ingestion, it was also used to estimate exposure and risk through dermal contact.

Additionally, not using the dioxin-like PCB congener TEQ to evaluate noncarcinogenic risks may underestimate the noncarcinogenic hazard associated with exposure to the PCBs. However, there is a lot of uncertainty with use of this process, and even more uncertainty with use of it for noncarcinogenic hazards since the TEFs are based on the relationship of the PCB congeners to the carcinogenic risks associated with dioxin. Although, there is a large degree of uncertainty associated with use of this method for noncarcinogenic-hazard evaluation, noncarcinogenic hazards were estimated as part of the uncertainty evaluation. Noncarcinogenic hazards were calculated for the dioxin-like PCB TEQ concentrations for sediment and fish/crab using the reference dose (RfD) for 2,3,7,8-TCDD from the 1998 dioxin Agency for Toxic Substances and Disease Registry (ATSDR) toxicity profile. It should be noted that use of this RfD in itself presents a source of uncertainty, as the ATSDR toxicity profiles are a Tier 3 source of toxicity information.[27] Noncarcinogenic hazards were calculated for the non-dioxin-like PCB concentrations using the RfD for Aroclor 1254. The sum of the noncarcinogenic hazards associated with the dioxin-like PCB TEQ concentrations and the non-dioxin-like PCB concentrations for all receptors for sediment and fish/crab are below 1 and in most cases are less than the noncarcinogenic hazards associated with the total PCB concentration, which were estimated using the total PCB concentrations and the RfD for Aroclor 1254. Therefore, evaluation of the noncarcinogenic hazards for the dioxin-like PCB TEQ concentrations does not change the conclusions of the HHRA.

Ecological Risk Assessment Uncertainties: Uncertainties are present in all ERAs because of the limitations in the available data and the need to make certain assumptions and extrapolations based upon the collected information. In addition, the

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[27] OSWER Directive 9285.7-53, Human Health Toxicity Values in Superfund Risk Assessments, December 5, 2003, recommends a hierarchy of toxicological sources of information for which risk assessors initially consider for site-specific risk assessments: Tier 1, EPA’s Integrated Risk Information System; Tier 2, EPA’s Provisional Peer Reviewed Toxicity Values and Tier 3, additional EPA and non-EPA sources of toxicity information with priority given to those sources of information that are the most current.

use of various models (for example, uptake and food web exposure models) introduce some associated uncertainty depending on how well the model reflects actual conditions. The primary uncertainties in the BERA for the Gowanus Canal are associated with the media sampled and the assumptions used in the risk analysis. Information on the eco-toxicological effects of constituent interactions is generally lacking, which requires (as is standard for ERAs, in general) that the constituents be compared individually to screening values. This could result in an underestimation of risk (if there are additive or synergistic effects among constituents) or an overestimation of risks (if there are antagonistic effects among constituents). For sediment and tissue, total PCB, dichlorodiphenyltrichloroethane and PAH concentrations were calculated and evaluated instead of addressing the individual compounds from these groups. In some cases, the detection limit for some non-detected chemicals exceeded applicable risk thresholds. The potential for risks associated with these chemicals cannot be fully evaluated and the risks associated with these chemicals may be underestimated.

There is some uncertainty as to whether chemical concentrations in fish and crab tissues can be attributed to the Gowanus Canal. The blue crabs and many of the fish species that were sampled represent transient populations that are only seasonally present in the canal. The body burden of these species is, therefore, likely to reflect chemical concentrations accumulated both from the Gowanus Canal and other locations.

Uncertainties related to the risk analysis include assumptions associated with modeling. Constituent concentrations in aquatic food items (*e.g.,* aquatic plants) were estimated by multiplying measured sediment concentrations by bioconcentration factors (BCFs) and were not directly measured in actual tissue (food). Therefore, the use of generic, literature-derived BCFs introduces some uncertainty into the resulting estimates. There is also some uncertainty associated with the receptors selected for the food web exposure assessment. Due to the urbanized setting and structure of the canal and surrounding area, only a limited number of upper trophic level receptors are expected to utilize this aquatic habitat. Therefore, it was assumed that the species most representative of the range of potential feeding groups using the canal included the green heron (omnivore), double-crested cormorant (piscivore) and black duck (herbivore). It was assumed that higher trophic level receptors received 100 percent of their dose from the Site. Assuming 100 percent of food and potential exposure is derived from the canal in the BERA is likely to overestimate actual risk. Data on the toxicity of some constituents to the upper trophic level receptor species were sparse or lacking, requiring the extrapolation of data from other wildlife species or from laboratory studies with non-wildlife species. Extrapolating is a typical limitation for ERAs because so few wildlife species have been tested directly for most constituents. The uncertainties associated with toxicity extrapolation were minimized by selecting the most appropriate test species for which suitable toxicity data were available. The factors considered in selecting a test species to represent a receptor species included taxonomic relatedness, trophic level, foraging method and similarity of diet.

This BERA considered multiple lines of evidence when evaluating the potential for adverse effects to the assessment endpoints that were evaluated. For example, risks to the benthic-dwelling community were evaluated using the results of two sediment bioassays along with chemical analytical data. Although the use of multiple lines of evidence does not eliminate the uncertainties inherent to the evaluation of ecological risk, it helps to substantiate the general outcomes and conclusions of the BERA. General agreement in the different lines of evidence evaluated for each of the ecological receptors increases the level of confidence in the final conclusions made in the BERA.

Summary of Human Health and Ecological Risks

The HHRA indicated completed human risk exposure pathways with unacceptable risk levels for surface water/sediment contact and fish consumption.

Human exposure to hazardous substances in surface water and surface sediment by recreating adults, adolescents and children may result in carcinogenic risks above the EPA's target risk range. These risks are associated primarily with exposure to carcinogenic PAHs in the surface water and the surface sediment. The total noncarcinogenic hazard for this pathway was within or below the EPA's acceptable risk levels.

Human exposure to surface water and surface sediment from canal overflow by residential adults and children may result in carcinogenic risks above the EPA's target risk range. The RME carcinogenic risk for the adult/child resident is associated with PAHs in sediment (with a smaller contribution from surface water).

The RME total noncarcinogenic hazards and/or carcinogenic risks for angler adult, adolescent and child receptors exceed the EPA's target risk range. The noncarcinogenic hazards and carcinogenic risks are associated with PCBs in fish and crab. The concentrations of PCBs in canal fish and crab samples were higher than the PCB concentrations in the reference area samples collected from Gowanus Bay and Upper New York Bay.[28] The HHRA showed that risk for airborne exposure from the canal was within the acceptable range.

Although not considered for CERCLA remedy selection purposes, a screening level risk assessment for CSO pathogens that was performed by National Grid found significant risk to child and adult recreational users and workers from CSO-related

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[28] As was noted previously, the PCB concentrations in the reference samples also result in noncarcinogenic hazards and carcinogenic risks above the EPA's target risk range.

pathogen exposure.[29] By reducing CSO discharges, the selected CERCLA remedy will produce the tangential benefit of reducing pathogen exposure levels.

The key results of the BERA indicated that PAHs, PCBs and metals in the sediment are toxic to benthic organisms. PAHs represent the greatest Site-related risk to the benthic community. PCBs and seven metals (barium, cadmium, copper, lead, mercury, nickel and silver) were also detected at concentrations that are associated with potentially unacceptable risk and are significantly higher than those detected in reference area sediments. The observed toxicity in laboratory tests could have resulted from the effects of one or a combination of these contaminants. The toxicity test results cannot be used to distinguish which contaminants were causing the effects, although the results for simultaneously extracted metals/acid volatile sulfide (SEM/AVS) analyses presented in the BERA indicate that the bioavailability of metals is low; thus, it is likely that PAHs caused a significant portion of the observed toxicity in laboratory tests. However, potential Site-related risk to the benthic community from metals cannot be dismissed. PAHs were found to be a potential risk to aquatic herbivores (represented by the black duck) and mercury was found to be a potential risk to avian omnivores (represented by the heron).

Basis for Action

Based upon the quantitative human-health risk assessment and ecological evaluation, the EPA has determined that actual or threatened releases of hazardous substances from the Site, if not addressed by the response action selected in this ROD, may present a current or potential threat to human health and the environment.

REMEDIAL ACTION OBJECTIVES

As was noted above, RAOs are specific goals to protect human health and the environment. These objectives are based on available information and standards, such as applicable or relevant and appropriate requirements (ARARs), to-be-considered guidance, Site-specific risk-based levels and background (*i.e.,* reference area) concentrations.

The following RAOs were established for the Site:

- Reduce the cancer risk to human health from the incidental ingestion of and dermal contact with PAHs in sediment during recreational use of the canal or from

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[29] Elevated HIs calculated for pathogens in National Grid's HHRA indicate an unacceptable risk of gastroenteritis from recreational contact with canal surface water, including light use contact. Therefore, the HHRA identified a significant risk to a child and adult recreational visitor from exposure to pathogens in canal surface water. See GEI, 2012a.

exposure to canal overflow to levels that are within or below the EPA's excess lifetime cancer risk range of 10^{-6} to 10^{-4}.

- Reduce the contribution of PCBs from the Gowanus Canal to fish and shellfish by reducing the concentrations of PCBs in Gowanus Canal sediment to levels that are within the range of Gowanus Bay and Upper New York Bay reference concentrations.
- Reduce the risks to benthic organisms in the canal from direct contact with PAHs, PCBs and metals in the sediments by reducing sediment toxicity to levels that are comparable to reference conditions in Gowanus Bay and Upper New York Bay;
- Reduce the risk to herbivorous birds from dietary exposure to PAHs.
- Eliminate the migration of NAPL into the canal so as to minimize NAPL serving as a source of contaminants, primarily PAHs, to the canal.

Preliminary Remediation Goals

Because there are no promulgated standards or criteria that apply to the cleanup of contaminated sediments in New York,[30] Site-specific, preliminary remediation goals (PRGs) for sediments in the Gowanus Canal were developed. PRGs are used to define the extent of cleanup needed to achieve the RAOs. A "clean" surface will be established at the bottom of the Gowanus Canal at the end of remedy construction. The PRGs will be used as performance targets for this "clean" surface.

It should be noted that for the following reasons, the PRGs that are being presented are unique to the Gowanus Canal. The canal, especially the upper portion, is a water body contained in a constructed confined space of relatively regular geometry and relatively shallow depth. The canal receives surface water and suspended sediment from New York Harbor through tidal exchanges from the south end of the canal and through flushing tunnel flow at the northern end.[31] Deposition of solids in the canal from the harbor and direct stormwater runoff from exposed soil, historic fill and rooftops will constitute the background level of contamination that should be within or slightly above the range of contaminant concentrations at the reference harbor sampling stations. As was noted above, the range of PAH concentrations in samples from the

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[30] New York's Technical Guidance for Screening Contaminated Sediments (NYSDEC, 1999) states the following: "Sediments with contaminant concentrations that exceed the criteria listed in this document are considered to be contaminated and potentially causing harmful impacts to marine and aquatic ecosystems. These criteria do not necessarily represent the final concentrations that must be achieved through sediment remediation. Comprehensive sediment testing and risk management are necessary to establish when remediation is appropriate and what final contaminant concentrations the sediment remediation efforts should achieve."

[31] The flushing tunnel connects the head of the canal with Buttermilk Channel in Upper New York Bay.

harbor reference stations collected during the RI is 1 to 14 mg/kg. The post-remediation level of contamination that would be expected in the Gowanus Canal after all of the major canal-related sources of contamination have been reduced or controlled is likely to be at the upper end of the range because of ongoing contributions from uncontrolled surface water runoff and stormwater discharges. Data recently collected from candidate reference areas for the Newtown Creek Superfund site RI indicate that PAH concentrations in enclosed and semi-enclosed industrial embayments without CSOs are comparable to the reference area concentrations measured in the Gowanus Canal RI.

Human Health

Risk-based human health PRGs were developed to address the identified Site risk using information developed from the HHRA. PRGs were developed for six carcinogenic PAHs for exposure to near-shore surface sediment during recreational use of the canal by adults, adolescents and children. PRGs were not included for surface water because the concentrations of carcinogenic PAHs in canal surface water are not significantly different than concentrations in the Gowanus Bay and Upper New York Bay reference area. PRGs were calculated based on the Site-specific exposure data presented in the HHRA. The ratio between the target risk and the calculated risk was determined for each PAH and then the ratio was multiplied by the exposure point concentration from the HHRA to calculate the PRG. A 10^{-5} target risk level was used for each individual PAH so that the cumulative risk from exposure to all carcinogenic PAHs would not exceed 10^{-4}, which is the upper bound of the EPA's acceptable risk range. Additional PRGs were developed based on a cumulative cancer risk of 10^{-6}, which is the lower bound of the EPA's acceptable risk range. The PRGs for the recreational use scenario for sediment and surface water are presented in Table 13.

PRGs were not developed to address potential risk from exposure to sediment deposited adjacent to the canal after overflow events because sediment remediation based on the recreational use scenario would also address potential risks from canal overflow.

The HHRA results indicated potentially unacceptable risk from the consumption of PCB-contaminated fish and crabs from the Gowanus Canal. However, game fish and blue crabs do not forage solely in the canal and the PCB concentrations in their tissues reflect cumulative uptake from all of the areas that they inhabit. Therefore, the objective is to reduce the contribution of PCBs from the Gowanus Canal to fish and crab tissue by reducing the concentrations of PCBs in Gowanus Canal sediments to levels that are within the range of Gowanus Bay and Upper New York Bay reference concentrations. The maximum concentration in reference area surface sediment was selected as the PRG (see Table 13).

Ecological

PRGs were developed for the protection of benthic (sediment-dwelling) organisms and herbivorous birds. The PRGs and their basis are presented below.

Protection of the Benthic Community

PRGs for the protection of benthic organisms were derived from a graphical analysis based on the Site-specific toxicity test and co-located sediment chemistry data collected for the RI. Concentrations of PAHs, PCBs and metals (barium, cadmium, copper, lead, mercury, nickel and silver) were greater than screening values in many samples as shown in Table 14. The observed toxicity in laboratory tests could have resulted from the effects of one or a combination of these contaminants. The toxicity test results cannot be used to distinguish which contaminants were causing the effects, although the results for SEM/AVS analyses presented in the BERA (EPA, 2011a) indicate that the bioavailability of metals is low; thus, it is likely that PAHs caused a significant portion of the observed toxicity in laboratory tests. Therefore, target areas for remediation were developed based on PRGs for total PAHs and then checked to verify that the potential for adverse effects from exposure to PCBs and metals were also addressed.

Sediment toxicity data are available for two test species: a polychaete (*Nereis virens*) and an amphipod (*Leptocheirus plumulosus*). Survival and growth of the polychaete and survival, growth and reproduction of the amphipod were measured in sediment samples from 17 locations, five of which represented Gowanus Bay and Upper New York Bay reference conditions. Laboratory control sediment was also used in each test. Because greater responses were seen in the amphipod tests, only those results were used to derive PRGs. The incidence of amphipod toxicity in bioassays using canal sediment was also consistently observed in toxicity tests conducted by National Grid (GEI, 2011; GEI, 2012a and GEI 2012b) and NYCDEP (NYCDEP, 2013).

Both graphical and statistical approaches were used to derive a PRG for PAHs. Regression analysis was attempted, but the confidence intervals around the PRG estimates were large, indicating high variability of the dose-response relationships. Therefore, the EPA relied on the graphical approach and the regression analysis was used only to verify the PRGs that were developed using the graphical approach.

Using graphical analysis, two alternative potential PRG calculation approaches for total PAHs that represent different levels of protection were determined through graphical analysis of toxicity test results (*i.e.*, examination of plots of total PAH concentration versus toxicity for each station tested). The first potential PRG was determined by inspecting the graph of the dose-response relationships and identifying the lowest observed adverse effect concentration (LOAEC). The second potential PRG was determined by selecting the concentration immediately below the LOAEC, which is the greatest no observed adverse effect concentration (NOAEC). The potential PRGs based on the NOAEC ranged from 39 mg/kg for amphipod survival to 7.8 mg/kg for amphipod growth and reproduction. Potential PRGs based on the LOAEC for total PAHs ranged from 67 mg/kg for amphipod survival to 14 mg/kg for amphipod growth and reproduction.

Because of the sample size and the variability of the Site-specific dose-response relationships, there is uncertainty in the NOAECs and LOAECs identified above for each endpoint. This uncertainty was addressed using the following approach:

- Identify all potential NOAECs and LOAECs from the Site-specific data using graphical analysis.
- Normalize the potential NOAECs and LOAECs for TOC content because organic carbon is a key parameter influencing PAH bioavailability and the TOC content of samples from the key stations varied.
- Calculate the geometric means of the TOC-normalized NOAECs and LOAECs.
- Convert the geometric means of the TOC-normalized NOAECs and LOAECs to a dry weight basis using the mean canal-wide surface sediment TOC concentration of 6 percent.

The NOAEC represents the concentration assumed to not cause adverse effects based on the Site-specific data. The LOAEC represents the lowest concentration associated with measureable effects. The threshold where effects start can be assumed to fall between those two concentrations. This threshold is commonly calculated at the geometric mean of the NOAEC and LOAEC. Therefore, the PRG for total PAHs was calculated as the geometric mean of the LOAEC and the NOAEC (see Table 15).

Additional data and analyses from the RI were considered in evaluating the efficacy of the PRGs. Site-specific bioavailability of PAHs is important in interpreting sediment toxicity test results. The bioavailability and potential toxicity of total PAHs in Gowanus Canal sediments were evaluated using the Equilibrium-Partitioning Sediment Benchmark Toxic Unit approach (described in EPA, 2003a), which estimates the bioavailable and potentially toxic fraction of the total PAHs in the bulk sediment. The results indicate that the PAHs are generally bioavailable and potentially toxic in the canal samples. These results are consistent with recent sediment pore water sampling results presented in *Sediment and Surface Water Sampling Winter Report for the Gowanus Canal Superfund Site* (GEI, 2011). Calculated toxic units based on PAHs measured in sediment porewater samples show that PAHs are bioavailable and potentially toxic throughout the canal.

The RI also identified metals as contributing to unacceptable ecological risks to benthic organisms. Based on measured concentrations in sediment, copper and lead were identified as the metals most likely associated with adverse effects. However, geochemical analyses (*i.e.*, SEM/AVS) indicate that these metals currently are minimally bioavailable and should not cause toxicity. However, metals may become bioavailable in the future if geochemical conditions in the canal change and do not favor the formation of insoluble sulfides. Therefore, PRGs for copper and lead are necessary in the event that metals become bioavailable and toxic in the future. The maximum Gowanus Bay and Upper New York Bay concentrations for the reference stations that showed no toxicity were selected as the PRGs for copper and lead (see Table 15).

Protection of Herbivorous Birds

The BERA found unacceptable risks to herbivorous birds through dietary exposure to PAHs. A total PAH PRG for protection of herbivorous birds was derived using the food web model developed for the BERA. The model was used to estimate the total PAH concentration in sediment that would not pose an unacceptable risk to water fowl eating aquatic plants in the Gowanus Canal.

Preliminary Remediation Goals for Protection of Ecological Community

PRGs for the protection of the ecological community for the post-remedy clean surface are summarized in Table 15. The PRGs will be used as performance standards for the post-remedy “clean” surface.

The PAH PRG of 20 mg/kg is specific to this Site; it is based on a Site-specific risk analysis. As a comparison, it is also within the range of published and commonly accepted sediment quality values for PAHs (Ingersoll *et al*., 1996; Long and Morgan, 1991; MacDonald, 1994 and Swartz, 1999). While not intended for use as PRGs, these values have been shown to be broadly predictive of sediment toxicity. Refined techniques for directly measuring PAH toxicity and assessment methodology continue to develop (*e.g.,* Burgess, 2009). Data recently collected from candidate reference areas for the Newtown Creek Superfund site RI indicate that PAH concentrations in enclosed and semi-enclosed industrial embayments without CSOs are comparable to the reference area concentrations measured in the Gowanus Canal RI. As was noted above, the EPA evaluated toxicity tests conducted by National Grid in 2011 and 2012 and by NYCDEP in 2013 and concluded that amphipod toxicity was consistently observed in all of these bioassays using Gowanus Canal sediment.

The comparison of PAH concentrations in sediment to the PRGs shows that the entire soft sediment column throughout the project area needs to be addressed. In addition, PAH concentrations in the majority of native sediment underlying the soft sediment north of the Gowanus Expressway also exceed the PRGs. Additionally, NAPL is present in native sediment north of the Gowanus Expressway to at least the maximum depth investigated in the RI (*i.e.,* generally 6 feet below the interface between soft and native sediments). NAPL saturation was not observed in the native sediment south of the Gowanus Expressway.

The EPA has adopted the PRGs identified above as the final Remediation Goals (RGs) for the Site.

SUMMARY OF REMEDIAL ALTERNATIVES

CERCLA Section 121(b)(1), 42 U.S.C. Section 9621(b)(1), mandates that remedial actions be protective of human health and the environment, cost-effective, comply with ARARs and utilize permanent solutions, alternative treatment technologies and resource recovery alternatives to the maximum extent practicable. Section 121(b)(1) also establishes a preference for remedial actions which employ, as a principal element, treatment to reduce the volume, toxicity or mobility of the hazardous substances, pollutants and contaminants at a site permanently and significantly. CERCLA Section 121(d), 42 U.S.C. Section 9621(d), further specifies that a remedial action must attain a level or standard of control of the hazardous substances, pollutants and contaminants, which at least attains ARARs under federal and state laws, unless a waiver can be justified pursuant to CERCLA Section 121(d)(4), 42 U.S.C. Section 9621(d)(4). Remedial alternatives are described below for the sediment and source control.

Sediment Alternatives

Detailed descriptions of the remedial alternatives for addressing the contaminated sediments can be found in the FS report. Seven dredging and capping remedial alternatives were considered in the FS report:

- Alternative 1: no action.
- Alternative 2: partially dredge soft sediment and cap with isolation layer and armor layer.
- Alternative 3: partially dredge soft sediment and cap with treatment layer, isolation layer and armor layer.
- Alternative 4: dredge entire soft sediment column and cap with isolation layer and armor layer.
- Alternative 5: dredge entire soft sediment column and cap with treatment layer, isolation layer and armor layer.
- Alternative 6: dredge entire soft sediment column, stabilize top 3–5 feet of native sediment in targeted areas and cap with isolation layer and armor layer.
- Alternative 7: dredge entire soft sediment column, stabilize top 3–5 feet of native sediment in targeted areas and cap with treatment layer, isolation layer and armor layer.

Alternatives 1, 5 and 7 were retained for further development and detailed evaluation; Alternatives 2, 3, 4 and 6 were screened out for the following reasons: Alternatives 2 and 3 include only partial removal of the soft sediment column. Although it may be possible to cap soft sediments which are stable in their composition and aquatic environment, the soft sediment column within the canal does not exhibit these characteristics. The column is subject to decomposition due to its organic nature, which is highly influenced by contaminated CSO solids, and subject to disturbance from vessels, tidal and weather conditions, and flushing tunnel operation. Capping extremely soft, fine-grained sediments with high water content poses technical challenges due to the sediments' low bearing capacity (USACE, 2000). Evaluation of geotechnical data submitted by National Grid in 2013 showed that capping on top of native sediment would be much more reliable than capping on soft sediment due to settlement. Contaminant levels deeper within the soft sediment column are generally greater due to older historic discharges and the influence of NAPL infiltration. Partial removal would therefore leave a large volume of impacted sediments with a broad range and high levels of residual contamination. Ebullition potential from partially leaving the high organic content soft sediments would still exist, increasing the risks of cap failure. Partial removal would also result in shallower cap depth, increasing cap damage potential from navigation. Complete soft sediment removal will eliminate mobility of those hazardous substances. Following removal, the soft sediment can be treated. This is consistent with CERCLA's statutory preference for actions in which treatment permanently and significantly reduces the volume, toxicity or mobility of the hazardous substances.[32] Given these risk management considerations, all of the soft sediment would need to be removed in order to ensure that the remedy will be protective of human health and the environment.

Alternatives 2, 4 and 6 include installation of a two-layer cap, with isolation and armor layers. These alternatives were not retained because an armored sand cap is not sufficient to control the long-term flux of NAPL and dissolved-phase contaminants.

While the temporary draining of all or portions of the canal to facilitate implementation of the remedy was considered, it was ruled out for the entire canal for several reasons: removal of canal water could induce canal wall and bottom instabilities due to increased exerted pressures; draining of the canal for remedy implementation would limit remedial and commercial barge access and conflict with the current configuration for CSO and stormwater discharges; and odor control for such a large area of dewatered sediments would be difficult.

Factors which determine the necessary depth of dredging include the extent of

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[32] "Remedial actions in which treatment which permanently and significantly reduces the volume, toxicity or mobility of the hazardous substances, pollutants, and contaminants is a principal element, are to be preferred over remedial actions not involving such treatment." See CERCLA Section 121(b)(1).

sediment chemical contamination and the presence of NAPL, navigational needs and remedy implementation needs, as described below. RTA 1 is no longer used for commercial navigation. However, this reach of the canal must have sufficient depth to operate the flushing tunnel and vessels will need to navigate this reach of the canal to perform cap monitoring and maintenance, as well as sewer system and flushing tunnel maintenance and bridge and bulkhead repairs. The final dredge depth would need to ensure that the final sediment surface remains submerged throughout the tidal cycle and minimize remedy implementation challenges (*e.g.,* allow sufficient water depth for construction work throughout the tidal cycle). In RTA 2, a navigation depth of -16 feet NAVD88 was used based on a 2009 dredging alternative analysis performed by the USACE which selected that depth for maintaining commercial navigation. The dredging depth in RTA 3 is in accordance with the federally-authorized navigation depth south of Hamilton Avenue--Hamilton to Sigourney Street, the authorized channel is 18 feet deep relative to MLLW; between Sigourney and Percival Street, the authorized depth increases to 30 feet deep relative to MLLW. These depths are equivalent to approximately -21 and -33 feet NAVD88, respectively.

Capping is a component of all alternatives, except the No- Action alternative, because NAPL-contaminated sediments are present to depths that exceed the practicable depth of removal. A capping-only alternative was not included since a cap in RTA 1 would further restrict the water depth in the canal and result in a relatively large area of exposed sediment at low tide, a cap in RTA 2 would compress soft sediments and mobilize the NAPL within them and a capping-only remedy would be incompatible with the continued use of the canal for commercial navigation.

The sediments dredged under any of the alternatives can be treated and/or disposed of using a variety of methods. The following treatment and disposal options for dredged sediments were identified and retained for further development and detailed evaluation:

- Option A: Off-Site thermal desorption and beneficial use.
- Option B: Off-Site disposal (landfill).
- Option C: Off-Site cogeneration and beneficial use.
- Option D: Off-Site stabilization and off-Site beneficial use.
- Option E: On-Site stabilization and on-Site beneficial use.
- Option F: Off-Site stabilization and placement in on-Site constructed CDF.
- Option G: On-Site stabilization and placement in on-Site constructed CDF.

Source Control Remedial Components and Costs

There are multiple sources of contamination causing on-going releases into the canal which must be controlled in order for the sediment remedy selected herein to be protective of human health and the environment and to be effective and sustainable. Therefore, implementation of control measures to address all other contaminant sources, either through state cleanup authorities or direct selection as part of this remedy, are common and integral to ensuring the effectiveness of both of the sediment action alternatives.

The primary on-going sources are the three former MGP facilities and the CSOs in the upper part of the canal (outfalls RH-034 and OH-007). Unlike more typical upland sources to sediment sites, the setting, volume and discharge pathways of these sources make addressing them fully integral to the selected remedy.

The three former MGP facilities are being addressed by National Grid pursuant to administrative orders with NYSDEC. The remedy selection for the three former MGP facilities is not within the scope of this decision document. However, significant portions of the remedial work for the three former MGP facilities are expected to occur in the canal, requiring coordination with the sediment remedy. As a result of the concentrated levels and widespread prevalence of MGP-related NAPL, the degree of MGP source control may also affect cap design for the sediment remedy. Finally, the cost of the MGP-related remedies is anticipated to be in a similar range as the selected sediment remedy. As a result, detailed information is provided below regarding the dynamic relationship between the selected sediment remedy and the remediation of the former MGP facilities to establish that appropriate consideration has been given to this integral, major source.

With regard to control of the CSOs, the other major, integral on-going contamination source to canal sediments, the selected remedy requires implementation of specific measures to significantly reduce contaminated CSO solids discharges to the upper canal. Although not considered for CERCLA remedy selection purposes, the remedy will also help address the presence of pathogens introduced into the canal by the ongoing CSO discharges.

Former Manufactured Gas Plant Source Control Measures and Costs – Concurrent Work under Separate State Authority

NYSDEC has not yet completed the remedy selection process for the former Fulton and Metropolitan MGP facilities. However, NYSDEC has selected a remedy for the Public Place former MGP facility. All of the major reports for the three former MGP facilities, including the screening of remedial alternatives for Public Place, have been reviewed by the EPA and are included in the EPA’s Administrative Record. New York State guidance governing the State Superfund program requires source removal or control for all remedies. This will ensure that the remedies for the two other former MGP facilities will adequately address the sources. The costs for addressing the Public Place former MGP facility are estimated by National Grid at $175-200 million, based on NYSDEC’s selected remedy and National Grid’s remedial design work performed to date. It is assumed that the costs for the two other sites will each be in the same range or less.

CSO Solids Control Measures and Costs

To address the discharge of hazardous substances, such as PAHs associated with typical urban drainage, the following CSO control measures were screened based on effectiveness, implementability and cost (see the FS report addendum): no action; optimization of existing trap chamber in CSO OH-007; CSO sediment trap at CSO RH-034; silt curtains and/or netting facilities, maintenance dredging; sewer cleaning and CSO storage. The permanent installation of silt curtains was screened out based on the fact that they would not provide sufficient solids control and they would deteriorate and require extensive maintenance over the long term in large part due to the surface water velocities in the canal once the flushing tunnel is put back into operation. The temporary use of silt curtains during dredging operations will be evaluated as part of the remedial design, but silt curtains are not practicable as a permanent source control option.

As is noted above, to ensure continued protection of the canal remedy, future permanent CSO sediment controls are required. The only practicable, cost-effective measure for control of this volume of contaminated CSO solids is the use of retention tanks. Scientific literature suggests that it can be assumed that the "first flush" comprises approximately 20% of the total discharge volume and contains between 30% and 60% of the total PAH load of the discharge (Stein, 2006). The first flush phenomenon under urban settings with regard to the discharge of contaminants such as PAHs and metals has been studied in various geographic regions in the U.S. that experience different hydrologic patterns and various levels of urbanization. For example, studies have been performed in an ultra-urban area in Maryland and the District of Columbia (Flint and Davis, 2007), California (Lau *et al,.* 2009; Stenstrom and Kayhanian, 2005; Li *et. al.,* 2008), Ohio (Sansalone and Buchberger, 1997), Florida (Mitsova *et al.,* 2011); and across other countries/continents (Bertrand-Krajewski, 1998; Deletic, 1998; Larsen *et al.,* 1998; Lee *et Al*,. 2002; Nazahiyah, 2007 and Zhang *et. al.,* 2009). These studies demonstrate that first flush phenomenon is observed for various precipitation patterns and different chemical compositions, including those for metals and PAHs. In summary, the findings of these studies across the country are consistent with Stein *et al.* (2006), which states that "within individual storms, PAHs exhibited a moderate first flush with between 30% and 60% of the total PAH load being discharged in the first 20% of the storm volume." Therefore, the first flush concept and taking advantage of it for controlling CSO discharges are directly applicable to the CSO controls developed for the Gowanus Canal.

A CSO solids reduction of 58 to 74 percent was preliminarily estimated to be needed at outfall RH-034 to meet the RGs of four contaminants (total PAH, copper, lead and total PCBs) including a 51 to 71 percent reduction needed for total PAHs. (see the FS report addendum). Similar reductions will be needed for outfall OH-007. That level of reduction would require capturing more than 20 percent of the initial CSO discharge volume when factoring in the first flush capture effect.

It is anticipated that capturing approximately twice the amount of the first flush of the design storm event from CSO outfalls RH-034 and OH-007 (WB/WS Plan)[33] can provide an initial estimate of the degree of control needed so that the protectiveness of the remedy is maintained. In order to achieve this minimum level of contaminated CSO solids control, based on the preliminary screening, in-line sewage retention tanks[34] would be constructed near outfalls RH-034 and OH-007 unless other technically viable alternatives are identified. Tank volumes of 6- to 8-million gallons and 3- to 4-million gallons were preliminarily selected for outfalls RH-034 and OH-007, respectively, on the basis of their capacity to reduce CSO volume and solids in an amount that will prevent recontamination of the canal after the implementation of the sediment cleanup components of the remedy.

For costing purposes, an 8-million-gallon in-line retention tank (estimated by the EPA to cost $46,429,000 to construct) would be installed for outfall RH-034 and a 4-million-gallon in-line retention tank (estimated by the EPA to cost $31,272,000) would be installed for outfall OH-007.[35] For the purpose of developing construction costs associated with CSO control, it was assumed that these tanks could be located on available NYC-owned land in the vicinity of the outfalls. The final selection of CSO control retention tank locations, as well as any further evaluations of measures to prevent recontamination of canal sediments, will be completed during the remedial design and in coordination with the contemporaneous LTCP development process.

NYCDEP's has stated that it costs $1 million per year to operate its Alley Creek CSO storage tank and $2 million per year to remove grit alone at its Flushing CSO storage

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[33] The EPA recognizes that, in the future, there may be more frequent large rainfall events due to climate change.

[34] As was noted above, combined sewers receive both sewage and stormwater flows, and discharge to the canal when the sewer system's capacity is exceeded. Rather than discharging the sewage and stormwater to the surface water when the system's capacity is exceeded, the excess flow would be diverted to tanks, which would store it until the wet weather subsides, when it would be pumped to the WWTP.

[36] The cost includes $172,000,000 to address the contaminated sediments (this cost does not include treatment and disposal of dredged sediment which are dependent upon the disposal and treatment option selected), $77,701,000 to install in-line storage tanks for outfalls RH-034 and OH-007 (8 million gallons and 4 million gallons, respectively) and $20,000,000 for the excavation and restoration of the portion of the filled-in former 1st Street turning basin, the excavation and restoration of the portion of the 4th Street turning basin underneath the 3rd Avenue bridge and the installation of a barrier or interception system on the 5th Street turning basin side of the bridge. The cost does not include remedial measures, such as the installation of cut-off walls, source removal or groundwater/NAPL collection systems at the three former MGPs, which will be implemented under State authorities.

tank. Based on the sizes of those facilities alone (and not taking into account the frequency of use and actual volumes of CSO stored among other differentiating factors), the O&M cost is $0.20/million gallons per year (MG/yr) including $0.05/MG/year for grit removal. With that cost basis, the combined costs of operating two tanks at Gowanus Canal may be on the order of $2,400,000 per year ($1,600,000 for RH-034, $800,000 for OH-007).

NYC is under order with New York State to achieve the water quality goals of the CWA and must ultimately meet the "highest attainable use" per the EPA's LTCP guidance. The LTCP, which is due to the State in June 2015, is expected to address, at a minimum, the EPA's remedial performance goals as noted above, for further contaminated CSO solids control in the upper reach of the canal. The EPA and NYSDEC are committed to work together throughout the development of the remedial design and the contemporaneous LTCP development process to ensure that both the Superfund and CWA goals are met in a timely, cost-effective manner. The EPA seeks to coordinate the CERCLA and CWA processes to the extent practicable, to ensure that the selected CERCLA remedy is implemented in an effective and timely manner. Since the EPA is incorporating contaminated CSO solids control in the remedy selection, siting, remedial design and remedial action pursuant to the authority of CERCLA, certain CERCLA statutory authorities, including, but not limited to, permit exemption and environmental impact statement functional equivalency apply.

Since the design and construction of permanent long-term CSO controls for the Superfund remedy might not take place by the time remedial dredging is carried out, interim contaminated CSO solids control measures would need to be developed during the remedial design to control the discharges until the permanent measures are implemented.

Current and future high density residential redevelopment along the banks of the canal and within the sewershed would need to adhere to NYC rules for sewer connections (Chapter 31 of Title 15 of the Rules of the City of New York) and be consistent with recently adopted NYC criteria for on-Site stormwater control and green infrastructure (NYCDEP, 2012) so as to ensure that hazardous substances and solids from additional sewage loads do not compromise the effectiveness of the permanent CSO control measures by exceeding their design capacity. In addition, separated stormwater outfalls may also require source controls pursuant to applicable SPDES permits and best management practices. In particular, such separated stormwater outfalls would need to utilize appropriate engineering controls to minimize the discharges of hazardous substances and solids.

Additional Source Control Measures and Costs

The costs to address the other (non-MGP) upland sources will vary from parcel to parcel and will depend on source control options that may include excavation, cutoff walls and other measures. The EPA did not estimate the costs of remediating these additional parcels as part of the FS and, thus, those costs are not directly included in the overall remedy costs. However, the EPA believes that, in comparison to the overall anticipated canal remedy cost, the cost of addressing each of these parcels would be small. The EPA anticipates that separate cleanup determinations will be made for such parcels under the appropriate cleanup program. The appropriate remedial measures and costs of these non-MGP upland sources will be addressed in those separate cleanup determinations. Based upon discussions with property owners willing to implement such measures for redevelopment purposes voluntarily, such measures are likely to cost several million dollars or less per property. In the unlikely event that a timely and effective state-selected remedy is not implemented at a given non-MGP facility, the EPA may implement actions pursuant to CERCLA to ensure the protectiveness of the selected remedy.

The costs to address the non-CSO open pipes along the canal are expected to be minimal in comparison to the overall Site remedy costs and would involve either sealing the pipes or requiring the property owner to obtain the necessary permit to continue the discharge. To reduce sewer, stormwater and runoff contaminant inputs, the EPA and NYCDEP have also discussed the use of “Best Management Practices” by various business sectors (*e.g.,* auto repair, vehicle storage) near the canal. The EPA anticipates that these measures will be implemented in a phased manner over the course of the remedial action through compliance assistance efforts and, as appropriate, enforcement actions.

Sediment Dredging, Capping and Disposal Alternatives

The sediment dredging, capping and disposal alternatives described below also include the excavation and restoration of approximately 475 feet of the filled-in former 1st Street turning basin and the excavation and restoration of a portion of the 5th Street turning basin beginning underneath the 3rd Avenue bridge and extending the excavation approximately 25 feet to the east, and the installation of a barrier or interception system at the eastern boundary of the excavation.

The construction time of approximately six years for each alternative reflects only the time required to construct or implement the remedy and achieve the RAOs. This period does not include the time required to discuss the design and implementation of the remedy with PRPs and to prepare the enforcement agreement that will govern this work, the time required for the design of the remedy, including the procurement of contracts, and the time for the procurement of contracts for the implementation of the remedy. This period also does not include time needed for enforcement-related activities, including time to discuss and come to an enforcement agreement with PRPs for the operational details for the performance of the work.

The sediment dredging, capping and disposal remedial alternatives are:

Alternative 1: No Action

Capital Cost:	$0
Annual Operation and Maintenance (O&M) Cost:	$0
Present-Worth Cost:	$0
Construction Time:	0 months

The Superfund program requires that the "no-action" alternative be considered as a baseline for comparison with the other alternatives. The no-action remedial alternative does not include any physical remedial measures that address the contamination at the Site.

Because this alternative would result in contaminants remaining above levels that allow for unrestricted use and unlimited exposure, CERCLA requires that the Site be reviewed at least once every five years. If justified by the review, remedial actions may need to be implemented to remove, treat or contain the contaminated soils and sediments.

Alternative 5: Dredge Entire Soft Sediment Column; Cap with Treatment, Isolation and Armor Layers

Volume of Sediment Removed:	588,000 cubic yards (CY)
Capital Cost:	$270,000,000[36]
Annual O&M Costs:	$4,400,000[37]
Present-Worth Cost:	$272,000,000
Construction Time:	6 years

Under this alternative, all of the soft sediment within the canal would be removed and a cap would be placed on top of the native sediment surface.

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[36] The cost includes $172,000,000 to address the contaminated sediments (this cost does not include treatment and disposal of dredged sediment which are dependent upon the disposal and treatment option selected), $77,701,000 to install in-line storage tanks for outfalls RH-034 and OH-007 (8 million gallons and 4 million gallons, respectively) and $20,000,000 for the excavation and restoration of the portion of the filled-in former 1st Street turning basin, the excavation and restoration of the portion of the 4th Street turning basin underneath the 3rd Avenue bridge and the installation of a barrier or interception system on the 5th Street turning basin side of the bridge. The cost does not include remedial measures, such as the installation of cut-off walls, source removal or groundwater/NAPL collection systems at the three former MGPs, which will be implemented under State authorities.

[37] This cost includes O&M related to the contaminated sediments and contaminated CSO solids controls (such as in-line storage tanks). It does not include O&M costs related to the three former MGPs.

The native sediment surface elevation is variable within the canal; therefore, there is not a single specific removal depth in RTAs 1 or 3 under this alternative. In RTA 1, the native surface elevation ranges from -11.8 to -25.6 feet NAVD88. In RTA 3, the native surface elevation—and therefore the target dredge elevation—ranges from -18.9 to -44.2 feet NAVD88. The removal of all the soft sediment would allow for the placement of the cap and, at the same time, meet maintenance considerations in RTA 1 and navigational needs in RTAs 2 and 3.

In RTA 2, a navigation depth of -16 feet NAVD88 was assumed based on present commercial navigational needs. Therefore, all of the soft sediment and some native sediment would be removed to accommodate the cap thickness and allow for continued commercial vessel use in this reach.

The cap for this alternative would consist of an armor layer, an isolation layer and an active treatment layer as follows from top to bottom:

- Armor layer: Stone sized to meet the erosion forces of the flushing tunnel and navigation impacts. Sufficient sand would be placed on top of the armor layer to fill in the voids between the stones and to establish sufficient depth of soft sediment in order to facilitate benthic recolonization.
- Isolation layer: Approximately 1 foot thick consisting of 0.5 feet of gravel and 0.5 feet of sand to provide transition and erosion protection of the treatment layer material from the overlying heavier armor layer.
- Treatment layer (represented in the FS by oleophilic clay): Conceptually consisting of 1 foot in RTA 1 and RTA 2 and 0.5 feet in RTA 3 of an oleophilic clay-sand mixture, with the exact configuration to be determined during the remedial design.

The cap would need to be designed to tolerate future maintenance dredging operations in the canal for the removal of contaminated solids that might settle on top of it. If possible, the treatment layer component of the cap would be designed to have an adequate life expectancy for absorbing NAPL without replacement. For areas with high NAPL or impacted groundwater discharge, treatment gates (*i.e.,* NAPL sump) will likely be needed where the treatment media can be removed without disturbing the cap outside these areas.

This alternative would include periodic maintenance of the cap and long-term monitoring to insure that the remedy continues to function effectively.

This alternative would also include institutional controls incorporating the existing fish consumption advisories (modified, as needed), as well as other controls to protect the integrity of the cap and limit construction within the canal, including bulkhead maintenance and navigation dredging within the canal.

Because this alternative would result in contaminants remaining on-Site above levels that allow for unrestricted use and unlimited exposure, CERCLA requires that the Site be reviewed at least once every five years.

Alternative 7: Dredge Entire Soft Sediment Column; Perform In-Situ Sediment Stabilization; Cap with Treatment, Isolation and Armor Layers

Volume Sediment Removed:	588,000 CY
Capital Cost:	$286,000,000[38]
Annual O&M Costs:	$4,400,000[39]
Present-Worth Cost:	$288,000,000
Construction Time:	6 years

Under this alternative, all of the soft sediment within the canal would be removed and ISS would be applied to targeted areas of native sediment to immobilize NAPL with upward migration potential. ISS would be performed to a depth of 3 to 5 feet and would consist of incorporating pozzolanic and/or adsorptive additives into the native sediment to stabilize the material. ISS would be applied to areas where data indicate the potential for active upward NAPL migration from the native sediment. The stabilization material would be delivered to the sediment in-situ from a barge using large augers without dewatering the canal. The area being stabilized would be surrounded by temporary sheet-piling to contain the contaminants that would be released when the augers are in use. Any impacted water would be treated as necessary.

The depth of removal for RTAs 1, 2 and 3 would be the same as Alternative 5.

The conceptual cap for this alternative would be the same as the cap described for Alternative 5, an armor layer, an isolation layer and a treatment layer (represented by oleophilic clay). In addition, treatment layer design will need to be incorporated into the

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[38] The cost includes $188,000,000 to address the contaminated sediments (this cost does not include treatment and disposal of dredged sediment which are dependent upon the disposal and treatment option selected) and $77,701,000 to install in-line storage tanks for outfalls RH-034 and OH-007 (8 million gallons and 4 million gallons, respectively) and $20,000,000 for the excavation and restoration of the portion of the filled-in former 1st Street turning basin, the excavation and restoration of the portion of the 4th Street turning basin underneath the 3rd Avenue bridge and the installation of a barrier or interception system on the 5th Street turning basin side of the bridge. The cost does not include remedial measures, such as the installation of cut-off walls, source removal or groundwater/NAPL collection systems at the three former MGPs, which will be implemented under State authorities.

[39] This cost includes only O&M related to the contaminated sediments and contaminated CSO solids controls (such as in-line storage tanks). It does not include O&M costs related to the three former MGPs.

stabilized native sediment layer where stabilization is implemented. ISS will inhibit groundwater discharge in the treated areas and treatment gates will likely be needed where the treatment media can be removed without disturbing the cap outside these areas.

The cap would need to be designed to tolerate future maintenance dredging operations in the canal for the removal of contaminated solids that might settle on top of it. If possible, the treatment layer component of the cap would be designed to have an adequate life expectancy for absorbing NAPL without replacement. If this is not feasible, the alternative may include the replacement of portions of the treatment layer (replacing the treatment layer would also necessitate the removal and replacement of the overlying sand and armor layers).

This alternative would include periodic maintenance of the cap and long-term monitoring to insure that the remedy continues to function effectively.

This alternative would also include institutional controls incorporating the existing fish consumption advisories (modified, as needed), as well as other controls to protect the integrity of the cap and in-situ stabilized material and limit construction within the canal, including bulkhead maintenance and navigation dredging within the canal.

Because this alternative would result in contaminants remaining on-Site above levels that allow for unrestricted use and unlimited exposure, CERCLA requires that the Site be reviewed at least once every five years.

Treatment and Disposal Options

This section describes the treatment and disposal or beneficial-use options that may be utilized to address sediments removed through the above-noted dredging and capping alternatives. All treatment and disposal facility selection and beneficial use determinations would be subject to the EPA oversight and approval. Due to the differences in the extent of NAPL contamination in different areas of the canal, some of the treatment and disposal options are not applicable to all RTAs. The seven treatment and disposal options with the RTAs to which they apply (noted in parenthesis) are:

- Option A: Off-Site thermal desorption and beneficial use (RTAs 1, 2 and 3).
- Option B: Off-Site disposal (landfill; RTAs 1, 2 and 3).
- Option C: Off-Site cogeneration and beneficial use (RTAs 1, 2 and 3).
- Option D: Off-Site stabilization and off-Site beneficial use (RTAs 1 and 3).
- Option E: On-Site stabilization and on-Site beneficial use (RTAs 1 and 3).
- Option F: Off-Site stabilization and placement in on-Site constructed CDF (RTA 3).
- Option G: On-Site stabilization and placement in on-Site constructed CDF (RTA 3).

The relative cost rankings for these disposal and treatment options are influenced by tipping fees, specific treatment technology and transport distance required. The approximate costs for the treatment and disposal options range from approximately $170 to $320 per ton.

All of the treatment/disposal options include barging of the dredged sediment to a local, on-Site dewatering and transfer facility.

Additional treatability testing and sampling would be needed for all of the options. Further testing of stabilized sediment would be required to confirm that dredged sediment can be accepted by thermal desorption (Option A) and cogeneration (Option C) facilities. Utilization of Option B (off-Site landfill) would require testing of the stabilized dredged sediment to confirm that it would meet acceptance criteria. Options D, E, F and G would require further evaluations to determine the appropriate reagents and dosing required for stabilization and to assess the leachability of the stabilized material. Options D and E would further require a beneficial use to be identified and a determination as to whether the stabilized sediment would meet the associated beneficial-use requirements. A CDF would be constructed under Options F and G, if selected based upon community acceptance and approval by NYSDEC and other appropriate governmental regulatory authorities.

Option A: Off-Site Thermal Desorption and Beneficial Use

Option A consists of transporting dredged and dewatered sediments by barge to an off-Site commercial facility for stabilization, followed by transport of the stabilized sediment to another off-Site facility for treatment by thermal desorption. The treatment residuals would be destroyed in an afterburner and the treated sediment would be transported for beneficial use, such as daily cover at a landfill, or for another beneficial use at an off-Site location. To develop the estimated costs, the FS assumed that transport following stabilization would occur by truck. The total PCB and lead concentrations present in the sediment may preclude this treatment option for some areas of the canal.

Option B: Off-Site Disposal (Landfill)

Option B consists of transporting the stabilized sediment from the off-Site dredge material processing facility to an appropriate landfill. It is assumed that transport from the dredge-material-processing facility to the disposal facility would occur by truck. Disposal at a RCRA Subtitle D landfill is assumed for the stabilized sediment. Stabilization would be performed to the degree needed for the dredged sediment to pass the paint filter test.[40]

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[40] This test method is used to determine the presence of free liquids in a representative sample of waste. A predetermined amount of material is placed in a paint filter. If any portion of the

Option C: Off-Site Cogeneration and Beneficial Use

Option C consists of transporting dredged, dewatered sediments that have been stabilized, as necessary, at the off-Site dredge-material-processing facility to an off-Site cogeneration electrical plant. The stabilized sediment would be mixed with coal and then burned to generate electricity, which would then be distributed to the receiving electrical grid. The organic contaminants in the sediment would be destroyed through burning of the sediments at high temperatures (greater than 1,400°C) during the co-generation process. The treated sediment would then be transported for use as daily cover at a landfill or other beneficial use. It is assumed that transport from the off-Site dredge-material-processing facility to the cogeneration plant and from the cogeneration plant to the location where the treated sediment would be beneficially used would occur by truck.

Additional bench-scale testing would be required to determine whether the sediment in all areas of the canal would provide sufficient energy value (in British Thermal Units, or BTUs) to make cogeneration a feasible treatment/disposal option for all of the dredge sediments and to determine which areas of the canal contain sediment with the appropriate BTU value. Bench testing would also be required to determine the amount of stabilization materials needed to reduce the moisture content of the material to approximately 20 percent (the desired limit for the receiving facilities).

Option D: Off-Site Stabilization and Beneficial Use

Option D consists of transporting dewatered sediments to an off-Site dredge material processing facility via barge, where the sediment would be stabilized to a greater degree than for mere disposal. The treated material would then be transported via truck or rail (assumed to be by truck) to the off-Site beneficial use location. Potential beneficial use options include the stabilized sediment's use as fill or landfill daily cover or incorporation into construction materials, such as concrete. A specific beneficial use applicant would need to be identified and further evaluations would be required to confirm the amounts and types of stabilizing agents that should be added to the sediment to result in the desired physical and chemical properties. Tests to assess the leachability of NAPL and other contaminants, as well as the material strength, would need to be performed on the stabilized material in order to determine whether it would meet the beneficial use requirements.

Option E: On-Site Stabilization and Beneficial Use

Option E includes stabilizing dredged sediment on-Site and beneficially using the

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material passes through and drops from the filter within the 5-minute test period, the material is deemed to contain free liquids.

treated sediment in areas adjacent to the canal. As with Option D, the degree of stabilization necessary for direct on-Site beneficial use without further treatment would need to be more substantial than the stabilization under Options A through C, where the stabilization process would be utilized to prepare sediments for off-Site transport by truck to be followed by treatment before final disposition. A specific beneficial use has not been determined, but potential uses include fill or creation of concrete blocks. Additional physical and chemical testing and cost analyses would be required to evaluate potential beneficial uses. Sediments would need to be stabilized to a degree consistent with their beneficial use including considerations on the leachability of contaminants.

A beneficial use for this material would need to be identified; the limitations, additional data needs and further evaluations described for Option D also apply to Option E. It is assumed that the beneficial use would be in a permanently controlled environment (*e.g.*, long-term potential human and ecological direct contact exposures and contaminant release are appropriately limited) and that long-term monitoring would be performed. Permanent institutional controls would be required to ensure the long-term effectiveness of this option. A temporary on-Site stabilization facility would need to be constructed and a location for this facility would need to be identified.

Option F: Off-Site Stabilization and Disposal in On-Site-Constructed CDF

Lesser-contaminated, stabilized sediments could be placed in the CDF[41] if approved by NYSDEC and other appropriate governmental regulatory authorities,[42] which would be filled and covered to match the existing ground surface elevation.

Option F would apply only to sediments at RTA 3 contaminant levels. RTA 3 sediments are less contaminated and with fewer NAPL impacts than the RTA 1 and 2 sediments. For this reason, RTA 3 sediments are more suitable for treatment via stabilization and placement in a CDF. Limiting Option F to RTA 3 sediments (and, space permitting, equivalent low level sediments from other areas, especially in RTA 1, that may be identified during design sampling) would also limit the space requirements needed to construct a CDF. The disposal of the lesser contaminated sediments in a CDF is projected to result in cost savings relative to the off-Site disposal options.

This option consists of transporting the stabilized sediment from the off-Site treatment facility back to the Site by barge and then transferring the sediment into an on-Site constructed CDF. The CDF would border water on one side and land on three sides. The layout includes installing a single sheet- pile wall on the sides adjacent to land and

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[41] The EPA previously identified a potential CDF location on privately-owned property at the Gowanus Bay Terminal on Columbia Street in Red Hook.

[42] The EPA will follow OSWER Directive 9355.7-03, *Permits and Permit "Equivalency" Processes for CERCLA On-Site Response Actions*.

installing a double sheet-pile wall on the side of the CDF adjacent to water. The void in the double sheet-pile wall would be filled with bentonite-augmented soil or a similar low-permeability material. Sufficient stabilization agents (*e.g.*, Portland cement) would be added to the dewatered sediment such that a monolithic mass would result. The material would be transferred into the CDF before it was completely hardened and would be placed using standard material-handling equipment. Once the treated sediment hardens, leaching is expected to be negligible, so a leachate collection system would not be necessary. Upon placement of the sediment in the CDF, the CDF would be capped. It is presumed that the top layer of the cap would be asphalt, allowing use of the surface. The CDF design would need to ensure long-term effectiveness in a coastal marine environment and be approved by NYSDEC and other appropriate governmental regulatory authorities. Surveys would be required on a regular basis to monitor the long-term integrity of the cap. Cap maintenance would include placement of additional clean materials/repaving to replace damaged areas of the cap.

For cost-estimating purposes, it was assumed that the CDF would accommodate the entire volume of sediment removed from RTA 3. The volume of in-situ sediment in RTA 3 has been estimated at 281,000 CY and an expansion factor of approximately 1.15 has been estimated for stabilized material, resulting in a CDF capacity of approximately 323,000 CY. If the CDF is constructed such that the thickness of stabilized sediment is 20 feet, the area required for the CDF would be 10 acres.

Bench-scale testing would be needed to determine the amounts of stabilizing agents that should be added to the sediment to result in the desired consistency. Tests to assess the leachability of contaminants would also need to be performed on the stabilized material in order to refine the CDF design. The design of the CDF would depend on its location and the characteristics of the stabilized sediment. Permanent institutional controls would be required to protect the long-term integrity of the CDF.

Option G: On-Site Stabilization and Disposal in On-Site-Constructed CDF

Option G consists of stabilizing dredged sediment on-Site and then transferring the sediment to a constructed on-Site CDF. The CDF would be the same as described in disposal Option F.

The disposal under Option G is the same as Option F, with the exception that the stabilization would be performed on-Site and transport of sediment to and from an off-Site stabilization facility would not be needed. It is assumed that an on-Site temporary stabilization facility would be constructed near or adjacent to the CDF location. Three concrete mixing facilities are located on the canal, of which two have expressed interest in providing stabilization services for the project.

The costs for the disposal options by RTA are summarized in Table 16.

COMPARATIVE ANALYSIS OF ALTERNATIVES

During the detailed evaluation of remedial alternatives, each alternative is assessed against nine evaluation criteria, namely, overall protection of human health and the environment, compliance with ARARs, long-term effectiveness and permanence, reduction of toxicity, mobility or volume through treatment, short-term effectiveness, implementability, cost, and state and community acceptance.

The evaluation criteria are described below.

- <u>Overall protection of human health and the environment</u> addresses whether or not a remedy provides adequate protection and describes how risks posed through each exposure pathway (based on a reasonable maximum exposure scenario) are eliminated, reduced or controlled through treatment, engineering controls or ICs.

- <u>Compliance with ARARs</u> addresses whether or not a remedy will meet all of the applicable or relevant and appropriate requirements of other federal and state environmental statutes and requirements or provide grounds for invoking a waiver.

- <u>Long-term effectiveness and permanence</u> refers to the ability of a remedy to maintain reliable protection of human health and the environment over time, once cleanup goals have been met. It also addresses the magnitude and effectiveness of the measures that may be required to manage the risk posed by treatment residuals and/or untreated wastes.

- <u>Reduction of toxicity, mobility or volume through treatment</u> is the anticipated performance of the treatment technologies, with respect to these parameters, which a remedy may employ.

- <u>Short-term effectiveness</u> addresses the period of time needed to achieve protection and any adverse impacts on human health and the environment that may be posed during the construction and implementation period until cleanup goals are achieved.

- <u>Implementability</u> is the technical and administrative feasibility of a remedy, including the availability of materials and services needed to implement a particular option.

- <u>Cost</u> includes estimated capital, O&M and present-worth costs.

- State acceptance indicates whether or not the State concurs with the selected remedy.

- Community acceptance refers to the public's general response to the results of RI and the alternatives described in the FS report, FS report addendum and Proposed Plan.

A comparative analysis of these alternatives based upon the evaluation criteria noted above follows.

Overall Protection of Human Health and the Environment

Alternative 1 would not provide overall protection of human health and the environment. This alternative would not achieve the RAOs for the canal. Contaminated sediments would remain and exposure to these sediments would continue to pose human health and ecological risks. NAPL migration from the sediment to the surface water would continue and the potential for direct contact with NAPL would remain.

Alternatives 5 and 7 are expected to be protective of human health and the environment. These alternatives would meet the RAOs by removing contaminated soft sediment and capping with an active treatment layer to reduce and control the long-term risks associated with the native sediment. Placing such an active cap over the contaminated native sediment remaining in the canal would prevent exposure to human and ecological receptors, thereby reducing and controlling toxicity to benthic organisms and eliminating the risks to herbivorous birds. The active cap would also prevent direct contact with NAPL and prevent NAPL migration to the surface water of the canal. Bench- scale testing performed by the EPA has demonstrated that ISS can sequester NAPL migration in native sediment. Implementation of ISS in targeted areas as part of Alternative 7 is expected to provide additional protectiveness against NAPL migration from the native sediment.

Implementation of Alternatives 5 or 7 would improve the surface water quality of the Gowanus Canal by controlling and eliminating NAPL migration and preventing contact of the surface water with the contaminated sediment.

Implementation of source controls to address CSO-related releases of hazardous substances associated with contaminated CSO solids, beyond those currently being implemented by NYCDEP, is necessary to provide overall protection of human health and the environment. In particular, such controls are necessary to protect the integrity of the canal remedy. By reducing discharges and accumulation of contaminated CSO solids, contaminant concentrations in surface sediments after remedy implementation are expected to meet the RGs, which are considered protective of human health and the environment. Absent additional controls, solids contaminated with hazardous substances will continue to be discharged through the CSOs, and will continue to adsorb and concentrate additional releases of hazardous substances, adversely affecting the sediments in the canal.

Compliance with ARARs

Below are the principal chemical-specific, action-specific and location-specific ARARs for the Site.

Since there are currently no federal or state promulgated standards for contaminant levels in sediments in New York, RGs for sediments in the Gowanus Canal were developed based on the results of the HHRA and BERA.

The EPA and New York State have promulgated surface water standards which are enforceable standards for various surface water contaminants. The New York State surface water quality standards are set forth at 6 NYCRR Part 703.

While Alternatives 5 and 7 would be expected to comply with all of the designated chemical-specific ARARs, Alternative 1 would not, since there would be no active remediation associated with the sediments.

During the implementation of Alternatives 5 and 7, any short-term excursions above surface water ARARs in the canal due to dredging and capping would be expected to be limited to the area in the vicinity of the work zone. Sufficient engineering controls would need to be put in place during dredging and capping to prevent excursions of surface water ARARs outside of the work zone.

Disposal of solids and liquid collected as part of contaminated CSO solids controls would be implemented in a manner that would achieve chemical-specific ARARs under the CWA. It is anticipated that any sewage stored in retention tanks would be processed by the existing WWTPs in accordance with each facility’s permits at the conclusion of storm events. In the event that solids are generated for disposal at the contaminated CSO solids control (*e.g.,* via maintenance of an in-line CSO retention facility), such disposal would be implemented in a manner which complied with RCRA requirements.

The principal action-specific ARARs include CWA Sections 401, 402 and 404; the Rivers and Harbors Act Section 10; the New York Environmental Conservation Law (ECL) Article 15 Water Resources, Article 17 Water Pollution Control and Article 27 Collection, Treatment and Disposal of Refuse and Other Solid Waste; and associated implementing regulations. Consideration of a CDF would be subject to review by NYSDEC and other appropriate governmental regulatory authorities.

The CWA Section 401 Water Quality Certification (WQC) is implemented by NYSDEC through ECL Article 15 and the associated regulations in 6 NYCRR Part 608 Use and Protection of Waters. The WQC may establish conditions such as preventive measures to minimize re-suspension of sediment and water quality monitoring during dredging, so that the remedy would not exceed water quality standards. Placement of fill (such as a cap or construction of an in-water confined disposal facility) and temporary discharges of decanted waters from dredge barges into waters of the United States would also be addressed through a WQC. The dredging or placement of fill or structures such as bulkheads or in-water confined disposal facilities within navigable waters of the United States and other activities which may adversely affect aquatic ecosystems are regulated by the Rivers and Harbors Act Section 10. Similar activities in any waters of the United States are addressed by CWA Section 404 for which the USACE has jurisdiction.

CWA Section 402 is implemented by NYSDEC through the ECL Article 17 SPDES requirements, which regulate the discharge of pollutants into waters of the state. Pre-treatment or monitoring of decanted water may be imposed and would be applicable to dewatering of the sediment at an on-Site noncommercial facility.

RCRA is the federal law addressing the storage, transportation and disposal of solid and hazardous waste. NYSDEC implements RCRA in New York under ECL Article 27. The dredged sediment would be considered solid waste; however, it can be exempted from being solid waste through the WQC program. If not exempted, RCRA requirements would be applicable.

In addition to the ARARs described above, the principal location-specific ARAR is the Federal Coastal Zone Management Act administered by the National Oceanic and Atmospheric Administration, and the associated NYSDEC regulations which apply to placement of bulkhead, sheet-piling within the canal, barge/boat docks, barge offloading facilities, boat launches, bridge abutment bulkhead protection, utility protection and dredging. Since both of the action alternatives include dredging and active capping within the canal, the final design of the remedy must meet the substantive requirements of these regulations. Both action alternatives are expected to be able to comply with all of the designated location-specific and action-specific ARARs.

The CSO outfall source controls would comply with all of the designated chemical-specific, location-specific and action-specific ARARs.

If a CDF were to be constructed, the design would need to consider whether the substantive requirements of the following action-specific ARARs would be triggered and indicate how compliance would be achieved:

- Clean Water Act Section 401 certification.
- 6 NYCRR Part 608 Use and Protection of Waters, 6 NYCRR Part 701, Classifications-Surface Waters and Groundwaters Clean Water Act Section 404(b).
- 40 CFR Part 230 Section 404(b)(1) Guidelines for Specification of Disposal Sites for Dredged or Fill Material.
- 40 CFR Part 122 EPA Administered Permit Programs: the National Pollutant Discharge Elimination System.
- 40 CFR Part 125 Criteria and Standards for the National Pollutant Discharge Elimination System.
- Clean Air Act, 40 CFR 50-99.
- New York State ECL Article 1 Title 1.
- New York State ECL Article 3 Title 3.
- New York State ECL Article 15 Title 5.
- New York State ECL Article 11, Title 5.
- New York State ECL Article 17, Title 5.
- New York State ECL Article 19, Title 3.
- 6 NYCRR Parts 200-257–Air Resources.
- NYSDEC - New York Guidelines for Soil Erosion and Sediment Control.

Long-Term Effectiveness and Permanence

Alternative 1 would not result in any significant change in risk associated with contaminated sediment or NAPL.

Alternatives 5 and 7 would result in significant, permanent reduction of the risks associated with contaminated canal sediments and would meet the RAOs. Both alternatives would provide long-term protection of human health and the environment. The risks associated with contaminated sediment and NAPL in the canal would be reduced over the implementation period of the alternatives as the sediments are removed from the canal. The NAPL-contaminated sediments constitute principal threat waste[43] for which removal and treatment is warranted.

The active cap would provide long-term control of the risks associated with the native sediment in the canal, provided that appropriate long-term cap monitoring and maintenance plans are implemented. Adsorptive caps to control NAPL migration can be designed for a set life expectancy where the NAPL migration rate is known. At the McCormick and Baxter Superfund site in Portland, Oregon, the NAPL discharge rate to

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[43] Principal threat wastes are source materials that include or contain hazardous substances that act as a reservoir for the migration of contamination to groundwater, surface water or air, or act as a source for direct exposure. These materials are considered to be highly toxic or highly mobile and, generally, cannot be reliably contained.

the cap was estimated and a design life of more than 100 years established (Blischke and Olsta, 2009). NAPL discharge rates at the Gowanus Canal would need to be determined prior to cap design to establish the appropriate adsorptive cap thickness requirements.

Alternatives 5 and 7 are considered to have a high degree of effectiveness because all the soft sediment would be removed and the exposure risks associated with the native sediment would be controlled by the active cap. The application of ISS to targeted areas of native sediment in Alternative 7 would be expected to reduce further the NAPL mobility from the native sediment; pilot testing would need to be performed to determine the most effective, implementable form of ISS within the canal. In the event that ISS is not fully effective, the multilayer cap would provide a redundant level of protectiveness.

The seven treatment and disposal options were ranked with respect to long-term effectiveness and permanence. Options A, B and C rank high with respect to this criterion because the material would be transferred off-Site and treated or contained in a managed landfill, alleviating the associated risk. Options D and E (stabilization and beneficial use) are considered to have low to moderate long-term effectiveness. The effectiveness would depend on the actual beneficial use. Use as an off-Site landfill daily cover, as is assumed for Option D, would be effective and permanent since the material is used in a controlled, monitored environment. Use as on-Site fill or concrete blocks could potentially be effective and permanent, but would require testing to ensure that appropriate treatment is applied and would require a suitable, controlled, end-use location to be identified. Long-term monitoring would also be needed to assure that performance criteria continue to be achieved. Permanent institutional controls would be needed to ensure that long-term potential human direct contact exposures are appropriately limited. The institutional controls would need to restrict digging or construction activities within the fill material and may need to be applied to one or more properties, depending on where the material is used. Depending on the number of properties and where on the properties the fill is placed, more effort and coordination may be needed to ensure successful implementation and enforcement of these controls. Institutional controls would require sustained application and monitoring to assure their success.

Options F and G (stabilization and placement into a constructed CDF) are considered to have a moderate to high ranking for this criterion because the sediment would remain on-Site, but would be contained in an engineered CDF. Under Options F and G, the sediment would be permanently stabilized into a relatively impermeable monolithic mass, which is the primary mechanism for reducing or controlling long-term risk. As previously noted, the less-impacted sediments would be placed in the CDF. Long-term monitoring and periodic maintenance would be needed to assure that the CDF continues to function effectively. Institutional controls, which would be relatively straightforward to implement and maintain, would be required to assure that the CDF remains undisturbed.

The commingling of solids and associated PAHs and other chemical constituents from the CSO outfalls with sediment and chemical constituents in the canal would potentially impact the integrity and long-term effectiveness of each of the active alternatives. Contaminated CSO solids control would reduce the mass of solids accumulating in the canal and, thus, reduce the residual risk from contaminants in newly deposited sediments after remedy implementation. Treatment of any stored sewage material would occur at the WWTPs in accordance with each facility’s permits at the conclusion of storm events. Contaminated CSO solids controls can be designed and implemented to provide reliable control of discharges at the selected design criteria, thus, reducing the potential for recontamination and the residual risk after remedy implementation.

The reliability of contaminated CSO solids control would require regular inspections and maintenance of the controls to ensure that they are operated in accordance with design criteria. Site management controls relating to future sewer capacity would be necessary to maintain the effectiveness of the CSO measures. Specifically, controls would be utilized to ensure that current and future high density residential redevelopment projects along the banks of the canal and within the sewershed would be constructed consistent with current NYC guidelines (NYCDEP, 2012) so as to not exceed the designed contaminated CSO solids control capacity, therefore avoiding the contribution of new sewage discharges to the canal that could compromise the remedy. Separated stormwater outfalls may also require discharge treatment controls.

NYCDEP’s WB/WS Plan, which followed the EPA’s LTCP guidance, was developed and approved by the State of New York on July 14, 2009 to achieve planned levels of CSO reductions for a typical rainfall year. The control technologies considered by NYCDEP for the WB/WS Plan are typical of reliable contaminated CSO solids control employed by NYCDEP and other cities around the world.

Monitoring of controls in support of the selected remedy can be integrated into NYCDEP’s monitoring plans under the WB/WS and LTCP. Specifically, following the implementation of the WB/WS Plan, NYCDEP will perform post-construction monitoring to assess the effectiveness of its plan. Monitoring will consist of collecting relevant sampling data from the canal, as well as collecting relevant precipitation data and data characterizing the operation of the sewer system (NYCDEP, 2009). Analyses will be performed to assess compliance with water quality standards as a measure of the effectiveness of the WB/WS Plan. Using the collected information, NYCDEP will assess whether or not additional CSO controls are needed to achieve compliance with the CWA as part of an Adaptive Management Approach. NYCDEP will then submit in June 2015, an LTCP, which may include additional CSO controls needed for compliance with the CWA and requiring further long-term post-construction monitoring.

This monitoring will likely be added to NYCDEP's SPDES permits and can integrate the monitoring of controls implemented in support of the selected remedy for the canal.

Reduction in Toxicity, Mobility or Volume through Treatment

Alternative 1 would not result in the reduction in toxicity, mobility or volume of contaminants nor does it include a treatment component.

The treatment component included in the Alternatives 5 and 7 cap layout is represented by a granular oleophilic clay layer. The treatment layer would reduce the mobility of NAPL and is considered a treatment technology. The overall reduction of NAPL mobility expected to be achieved by the treatment layer is high. Alternative 7 is considered to have a higher ranking because, while the capping component is the same as that included in Alternative 5, its effectiveness is supplemented by ISS (also a treatment technology). The application of ISS to targeted areas of native sediment in Alternative 7 has been shown from bench-scale testing to reduce the NAPL mobility from the native sediment further; however, pilot testing would need to be performed to determine the effectiveness and implementability of ISS within the canal.

The reduction of toxicity, mobility and volume of the dredged sediment is dependent upon the treatment/disposal option selected; therefore, the four treatment/disposal options are evaluated and ranked. Thermal treatment (Option A) and cogeneration (Option C) are both ranked high. Both treatment options would significantly reduce or eliminate the toxicity, mobility and volume associated with the dredged sediment and both options would satisfy the statutory preference for treatment as a principal element of the alternative. Disposal Options B (off-Site landfill disposal), D and E (stabilization and beneficial use) and F and G (stabilization and placement into a constructed CDF) are all ranked as moderate for this criterion. Stabilization of the sediment would reduce contaminant mobility, but toxicity and volume would not be affected. Thermal treatment (Option A) and thermal destruction through cogeneration (Option C) are irreversible. The stabilization components of Options F and G are considered irreversible since the treated sediment would be placed in a controlled and monitored disposal facility. The irreversibility of stabilization for Options D and E (beneficial use) would be dependent upon the conditions where the material is placed and the degree of stabilization performed. Additional testing would be required to determine if an irreversible stabilization process can be developed on the basis of beneficial use.

Contaminated CSO solids control would reduce the volume of contaminants and adsorbent organic solids discharged to the canal. The controls would permanently reduce the mobility of contaminants by capturing and containing solids prior to being discharged to the canal. The captured solids would then undergo appropriate treatment and/or disposal, with the specific methods to be determined during the remedial design. It is assumed that stored sewage would be managed at the WWTPs in accordance with each facility’s permits at the conclusion of storm events. The capture of the solids would be irreversible, since the solids would be prevented from discharging to the canal. The reduction of toxicity and volume achieved would be designed so that contaminated CSO solids control would result in surface sediment concentrations below the established RGs. CSO reductions needed to achieve the RGs in surface sediments after remedy implementation are estimated to be in the range of 58 to 74 percent.

Short-Term Effectiveness

Alternative 1, No Action, does not include any physical construction measures in any areas of contamination and, therefore, would not present any potential adverse impacts to on-Site workers or the community as a result of its implementation.

The preconstruction Site work, sediment removal and capping components of Alternatives 5 and 7 are considered to have moderate short-term effectiveness due to the construction duration and the potential construction-associated risks and short-term environmental impacts (traffic, odors, noise, etc.). Effective controls can be implemented to address short-term environmental impacts from temporary on-Site sediment handling and dewatering. Barges would be used for the transport of dredged sediment. Barges would also be used, to the extent possible, to limit traffic impacts related to the delivery of equipment and supplies and the transport of materials from the work area. Increased barge traffic may, however, result in vehicular traffic impacts as a result of more frequent drawbridge openings. Appropriate measures could be taken to limit noise, odors and other impacts associated with dredging and processing of the sediments. The short-term effectiveness of the treatment and disposal options is evaluated based on the potential short-term impacts to the Site associated with transportation and the transportation distance required. The short-term effectiveness is considered moderate to high for all of the treatment and disposal options that were evaluated.

The transportation distance of dredged material to the final treatment or disposal facility is an important consideration for short-term effectiveness. Distances were estimated in the FS for the purposes of comparing options and developing costs. Options E (on-Site stabilization and on-Site beneficial use) and G (on-Site stabilization and disposal in an on-Site CDF) do not require the dredged sediment to be transported off-Site, although stabilization reagents (*e.g.*, cement and blast furnace slag) would need to be transported to the on-Site facility. Of the remaining disposal options, Option F (off-Site stabilization and disposal in an on-Site CDF) offers the shortest transport distance for the dredged sediment (approximately 60 nautical miles round trip), all of it by barge. Disposal Option A (thermal treatment) consists of approximately 30 nautical miles of barge transport from the Site to the off-Site-dredge-material-processing facility and from there approximately 60 miles of transport by truck to the thermal treatment facility.

The transport distance for Option B (off-Site landfill) is estimated to be approximately 30 nautical miles by barge to the processing facility and then approximately 110 miles by truck to a disposal facility. Option C (cogeneration) is estimated to include approximately 30 nautical miles of transport to the processing facility and approximately 350 miles by truck to the cogeneration plant used as the example facility. The off-Site beneficial use for sediment under Option D has been assumed to be landfill daily cover; thus, it has been assumed that the material would need to be transported approximately 110 miles by truck from the off-Site stabilization facility to the disposal facility.

Contaminated CSO solids controls in the form of retention tanks can be designed, constructed and operated in a manner that does not present short-term implementation risks to the community and workers, manages environmental impacts and meets ARARs.

Ideally, contaminated CSO solids control would be in place before the implementation of the remedy for canal sediments. Alternatively, temporary CSO control measures may be needed to maintain remedy protectiveness while the permanent contaminated CSO solids controls are being implemented. At the time of the completion of the canal remedy, the canal surface would be “clean,” with surface sediment contaminant concentrations expected to increase over time as a result of new sediment deposition in the canal. However, as noted, the CSO control design criteria would be selected such that the deposition of solids from CSOs would not result in surface sediment concentrations above the RGs.

It is estimated that the design and construction of both action alternatives would take three years and six years, respectively.

Implementability

Alternative 1 is considered to be readily implementable because no remedial actions would be performed

Both Alternatives 5 and 7 would be administratively feasibile in terms of assuring that the off-site treatment/stabilization facilities have the required permits. The dredging and capping components of Alternatives 5 and 7 are considered moderately implementable. Both alternatives would require significant coordination between the EPA, USACE, NYSDEC, NYCDEP, PRPs and the property owners and tenants along the canal from the start of the design through completion of construction. The specific characteristics of the canal (*e.g.*, debris, degraded bulkheads, space limitations and the surrounding lively metropolitan residential and commercial community) and the large volumes of capping materials required would pose challenges to the remedy implementation. The amount of material required for the cap construction may require using several vendors, advanced planning and stockpiling material in advance of the construction to assure that enough material is available during the implementation period. It is anticipated that appropriate planning and engineering measures can address these issues. Alternative 5 is considered to have moderate overall implementability. Because there are more uncertainties associated with the ISS component of Alternative 7 and additional treatability and pilot testing are required to confirm the overall feasibility and effectiveness of this technology, Alternative 7 is considered to have moderate implementability, but to a lesser degree than Alternative 5. The location and construction of a temporary on-Site sediment handling and dewatering facility is considered to have moderate implementability.

The implementability of the different treatment and disposal options is more variable:

- Option A (off-Site thermal desorption and beneficial use): moderate
- Option B (off-Site land fill disposal): moderate to high
- Option C (off-Site cogeneration and beneficial use): moderate
- Option D (off-Site stabilization and off-Site beneficial use): moderate
- Option E (on-Site stabilization and on-Site beneficial use): moderate
- Option F (off-Site stabilization and disposal in on-Site constructed CDF): moderate
- Option G (on-Site stabilization and disposal in on-Site constructed CDF): moderate

Thermal treatment and cogeneration facilities (Options A and C, respectively) are limited within the geography, which would restrict the ability to competitively bid these services. The total PCB and lead concentrations in the soft sediment in some portions of the canal may also limit the potential for beneficial use after thermal treatment. Treatability testing would be needed to confirm that the available treatment facilities can accept the dewatered and stabilized sediment.

The availability of landfill facilities that would accept contaminated river sediment as waste and the existing capacity at these facilities within the geography is limited. Based on inquiries of Subtitle D landfills in the area, few facilities would accept materials originating from outside the county they serve and only a subset of these facilities would accept dredged material. Because Option B includes off-Site landfill disposal of the stabilized dredged sediment, the implementability of this option is reduced for disposal facilities in the area; however, additional disposal facilities are available outside of the area. Use of these facilities would result in increased transport costs. The beneficial use of treated sediment under Options A and C is expected to be readily implementable as long as treated sediment meets the end-use requirements.

The implementation of Options D and E (stabilization and beneficial use) would require identifying an off-Site or on-Site beneficial use of the stabilized material, as well as defining the performance standards for the end-use requirements. The stabilized material would need to meet the chemical and physical performance standards (*e.g.*, short- and long-term leachability and strength characteristics) in order for these options to be implemented. Additionally, on-Site use of the stabilized material would be dependent upon property owner acceptance and the sustained application of institutional controls. Due to these unknowns and challenges, these two disposal options are considered to have moderate implementability. The off-Site beneficial-use option has a slightly higher ranking due to the possibility of more beneficial-use applications. The on-Site beneficial-use option also is ranked slightly lower due to the potential difficulties associated with effective sustained implementation of institutional controls.

Implementation of disposal Options F and G (stabilization and on-Site CDF) is dependent on the acceptance from the community, review of NYSDEC and other appropriate governmental regulatory authorities and the sustained application of institutional controls. These options may be difficult to implement due to administrative considerations and, therefore, received a moderate ranking.

Various approaches to CSO solids control exist and have been successfully implemented elsewhere. NYCDEP has demonstrated that CSO discharges can be significantly reduced with the utilization of CSO retention tanks.

Cost

A summary of the estimated cost for each dredging and capping alternative and the associated treatment and disposal options, as well as the costs for the CSO retention tanks, is provided in Table 16.

Support Agency Acceptance

NYSDEC concurs with the selected remedy; a letter of concurrence is attached (see Appendix IV).

Community Acceptance

Comments received during the public comment period indicate that the public generally supports the dredging, capping and CSO abatement components of the selected remedy. While 15 local businesses and approximately 700 Red Hook residents located in close proximity to the proposed location of the CDF expressed support for its construction, approximately 900 parties located in other sections of Red Hook, elsewhere in New York State and in other states expressed strong opposition to the CDF option. In addition, two petitions containing over 3,000 signatures from business owners, residents, users of the recreation area, and concerned citizens expressing opposition to the processing of contaminated sediments in Red Hook and their placement in a CDF was presented to the EPA by “No Toxic Red Hook.” The comments are summarized and addressed in the Responsiveness Summary, which is attached as Appendix V to this document.

PRINCIPAL THREAT WASTE

The NCP establishes an expectation that the EPA will use treatment to address the principal threats posed by a site wherever practicable (NCP Section 300.430 (a)(1)(iii)(A)). The "principal threat" concept is applied to the characterization of "source materials" at a Superfund site. A source material is material that includes or contains hazardous substances, pollutants or contaminants that acts as a reservoir for the migration of contamination to groundwater, surface water or air, or acts as a source for direct exposure. Principal threat wastes are those source materials considered to be highly toxic or highly mobile and that generally cannot be reliably contained or will present a significant risk to human health or the environment should exposure occur. The decision to treat these wastes is made on a site-specific basis through a detailed analysis of alternatives, using the remedy-selection criteria that are described below. This analysis provides a basis for making a statutory finding that the remedy employs treatment as a principal element.

Elevated contaminant concentrations and visual evidence of the presence of NAPL exist in the canal. The RI indicated that the NAPL and contaminated sediments are mobile, at least when disturbed; have high concentrations of toxic compounds; and present significant risks. Therefore, they are characterized as principal threat wastes.

The selected remedy addresses source materials constituting principal threats by removing the entire accumulated sediment column, thermally treating the NAPL-impacted sediments dredged from the upper and mid-reaches of the canal and applying ISS in targeted NAPL areas of native sediment, thereby satisfying the preference for treatment.

SELECTED REMEDY

Summary of the Rationale for the Selected Remedy

Based upon consideration of the requirements of CERCLA, the results of the Site investigations, the detailed analysis of the alternatives and public comments, the EPA has determined that the following combination of alternatives[44] and treatment and disposal options satisfies the requirements of CERCLA Section 121, 42 U.S.C. § 9621, and provides the best balance of tradeoffs among the remedial alternatives with respect to the NCP's nine evaluation criteria at 40 CFR §300.430(e)(9):

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[44] While remedial alternatives are typically compared against each other with the intent of selecting one alternative, due to the different conditions at each of the RTAs, both action alternatives will be utilized.

- Alternative 5: Dredge the entire soft sediment column and cap with treatment, isolation and armor layers for RTA 3.
- Alternative 7: Dredge the entire soft sediment column, targeted ISS of native sediment in areas with potential for active upward NAPL migration from the native sediment and cap with treatment, isolation and armor layers for RTAs 1 and 2.
- Excavation and restoration of a portion of the original filled-in 1st Street turning basin.
- Excavation and restoration of the portion of the 5th Street turning basin beginning underneath the 3rd Avenue bridge and extending approximately 25 feet to the east and the installation of a barrier or interception system at the eastern boundary of the excavation.
- Option A: Off-Site thermal desorption/beneficial use for the sediments removed from the NAPL-impacted areas in RTA 1 and RTA 2.
- Option D: Off-Site stabilization/beneficial use for the sediments removed from the non-NAPL impacted areas in RTA 3.
- Contaminated CSO solids control through the use of CSO retention tanks.

The rationale for selecting this remedy is as follows:

- Removal of all of the soft sediment will remove the PAHs and collocated metals and PCBs which are found only in the soft sediment at concentrations of concern and is the most appropriate approach to address the principal threat waste (*i.e.,* NAPL present within the accumulated sediments).
- Removal of all soft sediment will limit the potential for future contaminant transport through localized portions of the cap that might be eroded.
- With the removal of all soft sediment, sediment stabilization will be needed only in select areas where the native sediment is contaminated with NAPL so as to control NAPL mobility, and will provide additional partial treatment of this residual principal threat waste
- The native sediment will provide higher long-term reliability for supporting the cap than would placing the cap directly on the soft sediment.
- Removal of the soft sediment removes the high organic carbon content sediment from the canal that is the likely cause of ebullition, which is a significant NAPL transport mechanism, thereby minimizing the gas buildup under the cap that could lead to cap failure.
- If the soft sediment were left in place, stabilization of the soft sediment might be needed to provide the needed cap support along the entire canal, rather than only in areas of NAPL mobility in native sediment; widespread stabilization may alter groundwater flow and/or result in localized flooding and will require removal of swelled material produced during the stabilization process for disposal.
- Removal of the soft sediment will provide for deeper water depths to support current

navigation uses and will better protect the cap and prevent damages from barges.

- Removal of much of the soft sediment is necessary for implementation of the remedy and future maintenance of the remedy and canal infrastructure, such as bulkheads.
- Removal of the soft sediment will limit the risk of future contaminant transport caused by storm-related cap damage.
- Off-Site thermal desorption of the dredged NAPL-impacted sediments from RTA 1 and RTA 2 is irreversible and would eliminate the toxicity and mobility of the contaminants in the sediments.
- The utilization of the non-NAPL impacted stabilized sediments dredged from RTA 3 as off-Site landfill daily cover would provide a beneficial use for the sediments in a controlled, monitored environment.
- CSO retention tanks and the permitting or elimination of unpermitted pipes will prevent recontamination of the canal bottom.

The primary reason for the removal of the accumulated soft sediment is the removal and treatment of the principal threat waste represented by the grossly-contaminated accumulated sediments. Removal of the accumulated sediments will result in the removal of contaminants of concern in that stratum, thereby reducing the risk of recontamination in the event of a cap failure. In addition, the removal of the majority of the accumulated sediments is necessary for constructability reasons. Nearly half of the soft sediment must be removed to create sufficient depth for work boats that will implement the remedy (debris removal, installing/removing temporary sheet-pilings, dredging, disposal barges and cap placement), to maintain the cap and conduct future repairs to bulkheads and other infrastructure throughout the canal and to avoid propeller wash cap damage by existing commercial barge navigation in the lower two thirds of the canal.

Current and expected major development projects in the area will likely bring substantially more people to upland portions of the canal, adding to the number of people subject to the identified exposure pathways. NYC has previously identified such redevelopment pressures as justification for the timely implementation of a remedy. The EPA believes that the remedy can be initiated after approximately three years of design work, and would be implemented within six years of initiation.

The EPA has determined and NYSDEC agrees that the selected remedy is protective of human health and the environment, provides the greatest long-term effectiveness, is able to achieve ARARs more quickly than other alternatives and is cost-effective. The selected remedy utilizes permanent solutions, alternative treatment technologies and resource-recovery technologies to the maximum extent practicable. Furthermore, the selected remedy meets the statutory preference for the use of treatment as a principal element.

Description of the Selected Remedy

The selected remedy includes dredging of accumulated sediments, capping, off-Site thermal treatment of dredged NAPL-impacted sediments in the canal and existing turning basins, in-situ stabilization of native sediments with high levels of NAPL, excavation and restoration of a portion of the filled-in former 1st Street and a portion of the 5th Street turning basin beginning underneath the 3rd Avenue bridge, stabilization of sediments not impacted by NAPL and reuse off-Site, institutional controls and combined sewer overflow controls.[45] The specific components of the selected remedy are as follows:

Dredging, Capping and Treatment/Disposal

Because of the substantial amounts of debris in the canal and in order to facilitate the dredging of the contaminated sediment, debris removal from the canal bottom will be completed prior to the commencement of the dredging.

RTAs 1 and 2: Alternative 7 (dredge entire soft sediment column, targeted ISS of native sediment in areas with potential for active upward NAPL migration from the native sediment and cap with treatment, isolation and armor layers). The armor layer will consist of stone sized to meet the erosion forces of the flushing tunnel and navigation impacts. Sufficient sand will be placed on top of the armor layer to fill in the voids between the stones and to establish sufficient depth of soft sediment in order to facilitate benthic recolonization.

RTA 3: Alternative 5 (dredge entire soft sediment column and cap with treatment, isolation and armor layers).

Although the FS report used mechanical dredging as the representative method of sediment removal, flexibility will be allowed in the selection of the most appropriate dredging method during the remedial design.

The remedy will also include the excavation and restoration of approximately 475 feet of the filled-in former 1st Street turning basin and the excavation and restoration of the portion of the 5th Street turning basin beginning underneath the 3rd Avenue bridge and extending approximately 25 feet to the east, and the installation of a barrier or interception system at the eastern boundary of the excavation.[46] In addition to the

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[45] See Figure 6 for an illustration of the selected remedy.

[46] Analytical data obtained during the RI in the former 1st Street turning basin showed the existence of significant contamination in soil and groundwater above cleanup standards. As with other former turning basins along the canal, it is believed that contaminated sediments within the 1st Street turning basin were left in place when it was filled in. In addition, there

removal of buried contaminated sediments which are ongoing contaminant source to the canal, the excavation of the turning basins will mitigate the loss of surface water area as a result of new bulkhead encroachment into the canal.

Addressing the contaminated sediments will remove PAHs and the other collocated risk-driving chemicals (PCBs and metals).

Approximately 307,000 CY of contaminated sediment would be dredged from RTA 1 and RTA 2 and approximately 281,000 CY of contaminated sediment would be dredged from RTA 3.

The cap would need to be designed to tolerate future maintenance dredging operations in the canal for the removal of contaminated solids that might settle on top of it. The specific type of the treatment layer will be selected during the remedial design, taking into consideration technological advances. If practicable, the treatment layer component of the cap will be designed to have an adequate life expectancy for absorbing NAPL without replacement. For areas with high NAPL or impacted groundwater discharge, treatment gates will likely be needed where the treatment media can be removed without disturbing the cap outside these areas.

Pilot testing will be performed to assess whether or not large-scale ISS of NAPL-impacted native sediments will have an adverse impact on groundwater flow and to provide information for the design of mitigation measures if results indicate that adverse impacts are expected.

Following on-Site dewatering, the disposition of the dredged sediments will be as follows:

RTA 1: NAPL Impacted Areas, Option A—Off-Site thermal desorption/beneficial use; Non-NAPL Impacted Areas, Option D—Off-Site stabilization/beneficial use.

RTA 2: Option A—Off-Site thermal desorption/beneficial use (NAPL impacts throughout RTA 2).

RTA 3: Option D—Off-Site stabilization/beneficial use.

Periodic maintenance of the cap and long-term monitoring will be performed to insure

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are indications that the fill itself may have included waste materials. The filled-in 1st Street turning basin may also have been subject to later spills and dumping. The turning basin is hydraulically connected to the canal (with no bulkhead standing between the canal and the basin) such that contaminants within the basin are an on-going source of contamination. Finally, unlike the filled in portions of the other former turning basins (with the exception of the portion of the 4th Street turning basin located underneath the 3rd Avenue bridge), the 1st Street turning basin has no standing structures on or near it.

that the remedy continues to function effectively. The frequency and specific details of the maintenance and monitoring programs will be developed during the remedial design.

Source Controls

In order for the selected remedy in the canal to be effective, sources that could recontaminate the canal must be addressed. The upland sources of contamination, including the former MGP facilities, the CSO discharges in the upper part of the canal (particularly, outfalls RH-034 and OH-007), contaminated areas along the canal (including contaminated solids contributed by erosion from the surface and through bulkheads in disrepair) and the unpermitted pipes along the canal will be addressed prior to the commencement of, or in phased coordination with, the implementation of the selected remedy.

The former MGP facilities are being addressed by National Grid under NYSDEC oversight. Based upon the first NYSDEC-selected remedy at one of these sites and NYSDEC guidance for presumptive remedies at former MGP facilities, it is assumed that actions such as removal of mobile sources, construction of cut-off walls along the canal, and active recovery of NAPL near the cut-off walls for each of the former MGP facilities will be implemented to prevent the migration of contamination from the former MGP facilities into the canal. The cleanup of the former MGP facilities will be completed in accordance with schedules agreed upon between the EPA and NYSDEC (see Appendix VI). In the unlikely event that a timely and effective state-selected remedy is not implemented at a given former MGP facility, the EPA may implement actions pursuant to CERCLA to ensure the protectiveness of the selected remedy.

NYSDEC is currently overseeing work being performed by NYCDEP to reduce CSOs to the canal by approximately 34 percent in lower canal outfalls. Additional long-term CSO reductions are anticipated result from the NYCDEP sewer separation project for flood control purposes in a 96-acre area around Carroll Street, and from the NYCDEP green infrastructure effort (however, the stormwater component of the CSOs will still discharge to the canal after the sewer separation project). To significantly reduce overall contaminated solid discharges to the canal, the selected remedy includes the following CSO control measures for the upper reach of the canal:

- Construction of in-line sewage/stormwater retention tanks in the vicinity of outfalls RH-034 and OH-007. It is estimated that an 8-million gallon tank and a 4-million gallon tank will be required for outfalls RH-34 and OH-007, respectively. In addition, smaller CSOs in the vicinity of outfalls RH-034 and OH-007 will be connected to the retention tanks. The location and capacity of the retention tanks will be determined during the remedial design. The capacity of the retention tanks will need to accommodate the projected additional loads to the combined sewer system as a result of current and future residential development, as well as a result of periods of high rainfall, including future rainfall increases that may result from climate change. The retention tanks will also need to conform with the requirements of the CWA and work in concert with NYC's wastewater treatment plants.

- In the event that the permanent measures described above are not implemented in a timely manner, implementation of interim controls, such as temporary solids capture and removal, to mitigate sediment from the CSO discharges until the permanent measures have been implemented.[47]

Since the EPA is incorporating contaminated CSO solids control in the remedy selection, siting, remedial design and remedial action, pursuant to the authority of CERCLA, certain CERCLA statutory authorities including, but not limited to, permit exemption and environmental impact statement functional equivalency apply. The EPA seeks to coordinate the CERCLA and CWA processes to the extent practicable, to ensure that the selected CERCLA remedy is implemented in an effective and timely manner.

The selected remedy also includes the following measures for discharges from upland Sites (other than the former MGP facilities) and for unpermitted pipes along the canal:

- The EPA and NYSDEC will coordinate measures to control discharges from upland contaminated areas adjacent to the canal that have already been referred to NYSDEC for action. The schedule for these measures will conform to the schedules for the cleanup of the canal.
- Under the selected remedy, unpermitted pipe outfalls will be either controlled or eliminated.

It is anticipated that temporary sheet-piling will be required for dredging and capping in locations where the condition of bulkheads warrants additional structural support. At the former MGP facilities, bulkhead replacement will likely be a component of the remedy. Other areas where significant NAPL is found at shallow depths in the banks of the canal may also require bulkhead replacement in conjunction with construction of subsurface barrier walls. Elsewhere, it is anticipated that bulkhead replacement will not be part of the remedy, unless a substandard bulkhead is judged to present an impediment to construction or a threat to the integrity of the remedy. Based on the anticipated interception walls for the former MGP facility cleanups and the EPA's current negotiations with various property owners along the canal for bulkhead upgrades, the EPA anticipates that a significant portion of the existing bulkheads will be upgraded to a standard before dredging so as to not require temporary shoring.

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[47] It is unlikely that permanent measures to control the CSO discharges will be in place before the commencement of the remediation of the canal sediments.

A temporary on-Site facility may be necessary for dewatering, water treatment and/or transfer of dredged sediments. To the extent practicable, such operations may take place on barges.

Barges will be used for the transport of dredged sediment. The use of barges and other project-related watercraft (for sampling, support, etc.) during project operations will impact the use of other commercial and recreational water-based traffic on the canal. The EPA will establish plans to mitigate such impacts, though these impacts cannot be eliminated. Appropriate measures will be taken to limit noise, odors and other impacts associated with dredging and processing of the sediments. The EPA will continue to conduct community outreach to involve and inform the public and address public concerns during the design and implementation of the remedy.

Current and future high density residential redevelopment along the banks of the canal and within the sewershed shall adhere to NYC rules for sewer connections (Chapter 31 of Title 15 of the Rules of the City of New York) and shall be consistent with current NYCDEP criteria (NYCDEP, 2012) and guidelines to ensure that hazardous substances and solids from additional sewage loads do not compromise the effectiveness of the permanent CSO control measures by exceeding their design capacity. For example, redevelopment projects will need to take mitigation measures to prevent or offset additional sewer loadings. Separated stormwater outfalls will also require engineering controls to ensure that hazardous substances and solids are not discharged to the canal.

Pilot projects supported by federal and NYC grants are currently under way for the control of street runoff along the Gowanus Canal using green street ends.[48]

The environmental benefits of the selected remedy may be enhanced by consideration, during the design, of technologies and practices that are sustainable in accordance with the EPA Region 2's Clean and Green Energy Policy and NYSDEC's Green Remediation Policy.[49] This will include consideration of green remediation technologies and practices.

Because this remedy will result in contaminants remaining on-Site above levels that allow for unrestricted use and unlimited exposure, CERCLA requires that the Site be reviewed at least once every five years after the initiation of the action.

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[48] Green street ends employ vegetation planted between the end of the street and the canal to prevent particulate matter and oils from discharging into the canal. The EPA supports the expanded use of such green street ends.

[49] See http://epa.gov/region2/superfund/green_remediation and http://www.dec.ny.gov/docs/remediation_hudson_pdf/der31.pdf.

As was noted in the "Scope and Role of the Operable Unit" section, above, contaminated groundwater that is migrating to the canal from upland areas will be investigated and addressed as part of the upland source remediation, as necessary.

Institutional Controls

Institutional controls are part of the selected remedy. Because of the anticipated unacceptable human health risk associated with the consumption of PCB-contaminated fish and shellfish after the remedy is implemented, the EPA will rely on existing New York State Department of Health (NYSDOH) fish consumption advisories. This existing fish consumption advisory for Upper New York Bay identifies PCBs as one of the contaminants of concern.

Institutional controls will also be used to protect the integrity of the cap and in-situ stabilized material. NYC owns the canal (with the exception of certain turning basins) and is among the government entities that regulates bulkhead construction. The institutional controls will include restrictions to prevent damage to the cap, limitations on construction within the canal, including bulkhead maintenance and navigation dredging within the canal. Where cutoff walls and other upland cleanup measures are implemented under NYSDEC or EPA oversight, appropriate protective easements or other deed restrictions would be implemented.

Summary of the Estimated Remedy Costs

The estimated capital cost is $285,700,000. The estimated treatment and disposal cost is $216,000,000. The estimated annual operation, maintenance and monitoring cost (using the federal standard seven percent discount rate and a 30-year interval) is $4,400,000 (the cost includes O&M related to the in-line retention tanks). The estimated present-worth cost is $506,100,000. Tables 17 and 18 provide the basis for the cost estimates for the selected remedy.

It should be noted that these cost estimates are order-of-magnitude engineering cost estimates that are expected to be within +50 to -30 percent of the actual project cost. These cost estimates are based on the best available information regarding the anticipated scope of the selected remedy. Changes in the cost elements are likely to occur as a result of new information and data collected during the engineering design of the remedy.

Expected Outcomes of the Selected Remedy

The results of the HHRA indicate that the canal, if left unremediated, presents unacceptable risk levels for surface water/sediment contact and fish consumption. Human exposure to hazardous substances in surface water and surface sediment by recreating adults, adolescents and children may result in carcinogenic risks above the EPA's target risk range. These risks are associated primarily with exposure to carcinogenic PAHs in the surface water and the surface sediment. Human exposure to surface water and surface sediment from canal overflow may result in carcinogenic risks above the EPA's target risk range.

Despite a New York State Department of Health fish advisory covering the entire Gowanus Canal, posted warnings and public outreach efforts, the canal is regularly used for fishing, particularly subsistence fishing by communities surrounding the canal with environmental justice concerns. A NYCDEP survey of residents indicated that fishing is the number one canal use by area residents (NYCDEP 2008). The EPA believes that the selected remedy will reduce risks to these communities by reducing sources which contribute to these risks. However, because the selected remedy will not fully eliminate the need for fishing advisories due to contaminants from New York Harbor, the EPA intends to continue to coordinate fishing advisory education and awareness efforts with the appropriate governmental agencies.

The key results of the BERA indicated that PAHs, PCBs and metals in the sediment are toxic to benthic organisms. PAHs were detected in sediment at the highest concentrations relative to their ecological screening benchmarks and represent the greatest Site-related risk to the benthic community. PCBs and seven metals (barium, cadmium, copper, lead, mercury, nickel and silver) were also detected at concentrations above their ecological screening benchmarks and at concentrations significantly higher than those detected in reference area sediments and also represent a potential Site-related risk to the benthic community. PAHs were found to be a potential risk to aquatic herbivores (represented by the black duck) and mercury was found to be a potential risk to avian omnivores (represented by the heron).

The selected remedy will reduce the above-noted risks by reducing sources which contribute to these risks.

Implementation of the selected remedy will improve the surface water quality of the Gowanus Canal by controlling and substantially eliminating sheens and preventing contact of the surface water with the contaminated sediment.

It is estimated that it will require six years to construct the selected remedy and achieve the RAOs.

Source Control

The coordination of upland cleanups, CSO control and the sediment remedy is necessary for a comprehensive and sustainable remedy.

With respect to the former MGP facilities and other upland source areas, the EPA and NYSDEC are closely coordinating and the EPA is confident that these source areas can be appropriately addressed within the anticipated remedial approach and schedule for the canal remedy.

The EPA and NYSDEC have agreed to a coordinated schedule for the former MGP facilities and canal sediment cleanup efforts based on the anticipated timing of the dredging in the canal (which will commence at the head of the canal).

Because the upland contamination source areas which may impact groundwater have been referred to NYSDEC for investigation and remediation, if necessary, the EPA believes that a groundwater remedy is not required as part of this remedy. As a result, the selected remedy will not rely on dilution or dispersion of contaminated groundwater which is discharging into the canal.

CSO controls are needed to prevent the discharge and transport of contaminated CSO solids which are contaminated with comparatively low levels of hazardous substances associated with urban CSO discharges. These solids also serve to capture and concentrate other contaminants. Such controls will ensure the long-term viability of a restored canal.

As noted in the “Site Background” section, above, a number of planned sewer system improvements will decrease the overall CSO discharges to the canal. As a result, the EPA does not foresee a need for additional CSO controls in the lower reaches of the canal, where all of the reductions will occur from the CSO control improvements now underway. Although the WB/WS Plan will achieve an overall estimated 34 percent reduction of CSOs to the canal, discharges at outfall RH-034 at the head of the canal are estimated by NYCDEP to increase by 5 percent. Planned development in the area has the potential to increase sewage flows further, which can contribute to increases in CSO discharges.

The selected remedy will not be inconsistent with the LTCP and the CWA. The canal’s current uses, fishing and recreation, and the physical conditions which lead to frequent flooding with the potential to distribute sediments and sewage contaminated with hazardous substances, provide a further basis for implementing additional contaminated CSO solids controls. Significant residential and commercial redevelopment pressures that exist adjacent to the canal increase the need for sediment, upland and CSO remedy components. However, new construction would be subject to NYC building codes and stormwater rules, updated in 2012, which would help reduce the impacts of such development.

The EPA is committed to achieving cost savings by working closely with NYCDEP to accomplish an effective Superfund cleanup while also realizing CSO benefits necessary to effectively implement the remedy through synergies and economies of scale. NYCDEP will complete a full assessment of achieving CWA goals with submission of the LCTP pursuant to the CSO Consent Order. The LTCP, which is due to the State in June 2015, is expected to address, at a minimum, the EPA's remedial performance goals for further contaminated CSO solids control in the upper reach of the canal.

The design of this Superfund remedy will be informed by NYC's contemporaneous work in developing the LTCP. The EPA will work with NYC to advance both Superfund and CWA goals by allowing NYCDEP the opportunity to evaluate locating CSO control facilities in areas where upland Site-related source removal work might take place, creating a synergy between programs that potentially could save time in Site acquisition and permitting and save significant construction costs. While final selection of the CSO control locations will occur during the remedial design, the EPA has identified the western two-thirds of Thomas Greene Park and the NYC Department of Transportation storage lot located at 2nd Avenue and 5th Street (which is adjacent to the sewage system infrastructure) as potentially suitable locations due to such synergies. Both are owned by NYC, eliminating property acquisition costs. Both parcels are located near the major CSO outfalls, RH-034 and OH-007, which require control.

Thomas Greene Park is part of the former Fulton MGP State Superfund site. Gas storage tanks and other operations were located on the parcels from 1879 until approximately 1938. The coal tar at this parcel and surrounding parcels is a major ongoing source of NAPL to the canal. As an owner of the park, NYC may also be considered liable for its remediation. The eastern third of the park, where no contamination is present, was renovated in 2012-2013. National Grid's RI Report indicates that the western two-thirds of the park contains high levels of MGP contamination at depths of 8 feet or more below the ground surface. Although the RI found that contamination poses no risk to current users of the park, any future renovation project in this area that involved extensive excavation would encounter MGP contaminated soils, and in some places could encounter soils with free liquid tar. Although NYSDEC has not yet selected a remedy for the former Fulton MGP facility, such remedial work on or near the park would be expected to cause temporary disruptions to public use of the park. In the event that excavation of NAPL source areas is necessary at the park, co-location of a CSO retention tank would potentially reduce the costs of both the MGP facility cleanup and the tank construction. Based on other existing CSO retention tank projects, the EPA believes that CSO controls can be integrated into both of the potential tank locations while maintaining their current uses.

Since the EPA is incorporating contaminated CSO solids control in the remedy selection, siting, remedial design and remedial action pursuant to the authority of CERCLA, certain CERCLA statutory authorities including, but not limited to, permit exemption and environmental impact statement functional equivalency apply. The EPA seeks to coordinate the CERCLA and CWA processes to the extent practicable, to ensure that the selected CERCLA remedy is implemented in an effective and timely manner.

Remedy Considerations--Bulkhead Replacement

The condition and appearance of the bulkheads is a matter of significant concern to affected property owners and the public. The cost of temporary shoring of bulkheads is included in the selected remedy. Only limited permanent bulkhead replacement is expected to occur as a direct part of the remedy. Other bulkhead replacement is expected to occur as a result of remedial work conducted by National Grid under NYSDEC oversight, and through re-development projects such as by the Lightstone Group and other developers, as well as via upgrades by private property owners. To facilitate each of these approaches, the EPA has held talks with the USACE, NYSDEC and NYC about cooperative approaches to address bulkhead replacement and restoration along the canal. To the extent that bulkhead replacement occurs, appropriate consideration will be given to bulkhead preservation, aesthetics and the use of soft edges. The restoration effort at the two turning basins will mitigate the loss of surface water area as a result of new bulkhead encroachment into the canal.

The EPA is developing a standard approach which will ensure that the bulkheads are upgraded in a manner consistent with the canal remedy and the substantive requirements of NYSDEC and other agencies. This includes a standardized design, promoting coordination among interested owners to reduce their costs through economies of scale, and application of the CERCLA permit exemption. The EPA has met with several property owners who are interested in replacing their properties' bulkheads. It is expected that bulkhead replacement would be conducted under an appropriate settlement agreement with EPA oversight.

The EPA believes that there are a moderate number of locations where bulkheads are so deteriorated that they may fail when the temporary sheet-piling is removed after dredging. In such cases, the EPA intends to cooperate with NYC on inspection and enforcement of existing NYC bulkhead maintenance requirements and seek to reduce costs for affected bulkhead owners through use of the EPA's standardized approach for design and construction.

While the EPA will continue working with all of the stakeholders, it recognizes that it is not possible to insure that all of the bulkheads that need to be replaced will be replaced. Therefore, some substandard bulkheads may still remain. If the continued presence of such substandard bulkheads is judged to present a threat to the integrity of the canal remedy, available CERCLA authorities and/or resources will be used as necessary to ensure their repair.

STATUTORY DETERMINATIONS

Under CERCLA Section 121 and the NCP, the lead agency must select remedies that are protective of human health and the environment, comply with ARARs (unless a statutory waiver is justified), are cost-effective and utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. Section 121(b)(1) also establishes a preference for remedial actions which employ treatment to permanently and significantly reduce the volume, toxicity or mobility of the hazardous substances, pollutants or contaminants at a site.

For the reasons discussed below, the EPA has determined that the selected remedy meets these statutory requirements.

Protection of Human Health and the Environment

The selected remedy is expected to be protective of human health and the environment. It will meet the RAOs by removing contaminated soft sediment and capping with an active treatment layer to reduce and control the long-term risks associated with the native sediment. Placing this type of active cap over the contaminated native sediment remaining in the canal will significantly reduce exposure to human and ecological receptors, thereby reducing and controlling toxicity to benthic organisms and significantly reducing the risks to herbivorous birds. The cap will also prevent direct contact with NAPL and prevent NAPL migration to the surface water of the canal.[50] Contingent upon the results of bench- and pilot-scale studies to determine the most effective, implementable form of ISS within the canal, the implementation of ISS in targeted areas is expected to provide additional protectiveness against NAPL migration from the native sediment. In the event that an area of ISS is not fully effective, the multilayer cap will provide a redundant level of protectiveness.

Implementation of the selected remedy will improve the surface water quality of the Gowanus Canal by controlling and substantially eliminating sheens and preventing contact of the surface water with the contaminated sediment.

The upland former MGP facility source controls (and other upland source areas) that have been or are anticipated to be selected by NYSDEC are expected to be protective of human health and the environment by controlling the primary source areas and minimizing the migration pathways into the canal.

Implementation of source controls to address CSO-related releases of hazardous

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[50] If possible, the treatment layer would be designed to have an adequate life expectancy for absorbing NAPL without replacement. If this is not feasible, the remedy may include the replacement of portions of the treatment layer (replacing the treatment layer would also necessitate the removal and replacement of the overlying sand and armor layers).

substances associated with contaminated CSO solids, beyond those currently being implemented by NYCDEP, is necessary to provide overall protection of human health and the environment. In particular, such controls are necessary to protect the integrity of the canal remedy. By reducing discharges and accumulation of contaminated CSO solids, contaminant concentrations in surface sediments after remedy implementation are expected to meet the cleanup levels, which are considered protective of human health and the environment. Absent additional controls, solids contaminated with hazardous substances will continue to be discharged through the CSOs, affecting sediments in the canal. In addition, absent controls, such solids will continue to adsorb and concentrate any residual, uncontrolled hazardous substance releases, potentially leading to an excursion of the cleanup levels.

Compliance with ARARs and Other Environmental Criteria

A summary of the ARARs and "Other Criteria, Advisories or Guidance TBCs" that will be complied with during implementation of the selected remedy are presented in Table 19.

Cost-Effectiveness

A cost-effective remedy is one whose costs are proportional to its overall effectiveness (NCP §300.430(f)(1)(ii)(D)). Overall effectiveness is based on the evaluations of the following: long-term effectiveness and permanence; reduction in toxicity, mobility and volume through treatment, and short-term effectiveness. Based on the comparison of overall effectiveness (discussed above) to cost, the selected remedy meets the statutory requirement that Superfund remedies be cost-effective in that it is the least-costly action alternative and will achieve the remediation goals in the same amount of time in comparison to the more costly alternatives.

The relationship of the overall effectiveness of the selected remedy was determined to be proportional to its costs and, hence, this remedy represents a reasonable value for the money to be spent.

Each of the alternatives underwent a detailed cost analysis. In that analysis, capital and annual O&M costs were estimated and used to develop present-worth costs. In the present-worth cost analysis, annual O&M costs were calculated for the estimated life of the groundwater alternatives using a 7% discount rate and a 30-year interval.

The estimated capital cost is $285,700,000. The estimated treatment and disposal costs is $216,000,000. The estimated annual operation, maintenance and monitoring costs (using the federal standard 7% discount rate and a 30-year interval) is $4,400,000 (the cost includes O&M related to the in-line retention tanks). The estimated present-worth cost is $503,700,000.

Utilization of Permanent Solutions and Alternative Treatment Technologies to the Maximum Extent Practicable

The selected remedy provides the best balance of tradeoffs among the alternatives with respect to the balancing criteria set forth in NCP §300.430(f)(1)(i)(B), such that it represents the maximum extent to which permanent solutions and treatment technologies can be utilized in a practicable manner at the Site.

Dredging of the contaminated soft sediments, targeted ISS of native sediment in areas with potential for active upward NAPL migration from the native sediment and stabilization and thermal treatment of the dredged sediments prior to off-Site disposal provide a permanent remedy and employ treatment technologies to reduce the toxicity, mobility and volume of the contaminants.

Preference for Treatment as a Principal Element

Elevated contaminant concentrations and visual evidence of the presence of NAPL exist in the canal. The NAPL and contaminated sediments are mobile, at least when disturbed, have high concentrations of toxic compounds and present significant risks. Therefore, they are characterized as principal threat wastes. The EPA's statutory preference for treatment of principal threat materials has been considered as part of this remedy. The selected remedy addresses source materials constituting principal threats by thermally treating the NAPL-impacted sediments dredged from the upper and mid-reaches of the canal, and through the application of ISS to targeted NAPL areas of native sediment, thereby satisfying the preference for treatment.

Five-Year Review Requirements

Because this remedy will result in hazardous substances, pollutants or contaminants remaining on Site above levels that allow for unlimited use and unrestricted exposure to Site media, a statutory review will be conducted within five years after initiation of the remedial action. The five-year review will evaluate the results from monitoring programs established as part of this remedy and developed during the design to ensure that the remedy remains protective of human health and the environment.

DOCUMENTATION OF SIGNIFICANT CHANGES

During the public comment period, significant concerns were expressed about the option of stabilizating the lesser contaminated sediments dredged from RTA 3 and then placing them in an on-Site CDF. As a result of the concerns, this disposal option was eliminated from consideration. These sediments will be disposed of in the same manner as the RTA 1 non-NAPL impacted area sediments, utilizing Option D under which the sediments will be stabilized off-Site and beneficially reused to the extent possible.

Based upon suggestions made during the public comment period, the remedy will also include the excavation and restoration of the portion of the 5th Street turning basin beginning underneath the 3rd Avenue bridge and extending approximately 25 feet to the east and the installation of a barrier or interception system at the eastern boundary of the excavation. This parcel is a small part of an area that was previously referred by the EPA to NYSDEC for investigation as an additional upland source area.

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