Feasibility Study Report Addendum
Gowanus Canal
Brooklyn, New York

Prepared for

U.S. Environmental Protection Agency Region 2

December 2012

Prepared under contract
AES10 Task Order 072-RI-FS-02ZP
Architect and Engineering Services Contract
Contract No. 68-S7-04-01

Prepared by

CH2MHILL

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Feasibility Study Report Addendum

Contents

Forward

This document provides several additional evaluations in support of the Feasibility Study (FS) Report for the Gowanus Canal site prepared in December 2011. These evaluations were prepared to clarify the analyses presented in the FS report. Eight evaluations were completed focusing on refining the remedial goals and upland controls needed to prevent recontamination of the canal.

Impact of Combined Sewer Overflows on Gowanus Canal Sediments
Gowanus Canal, Brooklyn, New York

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Impact of Combined Sewer Overflows on Gowanus Canal Sediments

Contents

SECTION 1

Introduction

Combined sewer overflows (CSOs) to the Gowanus Canal adversely affect sediment quality and are contributing to unacceptable risks that must be addressed under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). The New York City Department of Environmental Protection (NYCDEP) is currently making sewer infrastructure and flushing tunnel repairs and upgrades which will partially reduce CSOs and will improve canal water circulation to address Clean Water Act requirements. However, additional CSO control measures will be necessary pursuant to CERCLA to prevent hazardous substance recontamination of the canal after the canal sediments are remediated.

This memorandum presents multiple lines of evidence related to CSO impacts on surface sediments in the canal. The Remedial Investigation (RI) and Feasibility Study (FS) for the Gowanus Canal were completed in 2011 (USEPA, 2011a and 2011b). This memorandum is an addendum to the FS report.

SECTION 2

Background

CSO and stormwater discharges are the only fresh surface water inflows to the Gowanus Canal. Combined sewers (i.e., sewers that receive both sewage and stormwater flows) serve 92 percent of the Gowanus Canal watershed, storm sewers serve 2 percent, and direct runoff drains 6 percent of the watershed (NYCDEP, 2008). In a modeling analysis performed to support the City-wide Long Term CSO Control Planning Project, NYCDEP concluded that direct overland runoff was insignificant in terms of magnitude and impact when compared to combined sewer and stormwater discharges, and nonpoint source loads were not included in their receiving water model (NYCDEP, 2007).

Ten CSO and three stormwater outfalls discharge approximately 355 million gallons of sewage and stormwater annually to the Gowanus Canal project area (Figure 1). Four outfalls contribute 95 percent of the annual discharge volume to the canal: RH-034 (upper reach), RH-035 and OH-007 (middle reach), and RH-031 (lower reach)[1]. The single largest contribution comes from RH-034 at the head of the canal. Collection system modeling performed by NYCDEP for the development of the Waterbody/Watershed (WB/WS) Facility Plan estimates that the current annual loading of total suspended solids (TSS) to the canal is approximately 259,000 lbs (222,000 lbs from CSOs and 37,000 lbs from stormwater discharges) (NYCDEP, 2007). NYCDEP describes the deposition and accumulation of CSO solids in the canal as follows (NYCDEP, 2008):

> "Gowanus Canal's limited capacity for exchange produces a stilling effect that allows suspended solid materials to settle to the bottom of the waterbody. Heavier solids and organic material discharged during wet weather from CSOs and stormwater have created a sediment mound near the head of the Canal. This mound becomes exposed at some points during low tide, when noxious odors are released from the anaerobic decay of the highly organic material. Similarly, lighter materials discharged during wet-weather or imported from the waters beyond the canal have settled throughout the Canal. These settled materials build up over time and need to be removed via periodic dredging to maintain navigable depths throughout the Canal."

and

> "Historical discharges by CSOs and stormwater have impacted almost the entire Canal bottom, which can be described as 'black mayonnaise' – a dark, black material containing large amounts of organic matter and a low percentage of solids. This is most predominately observed upstream of Hamilton Avenue."

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[1] The upper reach of the canal extends from the head to 3rd Street, the middle reach extends from 3rd Street to the Gowanus Expressway, and the lower reach extends from the Gowanus Expressway to 22nd Street, the south end of the study area.

Figure 2 shows a CSO discharge from RH-034 at the head of the canal and a portion of the exposed sediment mound. Solids from CSO discharges appear to be transported down the canal and deposited as the energy from the CSOs dissipates with increasing distance from the head of the canal. Currents from the flushing tunnel, when operating, may also facilitate transport.

Figure 3 shows the major sources of surface water and solids to the canal. In addition to CSOs, the other major source of solids to the Gowanus Canal is suspended sediment from Upper New York Bay transported into the canal through the flushing tunnel (when operating), and tidal advection-dispersion through Gowanus Bay at the south end of the project area. A portion of the suspended sediment in these inflows settles in the canal as the current velocities decrease to slack tide. The mass of solids delivered to the canal by each source was not quantified in the RI/FS. As discussed below in additional detail, multiple lines of evidence confirm that CSO solids contributions dominate the canal's upper reach.

The water quality model developed by NYCDEP for the WB/WS Plan included modeling of TSS, which was separated 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 results were used to quantify sedimentation in the canal under baseline and anticipated future conditions[2], although the relative contributions of outfall and background sources were not reported.

[2] Baseline conditions approximately represent current conditions with no flushing tunnel operations, and anticipated future conditions represent conditions after the Waterbody/Watershed Facility Plan is implemented. The baseline condition assumes estimated future sanitary flow for the year 2045, past wastewater treatment and pumping capacities, and sedimentation levels in sewers associated with reasonable maintenance.

SECTION 3

Combined Sewer Overflow Impacts

CSO impacts are most apparent in the upper reach of the canal because most of the outfalls are located within or near this reach. CSO solids discharged to the canal are subjected to a variety of physical, chemical and biological processes (e.g. advection, dispersion, chemical partitioning) before being incorporated into the sediment bed, resulting in some attenuation. However, physical and chemical characteristics of the newly deposited sediments indicate that CSO solids have a greater influence on the quality of shallow sediments in the upper reach of the canal than incoming suspended sediments from Upper New York Bay, and the results of the baseline ecological risk assessment performed for the RI showed adverse impacts to the benthic community in the canal relative to reference area locations in Gowanus Bay and Upper New York Bay. The lines of evidence presented below describe the impacts of CSOs on shallow sediments in the upper reach of the canal.

3.1 Sediment Accumulation Patterns

Figure 3 shows bathymetric differences (changes in the sediment surface elevation) in the Gowanus Canal between 2003 and 2010, as reported in the RI (USEPA, 2011a). The uncertainty associated with the comparison was determined to be +/-0.6 ft. The confidence in the estimates is greatest in the upper reach of the canal because of greater data density. Figure 4 shows the difference in the upper reach of the canal in more detail. Over this 7-year period, elevation differences were minor upstream of Sackett Street (approximately 500 feet downstream of the head of the canal), except for a small area of sediment accumulation near the flushing tunnel outlet. Additional accumulation in this area is limited by the shallow depth (i.e., sediment mound) and presumed equilibrium between deposition and scour by CSOs and possibly flushing tunnel currents. The accumulation near the flushing tunnel outlet may be due to infilling after the 1999 dredging event.

Between 2003 and 2010, approximately 2 to 3 feet of sediment accumulated between Sackett Street and Carroll Street (approximately 1,400 feet downstream of the head of the canal), and 1 to 2 feet accumulated between Carroll Street and 3rd Street (approximately 2,200 feet from the head of the canal). These results are consistent with bathymetric differences in different surveys performed by National Grid in 2005 and 2010.[3] The bathymetric differences between Sackett Street and 3rd Street translate to net sediment accumulation rates on the order of 1.5 to 5 in/year between 2003 and 2010.

[3] Bathymetric differences from 2003-2010 (USEPA) and 2005-2010 (National Grid) surveys were also consistent in the middle and lower reaches of the canal. The USEPA and National Grid surveys were performed by different surveyors.

Bathymetric differences between 2003 and 2010 showed an overall lack of sediment accumulation in the middle reach of the canal, even though two major CSO outfalls are located in this reach (Figure 3). The lack of accumulation in this reach is most likely due to frequent resuspension of solids by vessel propeller wash and redistribution by tidal and possibly flushing tunnel currents.

Radioisotope profiles of Cesium-137 and Lead-210 in sediment cores collected by National Grid in the upper reach of the canal (Figure 5) do not resemble the ideal profiles that would form in an undisturbed depositional environment such as continuous settlement of suspended sediments from the water column. The evidence of disruption in the core profiles is consistent with episodic deposition of solids from CSOs and/or other disturbances.

3.2 Physical and Chemical Characteristics of Recently Deposited Sediment

The influence of CSO discharges on sediment quality is greatest in the upper reach of the canal because (1) the outfall at head of canal (RH-034) has the single largest contribution to annual discharge; (2) the shallow sediments (0-2 feet depth interval) in upper reach are less influenced by impacts from former manufactured gas plants (MGPs) or historical industrial discharges, and (3) the sediments in the upper reach are less susceptible to resuspension by propeller wash from vessel traffic or from tidal forces.

The physical and chemical characteristics of the shallow sediments in the upper reach of the canal more closely resemble CSO solids than reference sediments from Gowanus Bay and Upper New York Bay. Shallow sediments (i.e., 0-2 foot depth interval) in the upper reach of the canal were deposited after the period of greatest industrial activity in the canal. Industrial use of the Gowanus Canal peaked in the 1930s, declined until the 1940s, stabilized at a lower level until the mid-1960s, and then declined from the mid-1960s to the present (Hunter Research, 2004). The upper reach of the canal was last dredged to a depth of 7 feet in 1975 (except for a small area near the flushing tunnel outlet that was dredged in 1999). The bathymetric differencing analysis described in Section 3.1 indicates that approximately 1 to 3 feet of sediment has been deposited since 2003. Therefore, these shallow sediments are expected to be more influenced by CSO discharges and less influenced by legacy contamination from historical industrial activity. The data sets used in the following analysis of the physical and chemical characteristics of the newly deposited sediments are summarized in Attachment 1.

3.2.1 Physical Characteristics

CSO solids have high organic carbon content (NYCDEP, 2008). Figure 6 shows the total organic carbon (TOC) content of surface sediment samples (0-0.5 foot interval) and sediment core samples (0-2 foot interval) collected from the upper reach of the canal in 2010, as well as the reference area surface sediment samples. The average TOC contents of the 0-0.5 foot and 0-2 foot sediment samples were 5.7 and 6.7 percent, respectively. These concentrations are statistically significantly higher than the average TOC content in surface sediments from the

Gowanus Bay and Upper New York Bay reference area, which was 2.8 percent.[4] The reference area average is consistent with average TOC values previously reported for Upper New York Harbor (2.5 +/- 0.5 percent[5]; USEPA, 1998).

Figure 7 shows the sand content in surface sediment samples (0-0.5 foot interval) and sediment core samples (0-2 foot interval) from the upper reach of the canal, as well as the reference area. The sand content decreases in a downstream direction from the head of the canal to 3rd Street (except at the flushing tunnel outlet), which is consistent with the conceptual model of heavier solids from the CSOs settling out closer to the head of the canal. Sand particles are typically not carried in suspension in estuarine waters.

3.2.2 Chemical Contamination

Wet weather CSO discharges contain chemical contaminants that accumulate in canal sediments to levels that pose a risk to ecological receptors. As noted in Section 2, some of the sediments that accumulate in the Gowanus Canal originate from Upper New York Bay and enter the canal through the flushing tunnel (when operating) and through Gowanus Bay at the south end of the canal. The relative influence of CSO solids and suspended sediments from Upper New York Bay on sediment quality in the upper reach of the canal was evaluated by comparing contaminant concentrations in the following matrices:

- CSO solids from the four outfalls contributing 95 percent of the annual discharge (estimated concentrations)
- CSO sediments collected from the sewers for three of the outfalls that contribute 95 percent of the annual discharge[6]
- Shallow sediments in the upper reach of the canal (0-0.5 and 0-2 foot depth intervals)
- Surface sediments in the Gowanus Bay and Upper New York Bay reference area (0-0.5 foot interval)
- Suspended sediments from the Gowanus Bay and Upper New York Bay reference area (estimated concentrations)

As described in the FS Report, estimated chemical concentrations on CSO solids were calculated using wet weather CSO whole water sample data. These calculations were performed using the assumption that all of the contamination was adsorbed to the suspended solids in the water samples. This is a reasonable assumption because stormwater is the predominant component of CSOs, and previous studies have shown that PAHs and metals in urban and stormwater runoff are strongly associated with the particulate phase (Grant et al., 2003; Engstrom, 2004; Hwang and Foster, 2005; Brown et al., 2011). Stormwater sample analyses reported in these studies indicated that 87 percent to greater than 90 percent of the PAHs were associated with the particulate phase. The Gowanus Canal RI data indicate that about 92 percent of the lead and 76

[4] All statistical tests reported in this memorandum were performed at a 0.05 significance level.
[5] 90 percent confidence interval
[6] A CSO sediment sample could not be collected from the RH-034 sewer due to the high velocity of the flow.

percent of the copper in wet weather CSO water samples from the four major outfalls was in the particulate phase.[7]

The wet weather CSO water samples represent solids and contaminants actually discharged to the canal. The CSO sediment data are samples of residual sediment collected from the sewers. No field investigations or analyses were performed to determine if and/or how much residual sediments in sewers are mobilized during wet weather and discharged by CSOs.

The Gowanus Bay and Upper New York Bay reference area suspended sediment concentrations were estimated using reference area surface water sample data collected during wet and dry weather conditions, and assuming that all of the contamination was adsorbed to the suspended sediments in the surface water samples. This assumption provides a conservative estimate of the contaminants transported into the canal on suspended sediments from Upper New York Bay.

Figures 8a through 8c summarize the data for total PAHs, lead, and copper, respectively. The concentration ranges are shown on a log scale. The preliminary remediation goals (PRGs) for the contaminants are also shown. The relative concentration distributions for these three contaminants are similar: concentrations in CSO solids, CSO sediments, surface sediments (0-0.5 feet), and shallow sediments (0-2 feet) in the upper reach of the canal are similar, whereas concentrations in reference area surface sediment samples and reference area suspended solids are similar to each other and substantially lower[8], with the exception of PAH concentrations in CSO sediments (which are lower) and in some of the 0-2 foot samples (which are higher than the surface sediment concentrations). Total PAH, lead and copper concentrations in sediment samples from the 0-0.5 and 0-2 foot intervals are significantly higher than concentrations in reference area sediment. These relationships indicate that solids from CSO discharges have a greater influence on surface sediment quality in the upper reach of the Gowanus Canal than the suspended sediment contributions from Gowanus Bay and Upper New York Bay.

Because the relative contributions of individual PAHs contributing to the total PAH concentration can vary from sample to sample, the concentrations of the four individual PAHs most frequently in surface sediments and CSO solids were also compared. Figures 9a through 9d show the concentrations of acenaphthene, benzo(b)fluoranthene, benzo(k)fluoranthene, and pheneanthrene in CSO solids, surface sediments from the upper reach of the canal, and reference sediments. Relative concentrations of the individual PAHs show the same pattern as total PAHs: concentrations in CSO solids and surface sediments from the upper reach of the canal are similar to each other and are substantially higher than reference area concentrations.

[7] In the RI, only whole water CSO water samples were analyzed for PAHs. Whole water and filtered samples were analyzed for metals; however, the samples were collected successively rather than as splits from the sample bulk sample.

[8] Reference area suspended solids concentrations could not be estimated for copper because of high detection limits in surface water samples.

The surface sediment concentrations for all four PAHs in the upper reach of the canal are significantly higher than concentrations in reference area samples.

Figures 10a through 10c show longitudinal profiles of total PAH, lead, and copper in surface sediment samples and average concentrations on CSO solids from each outfall along the length of the canal. The average concentrations in the reference area are also shown. The surface sediment and CSO solids concentration trends are variable, but concentrations are consistently higher than reference area concentrations along the entire length of the canal.

3.3 Geochemical Evaluation

Geochemical analysis based on metal/iron or metal/aluminum ratios in sediment can be used to differentiate background metals concentrations from localized releases (Daskalakis and O'Connor, 1995; U.S. Navy, 2003; Schropp and Windom, 1988) and estimate the degree of metals enrichment in contaminated sediments (Velinsky and Ashley, 2001). *Background* refers to constituents or locations that are not influenced by the releases from a site, and is usually described as naturally occurring or anthropogenic (USEPA, 2002). The Gowanus Bay and Upper New York Bay reference area is considered "background" for this analysis. This approach is based on the geochemical association between metal contaminants and a non-contaminant normalizing parameter such as aluminum or iron. The following conditions should be met for this analysis (U.S. Navy, 2003):

- A significant relationship (correlation) exists between the metal of concern and the normalizing parameter in the background samples
- The normalizing parameter is insensitive to anthropogenic inputs (in this case, concentrations of the normalizing parameter should not be significantly different in Gowanus Canal and reference area sediments)
- The normalizing parameter is stable (non-reactive) under the geochemical conditions in site sediments.

The data used in the geochemical evaluation for the Gowanus Canal are provided in Attachment 2. Statistically significant relationships exist between lead/aluminum (Pb/Al) and lead/iron (Pb/Fe) in reference area samples after the sample from location 326 is removed from the regression analysis (Figure 11). Location 326 was removed from the analysis because it is clearly an outlier, with a lead concentration that is 2.5 times higher than the other reference are samples. The coefficients of determination (R^2) for the Pb/Al and Pb/Fe relationships were 0.87 and 0.90, respectively. These results indicate that background relationships for lead can be established. Copper/aluminum (Cu/Al) and copper/iron (Cu/Fe) relationships in reference area samples were also statistically significant after location 326 was removed from the data set; however, the coefficients of determination were lower (R^2 = 0.60 and 0.55, respectively). Therefore, Cu/Al and Cu/Fe ratios were not evaluated further.

Iron and aluminum can both be used as normalizers for the Gowanus Canal. The concentrations of iron and aluminum are not significantly different in surface sediment samples from the upper reach of the canal and the reference area. Aluminum is less reactive than iron in anoxic conditions and tends to be the more appropriate normalizer for east coast sediments (Daskalis and O'Connor, 1995). However, a covariate plot of iron and aluminum (Figure 12) indicates that neither normalizer is enriched in surface sediments from the canal or reference area, or in CSO solids from the four major outfalls with the exception of iron in two CSO samples and the sediment sample from location 308A (average of field duplicates). These samples were excluded from further analysis due to evidence of this iron enrichment.

Relationships between Pb and Al and Pb and Fe were evaluated for surface sediments from the upper reach of the canal and the reference area, and CSO solids from the four major outfalls (Figure 13). Visual inspection of these plots indicates that surface sediments in the upper reach of the canal are enriched in lead relative to reference levels, and that CSO solids from the four major outfalls are enriched in lead relative to both reference and the majority of the canal sediments.

A lead enrichment factor (EF) can be calculated by dividing the Pb/Al and Pb/Fe ratios for each canal sample by the average reference area ratios:

$$EF = \frac{\left(\frac{Pb}{N}\right)_{site}}{\left(\frac{Pb}{N}\right)_{ref}}$$

Where

EF = enrichment factor

$\left(\frac{Pb}{N}\right)_{site}$ = average ratio of lead to the normalizer for the canal samples, and

$\left(\frac{Pb}{N}\right)_{ref}$ = average ratio of lead to the normalier for the reference samples.

The data sets and calculations are provided in Attachment 2. The average lead enrichment factors for surface sediments in the upper reach of the Gowanus Canal (excluding location 308A, which was excluded due to iron enrichment) are summarized in Table 2. These results indicate that surface sediments in the upper reach of the canal are enriched in lead by a factor of about 3.7 above regional background (reference) levels.

TABLE 2
Lead Enrichment Factors for Upper Canal Surface Sediments

Normalizer	Average Lead Enrichment Factor
Aluminum	3.7
Iron	3.8

3.4 Bacteriological Contamination

National Grid collected sediment samples for pathogen analysis during sampling events in 2010 and 2011 (GEI, 2011a and 2011b). Pathogens were detected in every sample analyzed, including fecal coliform, *Clostridium perfringens, Enterococci,* and *E. coli.* Figures 14a and 14b show the distribution of fecal coliform in surface sediments in the upper and lower reaches of the canal. The highest fecal coliform concentrations were detected in the upper reach of the canal, where CSO impacts are most severe. High concentrations were also found in the lower canal near CSO outfall RH-031.

3.5 PAH Composition

Compositional differences in PAH mixtures can be used to differentiate the sources of the PAHs (Boehm, 2006; Costa and Sauer, 2005). Petrogenic PAHs are produced through the slow, long-term moderate-temperature formation of fossil fuels (i.e., petroleum products). Pyrogenic PAHs are produced through rapid, high-temperature incomplete combustion of organic material or fossil fuels (e.g., soot, coal tar). A variety of potential PAH sources exist along the Gowanus Canal, including urban runoff, former MGPs, bulk petroleum storage, and coal yards. Urban runoff contains a mixture of PAHs of both petrogenic and pyrogenic origin (e.g., spilled petroleum, dust, soot, fuel and wood combustion products, degraded asphalt).

A subset of sediment samples collected by National Grid in 2005 were analyzed for an expanded list of PAHs and other hydrocarbons to facilitate identification of the likely origins of PAHs in Gowanus Canal sediments (NewFields, 2007). Figure 15 presents high resolution hydrocarbon fingerprints for shallow sediment samples in the upper reach of the canal (0-1.5 ft interval) and for native sediment samples. The NewFields analysis concludes that the shallow sediments are dominated by an unresolved complex mixture (UCM) with multiple sources of PAHs. The UCM fingerprint is consistent with impacts from urban runoff in CSO discharges. The fingerprints of the native sediment samples shown in Figure 14 are characteristic of coal tar.

SECTION 4

Summary

Multiple lines of evidence indicate that CSOs to the Gowanus Canal adversely affect canal sediment quality and are contributing to unacceptable risks that must be addressed under CERCLA. CSO impacts are most apparent in the upper reach of the canal because most of the outfalls are located within or near this reach. The influence of CSO discharges on sediment quality is greatest in the upper reach because (1) the outfall at head of canal (RH-034) has the single largest contribution to annual discharge; (2) the shallow sediments are less influenced by impacts from former MGPs or historical industrial discharges, and (3) the sediments in the upper reach are less susceptible to resuspension by propeller wash from vessel traffic or from tidal forces.

Shallow sediments (i.e., 0-2 foot depth interval) in the upper reach were deposited after the period of greatest industrial activity in the canal. The following lines of evidence indicate that CSOs have a substantial negative impact on surface sediments in the upper reach of the canal:

- Bathymetric differences over a 5 to 7 year time frame measured independently by USEPA and National Grid indicate that sediment accumulation is greatest in the upper reach of the canal. The bathymetric differences translate to net sediment accumulation rates on the order of 1.5 to 5 in/year.
- Radioisotope profiles of Cesium-137 and Lead-210 in sediment cores from the upper reach of the canal show evidence of disturbance consistent with episodic deposition of solids from CSOs rather than the ideal profiles characteristic of continuous settlement of suspended sediments from the water column.
- CSO solids have high organic carbon content (NYCDEP, 2008). Average TOC concentrations in shallow sediments in the upper reach of the canal are approximately two times higher than TOC concentrations in sediments from Gowanus Bay and Upper New York Bay.
- Concentrations of total PAHs, lead and copper on CSO solids, surface sediments (0-0.5 feet), and shallow sediments (0-2 feet) in the upper reach of the canal are similar, whereas concentrations in reference area surface sediment samples and suspended solids are similar to each other and substantially lower. Total PAH, lead and copper concentrations in surface sediment (0-0.5 foot interval) and shallow sediment (0-2 foot interval) are significantly higher than concentrations in reference area sediment. These relationships indicate that solids from CSO discharges have a greater influence on surface sediment quality in the upper reach of the Gowanus Canal than the suspended sediment contributions from Gowanus Bay and Upper New York Bay.
- Relative concentrations of the four most frequently detected individual PAHs (acenaphthene, benzo(b)fluoranthene, benzo(k)fluoranthene, and pheneanthrene) show the same pattern as total PAHs: concentrations in CSO solids and surface sediments from the upper reach of the canal are similar and are substantially higher than reference area

concentrations. The concentrations for all four PAHs in surface sediments in the upper reach of the canal are significantly higher than concentrations in the reference area.

- Longitudinal profiles of total PAH, lead, and copper concentrations in surface sediment samples and average concentrations on CSO solids from each outfall along the length of the canal are variable, but concentrations are consistently higher than reference concentrations along the entire length of the canal.
- A geochemical evaluation based on the analysis of Pb/Al and Pb/Fe ratios in surface sediments from the upper canal and reference area indicate that the canal sediments are enriched in lead by a factor of about 3.7 above regional background (reference) levels.
- Pathogens have been detected in surface sediments collected throughout the Gowanus Canal. Fecal coliform concentrations are highest in the upper reach of the canal adjacent to CSO outfalls.
- High resolution hydrocarbon fingerprints of shallow sediment samples from the upper reach of the canal are characterized by an UCM fingerprint consistent with urban runoff.

These data-based lines of evidence are consistent with descriptions of CSO impacts described in NYCDEP technical reports (NYCDEP, 2007 and 2008).

The relative sediment source contributions in the upper canal have been prioritized qualitatively. Establishing a precise baseline is not feasible because CSO discharge events vary greatly in terms of the size, frequency and intensity. In addition, sewer system changes will occur as a result of current and planned upgrades (e.g., flushing tunnel and localized sewer separation) and major redevelopment projects (e.g., Whole Foods Market, Lightstone Group development plans and Barclay Arena). Relative sediment contributions, however, are likely to remain unchanged in the upper canal. As a result, further study would delay rather than contribute to remedial progress. Additional sampling and modeling will be performed during remedial design to reduce uncertainty and ensure remedy effectiveness.

SECTION 5

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ATTACHMENT 1

Data sets used in this technical memorandum are summarized in the table below.

Sample Type	Parameters	Description	Number of Data Points
Upper reach – surface sediment (0-0.5 feet)	TOC Lead Copper Total PAHs Iron Aluminum	Samples collected for the Gowanus Canal RI; field duplicate concentrations averaged	10
Upper reach – sediment core (0-2 feet)	TOC Lead Copper Total PAHs	Samples collected for RI; field duplicate concentrations averaged	40
Reference area surface sediment (0-0.5 feet)	TOC Lead Copper Total PAHs Iron Aluminum	Samples collected for RI; field duplicate concentrations averaged	10
CSO solids	Lead Copper Total PAHs Iron Aluminum	Wet weather CSO water samples collected for RI from the four major outfalls (RH-034, RH-035, OH-007 and RH-031); solids concentrations estimated using whole water contaminant and TSS data	7
CSO sediment	Lead Copper Total PAHs	Residual sediment samples collected from RH-035, OH-007 and RH-031 sewers for the RI; field duplicate concentrations averaged	3
Reference area suspended sediments	Lead Total PAHs	Wet and dry weather surface water samples collected for RI; solids concentrations estimated using whole water contaminant and TSS data	Lead – 20 Total PAHs - 22

TOC – total organic carbon, PAH – polycyclic aromatic hydrocarbon, HPAH – high molecular weight PAH, RI – remedial investigation, CSO – combined sewer overflow, TSS – total suspended solids

Non-detected PAHs included as 0 in sums of total PAH and HPAH

ATTACHMENT 2

Lead-Iron and Lead-Aluminum Ratios in Surface Sediments

Gowanus Canal

Brooklyn, New York

METHOD:

Calculated Pb/Fe and Pb/Al ratio for each sample

Excluded reference station 326 due to lead enrichment and canal station 308A due to iron enrichment

Calculated average Pb/Fe and Pb/Al ratios for canal and reference

Calculated enrichment factor for canal (average canal ratio / average reference ratio)

Station	Sample ID		Aluminum	Iron	Lead	Pb/Fe	Pb/Al
Upper Reach - Gowanus Canal							
301	GC-SD301-0.0-0.5	N	5,710	12,400	201	0.0162	0.0352
302	GC-SD302-0.0-0.5	N	13,600	25,600	239	0.0093	0.0176
303	GC-SD303-0.0-0.5	N	16,200	29,600	201	0.0068	0.0124
304	GC-SD304-0.0-0.5	N	16,100	29,500	247	0.0084	0.0153
305	GC-SD305-0.0-0.5	N	16,300	28,000	230	0.0082	0.0141
306	GC-SD306-0.0-0.5	N	16,700	29,300	238	0.0081	0.0143
307A	GC-SD307A-0.0-0.5	N	15,900	27,700	776	0.0280	0.0488
307B	GC-SD307B-0.0-0.5	N	18,200	28,800	216	0.0075	0.0119
308A	GC-SD308A-0.0-0.5	N	4,760	53,200	4,220	Excluded	
308A	D-062310-01	FD	4,870	87,000	2,710		
308B	GC-SD308B-0.0-0.5	N	13,500	27,100	312	0.0115	0.0231
Average						0.0116	0.0214
Reference Area							
326	GC-SD326-0.0-0.5	N	17,900	34,400	244	Excluded	
327	GC-SD327-0.0-0.5	N	19,400	35,500	95.5	0.0027	0.0049
328	GC-SD328-0.0-0.5	N	9,890	18,200	61.7	0.0034	0.0062
329	GC-SD329-0.0-0.5	N	15,500	31,600	90	0.0028	0.0058
330	GC-SD330-0.0-0.5	N	18,000	33,300	93.5	0.0028	0.0052
331	GC-SD331-0.0-0.5	N	12,800	26,600	93.1	0.0035	0.0073
332	GC-SD332-0.0-0.5	N	8,330	15,400	53.4	0.0035	0.0064
333	GC-SD333-0.0-0.5	N	16,800	29,900	87.5	0.0029	0.0052
334	GC-SD334-0.0-0.5	N	4,750	10,700	25.5	0.0024	0.0054
335	GC-SD335-0.0-0.5	N	15,300	26,800	86.3	0.0032	0.0056
Average						0.0030	0.0058
Enrichment Factor						3.8	3.7

SECTION 1
Introduction

Combined sewer overflows (CSOs) to the Gowanus Canal adversely affect sediment quality and are contributing to unacceptable risks that must be addressed under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). The New York City Department of Environmental Protection (NYCDEP) is currently making sewer infrastructure and flushing tunnel repairs and upgrades which will partially reduce CSOs and will improve canal water circulation to address Clean Water Act requirements. However, additional CSO control measures will be necessary pursuant to CERCLA to prevent hazardous substance recontamination of the canal after the canal sediments are remediated.

This memorandum presents multiple lines of evidence related to CSO impacts on surface sediments in the canal. The Remedial Investigation (RI) and Feasibility Study (FS) for the Gowanus Canal were completed in 2011 (USEPA, 2011a and 2011b). This memorandum is an addendum to the FS report.

SECTION 2

Background

CSO and stormwater discharges are the only fresh surface water inflows to the Gowanus Canal. Combined sewers (i.e., sewers that receive both sewage and stormwater flows) serve 92 percent of the Gowanus Canal watershed, storm sewers serve 2 percent, and direct runoff drains 6 percent of the watershed (NYCDEP, 2008). In a modeling analysis performed to support the City-wide Long Term CSO Control Planning Project, NYCDEP concluded that direct overland runoff was insignificant in terms of magnitude and impact when compared to combined sewer and stormwater discharges, and nonpoint source loads were not included in their receiving water model (NYCDEP, 2007).

Ten CSO and three stormwater outfalls discharge approximately 355 million gallons of sewage and stormwater annually to the Gowanus Canal project area (Figure 1). Four outfalls contribute 95 percent of the annual discharge volume to the canal: RH-034 (upper reach), RH-035 and OH-007 (middle reach), and RH-031 (lower reach)[1]. The single largest contribution comes from RH-034 at the head of the canal. Collection system modeling performed by NYCDEP for the development of the Waterbody/Watershed (WB/WS) Facility Plan estimates that the current annual loading of total suspended solids (TSS) to the canal is approximately 259,000 lbs (222,000 lbs from CSOs and 37,000 lbs from stormwater discharges) (NYCDEP, 2007). NYCDEP describes the deposition and accumulation of CSO solids in the canal as follows (NYCDEP, 2008):

> "Gowanus Canal's limited capacity for exchange produces a stilling effect that allows suspended solid materials to settle to the bottom of the waterbody. Heavier solids and organic material discharged during wet weather from CSOs and stormwater have created a sediment mound near the head of the Canal. This mound becomes exposed at some points during low tide, when noxious odors are released from the anaerobic decay of the highly organic material. Similarly, lighter materials discharged during wet-weather or imported from the waters beyond the canal have settled throughout the Canal. These settled materials build up over time and need to be removed via periodic dredging to maintain navigable depths throughout the Canal."

and

> "Historical discharges by CSOs and stormwater have impacted almost the entire Canal bottom, which can be described as 'black mayonnaise' – a dark, black material containing large amounts of organic matter and a low percentage of solids. This is most predominately observed upstream of Hamilton Avenue."

[1] The upper reach of the canal extends from the head to 3rd Street, the middle reach extends from 3rd Street to the Gowanus Expressway, and the lower reach extends from the Gowanus Expressway to 22nd Street, the south end of the study area.

Figure 2 shows a CSO discharge from RH-034 at the head of the canal and a portion of the exposed sediment mound. Solids from CSO discharges appear to be transported down the canal and deposited as the energy from the CSOs dissipates with increasing distance from the head of the canal. Currents from the flushing tunnel, when operating, may also facilitate transport.

Figure 3 shows the major sources of surface water and solids to the canal. In addition to CSOs, the other major source of solids to the Gowanus Canal is suspended sediment from Upper New York Bay transported into the canal through the flushing tunnel (when operating), and tidal advection-dispersion through Gowanus Bay at the south end of the project area. A portion of the suspended sediment in these inflows settles in the canal as the current velocities decrease to slack tide. The mass of solids delivered to the canal by each source was not quantified in the RI/FS. As discussed below in additional detail, multiple lines of evidence confirm that CSO solids contributions dominate the canal's upper reach.

The water quality model developed by NYCDEP for the WB/WS Plan included modeling of TSS, which was separated 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 results were used to quantify sedimentation in the canal under baseline and anticipated future conditions[2], although the relative contributions of outfall and background sources were not reported.

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[2] Baseline conditions approximately represent current conditions with no flushing tunnel operations, and anticipated future conditions represent conditions after the Waterbody/Watershed Facility Plan is implemented. The baseline condition assumes estimated future sanitary flow for the year 2045, past wastewater treatment and pumping capacities, and sedimentation levels in sewers associated with reasonable maintenance.

SECTION 3

Combined Sewer Overflow Impacts

CSO impacts are most apparent in the upper reach of the canal because most of the outfalls are located within or near this reach. CSO solids discharged to the canal are subjected to a variety of physical, chemical and biological processes (e.g. advection, dispersion, chemical partitioning) before being incorporated into the sediment bed, resulting in some attenuation. However, physical and chemical characteristics of the newly deposited sediments indicate that CSO solids have a greater influence on the quality of shallow sediments in the upper reach of the canal than incoming suspended sediments from Upper New York Bay, and the results of the baseline ecological risk assessment performed for the RI showed adverse impacts to the benthic community in the canal relative to reference area locations in Gowanus Bay and Upper New York Bay. The lines of evidence presented below describe the impacts of CSOs on shallow sediments in the upper reach of the canal.

3.1 Sediment Accumulation Patterns

Figure 3 shows bathymetric differences (changes in the sediment surface elevation) in the Gowanus Canal between 2003 and 2010, as reported in the RI (USEPA, 2011a). The uncertainty associated with the comparison was determined to be +/-0.6 ft. The confidence in the estimates is greatest in the upper reach of the canal because of greater data density. Figure 4 shows the difference in the upper reach of the canal in more detail. Over this 7-year period, elevation differences were minor upstream of Sackett Street (approximately 500 feet downstream of the head of the canal), except for a small area of sediment accumulation near the flushing tunnel outlet. Additional accumulation in this area is limited by the shallow depth (i.e., sediment mound) and presumed equilibrium between deposition and scour by CSOs and possibly flushing tunnel currents. The accumulation near the flushing tunnel outlet may be due to infilling after the 1999 dredging event.

Between 2003 and 2010, approximately 2 to 3 feet of sediment accumulated between Sackett Street and Carroll Street (approximately 1,400 feet downstream of the head of the canal), and 1 to 2 feet accumulated between Carroll Street and 3rd Street (approximately 2,200 feet from the head of the canal). These results are consistent with bathymetric differences in different surveys performed by National Grid in 2005 and 2010.[3] The bathymetric differences between Sackett Street and 3rd Street translate to net sediment accumulation rates on the order of 1.5 to 5 in/year between 2003 and 2010.

[3] Bathymetric differences from 2003-2010 (USEPA) and 2005-2010 (National Grid) surveys were also consistent in the middle and lower reaches of the canal. The USEPA and National Grid surveys were performed by different surveyors.

Bathymetric differences between 2003 and 2010 showed an overall lack of sediment accumulation in the middle reach of the canal, even though two major CSO outfalls are located in this reach (Figure 3). The lack of accumulation in this reach is most likely due to frequent resuspension of solids by vessel propeller wash and redistribution by tidal and possibly flushing tunnel currents.

Radioisotope profiles of Cesium-137 and Lead-210 in sediment cores collected by National Grid in the upper reach of the canal (Figure 5) do not resemble the ideal profiles that would form in an undisturbed depositional environment such as continuous settlement of suspended sediments from the water column. The evidence of disruption in the core profiles is consistent with episodic deposition of solids from CSOs and/or other disturbances.

3.2 Physical and Chemical Characteristics of Recently Deposited Sediment

The influence of CSO discharges on sediment quality is greatest in the upper reach of the canal because (1) the outfall at head of canal (RH-034) has the single largest contribution to annual discharge; (2) the shallow sediments (0-2 feet depth interval) in upper reach are less influenced by impacts from former manufactured gas plants (MGPs) or historical industrial discharges, and (3) the sediments in the upper reach are less susceptible to resuspension by propeller wash from vessel traffic or from tidal forces.

The physical and chemical characteristics of the shallow sediments in the upper reach of the canal more closely resemble CSO solids than reference sediments from Gowanus Bay and Upper New York Bay. Shallow sediments (i.e., 0-2 foot depth interval) in the upper reach of the canal were deposited after the period of greatest industrial activity in the canal. Industrial use of the Gowanus Canal peaked in the 1930s, declined until the 1940s, stabilized at a lower level until the mid-1960s, and then declined from the mid-1960s to the present (Hunter Research, 2004). The upper reach of the canal was last dredged to a depth of 7 feet in 1975 (except for a small area near the flushing tunnel outlet that was dredged in 1999). The bathymetric differencing analysis described in Section 3.1 indicates that approximately 1 to 3 feet of sediment has been deposited since 2003. Therefore, these shallow sediments are expected to be more influenced by CSO discharges and less influenced by legacy contamination from historical industrial activity. The data sets used in the following analysis of the physical and chemical characteristics of the newly deposited sediments are summarized in Attachment 1.

3.2.1 Physical Characteristics

CSO solids have high organic carbon content (NYCDEP, 2008). Figure 6 shows the total organic carbon (TOC) content of surface sediment samples (0-0.5 foot interval) and sediment core samples (0-2 foot interval) collected from the upper reach of the canal in 2010, as well as the reference area surface sediment samples. The average TOC contents of the 0-0.5 foot and 0-2 foot sediment samples were 5.7 and 6.7 percent, respectively. These concentrations are statistically significantly higher than the average TOC content in surface sediments from the

Gowanus Bay and Upper New York Bay reference area, which was 2.8 percent.[4] The reference area average is consistent with average TOC values previously reported for Upper New York Harbor (2.5 +/- 0.5 percent[5]; USEPA, 1998).

Figure 7 shows the sand content in surface sediment samples (0-0.5 foot interval) and sediment core samples (0-2 foot interval) from the upper reach of the canal, as well as the reference area. The sand content decreases in a downstream direction from the head of the canal to 3rd Street (except at the flushing tunnel outlet), which is consistent with the conceptual model of heavier solids from the CSOs settling out closer to the head of the canal. Sand particles are typically not carried in suspension in estuarine waters.

3.2.2 Chemical Contamination

Wet weather CSO discharges contain chemical contaminants that accumulate in canal sediments to levels that pose a risk to ecological receptors. As noted in Section 2, some of the sediments that accumulate in the Gowanus Canal originate from Upper New York Bay and enter the canal through the flushing tunnel (when operating) and through Gowanus Bay at the south end of the canal. The relative influence of CSO solids and suspended sediments from Upper New York Bay on sediment quality in the upper reach of the canal was evaluated by comparing contaminant concentrations in the following matrices:

- CSO solids from the four outfalls contributing 95 percent of the annual discharge (estimated concentrations)
- CSO sediments collected from the sewers for three of the outfalls that contribute 95 percent of the annual discharge[6]
- Shallow sediments in the upper reach of the canal (0-0.5 and 0-2 foot depth intervals)
- Surface sediments in the Gowanus Bay and Upper New York Bay reference area (0-0.5 foot interval)
- Suspended sediments from the Gowanus Bay and Upper New York Bay reference area (estimated concentrations)

As described in the FS Report, estimated chemical concentrations on CSO solids were calculated using wet weather CSO whole water sample data. These calculations were performed using the assumption that all of the contamination was adsorbed to the suspended solids in the water samples. This is a reasonable assumption because stormwater is the predominant component of CSOs, and previous studies have shown that PAHs and metals in urban and stormwater runoff are strongly associated with the particulate phase (Grant et al., 2003; Engstrom, 2004; Hwang and Foster, 2005; Brown et al., 2011). Stormwater sample analyses reported in these studies indicated that 87 percent to greater than 90 percent of the PAHs were associated with the particulate phase. The Gowanus Canal RI data indicate that about 92 percent of the lead and 76

[4] All statistical tests reported in this memorandum were performed at a 0.05 significance level.
[5] 90 percent confidence interval
[6] A CSO sediment sample could not be collected from the RH-034 sewer due to the high velocity of the flow.

percent of the copper in wet weather CSO water samples from the four major outfalls was in the particulate phase.[7]

The wet weather CSO water samples represent solids and contaminants actually discharged to the canal. The CSO sediment data are samples of residual sediment collected from the sewers. No field investigations or analyses were performed to determine if and/or how much residual sediments in sewers are mobilized during wet weather and discharged by CSOs.

The Gowanus Bay and Upper New York Bay reference area suspended sediment concentrations were estimated using reference area surface water sample data collected during wet and dry weather conditions, and assuming that all of the contamination was adsorbed to the suspended sediments in the surface water samples. This assumption provides a conservative estimate of the contaminants transported into the canal on suspended sediments from Upper New York Bay.

Figures 8a through 8c summarize the data for total PAHs, lead, and copper, respectively. The concentration ranges are shown on a log scale. The preliminary remediation goals (PRGs) for the contaminants are also shown. The relative concentration distributions for these three contaminants are similar: concentrations in CSO solids, CSO sediments, surface sediments (0-0.5 feet), and shallow sediments (0-2 feet) in the upper reach of the canal are similar, whereas concentrations in reference area surface sediment samples and reference area suspended solids are similar to each other and substantially lower[8], with the exception of PAH concentrations in CSO sediments (which are lower) and in some of the 0-2 foot samples (which are higher than the surface sediment concentrations). Total PAH, lead and copper concentrations in sediment samples from the 0-0.5 and 0-2 foot intervals are significantly higher than concentrations in reference area sediment. These relationships indicate that solids from CSO discharges have a greater influence on surface sediment quality in the upper reach of the Gowanus Canal than the suspended sediment contributions from Gowanus Bay and Upper New York Bay.

Because the relative contributions of individual PAHs contributing to the total PAH concentration can vary from sample to sample, the concentrations of the four individual PAHs most frequently in surface sediments and CSO solids were also compared. Figures 9a through 9d show the concentrations of acenaphthene, benzo(b)fluoranthene, benzo(k)fluoranthene, and pheneanthrene in CSO solids, surface sediments from the upper reach of the canal, and reference sediments. Relative concentrations of the individual PAHs show the same pattern as total PAHs: concentrations in CSO solids and surface sediments from the upper reach of the canal are similar to each other and are substantially higher than reference area concentrations.

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[7] In the RI, only whole water CSO water samples were analyzed for PAHs. Whole water and filtered samples were analyzed for metals; however, the samples were collected successively rather than as splits from the sample bulk sample.

[8] Reference area suspended solids concentrations could not be estimated for copper because of high detection limits in surface water samples.

The surface sediment concentrations for all four PAHs in the upper reach of the canal are significantly higher than concentrations in reference area samples.

Figures 10a through 10c show longitudinal profiles of total PAH, lead, and copper in surface sediment samples and average concentrations on CSO solids from each outfall along the length of the canal. The average concentrations in the reference area are also shown. The surface sediment and CSO solids concentration trends are variable, but concentrations are consistently higher than reference area concentrations along the entire length of the canal.

3.3 Geochemical Evaluation

Geochemical analysis based on metal/iron or metal/aluminum ratios in sediment can be used to differentiate background metals concentrations from localized releases (Daskalakis and O'Connor, 1995; U.S. Navy, 2003; Schropp and Windom, 1988) and estimate the degree of metals enrichment in contaminated sediments (Velinsky and Ashley, 2001). *Background* refers to constituents or locations that are not influenced by the releases from a site, and is usually described as naturally occurring or anthropogenic (USEPA, 2002). The Gowanus Bay and Upper New York Bay reference area is considered "background" for this analysis. This approach is based on the geochemical association between metal contaminants and a non-contaminant normalizing parameter such as aluminum or iron. The following conditions should be met for this analysis (U.S. Navy, 2003):

- A significant relationship (correlation) exists between the metal of concern and the normalizing parameter in the background samples
- The normalizing parameter is insensitive to anthropogenic inputs (in this case, concentrations of the normalizing parameter should not be significantly different in Gowanus Canal and reference area sediments)
- The normalizing parameter is stable (non-reactive) under the geochemical conditions in site sediments.

The data used in the geochemical evaluation for the Gowanus Canal are provided in Attachment 2. Statistically significant relationships exist between lead/aluminum (Pb/Al) and lead/iron (Pb/Fe) in reference area samples after the sample from location 326 is removed from the regression analysis (Figure 11). Location 326 was removed from the analysis because it is clearly an outlier, with a lead concentration that is 2.5 times higher than the other reference are samples. The coefficients of determination (R^2) for the Pb/Al and Pb/Fe relationships were 0.87 and 0.90, respectively. These results indicate that background relationships for lead can be established. Copper/aluminum (Cu/Al) and copper/iron (Cu/Fe) relationships in reference area samples were also statistically significant after location 326 was removed from the data set; however, the coefficients of determination were lower (R^2 = 0.60 and 0.55, respectively). Therefore, Cu/Al and Cu/Fe ratios were not evaluated further.

Iron and aluminum can both be used as normalizers for the Gowanus Canal. The concentrations of iron and aluminum are not significantly different in surface sediment samples from the upper reach of the canal and the reference area. Aluminum is less reactive than iron in anoxic conditions and tends to be the more appropriate normalizer for east coast sediments (Daskalis and O'Connor, 1995). However, a covariate plot of iron and aluminum (Figure 12) indicates that neither normalizer is enriched in surface sediments from the canal or reference area, or in CSO solids from the four major outfalls with the exception of iron in two CSO samples and the sediment sample from location 308A (average of field duplicates). These samples were excluded from further analysis due to evidence of this iron enrichment.

Relationships between Pb and Al and Pb and Fe were evaluated for surface sediments from the upper reach of the canal and the reference area, and CSO solids from the four major outfalls (Figure 13). Visual inspection of these plots indicates that surface sediments in the upper reach of the canal are enriched in lead relative to reference levels, and that CSO solids from the four major outfalls are enriched in lead relative to both reference and the majority of the canal sediments.

A lead enrichment factor (EF) can be calculated by dividing the Pb/Al and Pb/Fe ratios for each canal sample by the average reference area ratios:

$$EF = \frac{\left(\frac{Pb}{N}\right)_{site}}{\left(\frac{Pb}{N}\right)_{ref}}$$

Where

$EF =$ enrichment factor

$\left(\frac{Pb}{N}\right)_{site}$ = average ratio of lead to the normalizer for the canal samples, and

$\left(\frac{Pb}{N}\right)_{ref}$ = average ratio of lead to the normalier for the reference samples.

The data sets and calculations are provided in Attachment 2. The average lead enrichment factors for surface sediments in the upper reach of the Gowanus Canal (excluding location 308A, which was excluded due to iron enrichment) are summarized in Table 2. These results indicate that surface sediments in the upper reach of the canal are enriched in lead by a factor of about 3.7 above regional background (reference) levels.

TABLE 2
Lead Enrichment Factors for Upper Canal Surface Sediments

Normalizer	Average Lead Enrichment Factor
Aluminum	3.7
Iron	3.8

3.4 Bacteriological Contamination

National Grid collected sediment samples for pathogen analysis during sampling events in 2010 and 2011 (GEI, 2011a and 2011b). Pathogens were detected in every sample analyzed, including fecal coliform, *Clostridium perfringens, Enterococci,* and *E. coli.* Figures 14a and 14b show the distribution of fecal coliform in surface sediments in the upper and lower reaches of the canal. The highest fecal coliform concentrations were detected in the upper reach of the canal, where CSO impacts are most severe. High concentrations were also found in the lower canal near CSO outfall RH-031.

3.5 PAH Composition

Compositional differences in PAH mixtures can be used to differentiate the sources of the PAHs (Boehm, 2006; Costa and Sauer, 2005). Petrogenic PAHs are produced through the slow, long-term moderate-temperature formation of fossil fuels (i.e., petroleum products). Pyrogenic PAHs are produced through rapid, high-temperature incomplete combustion of organic material or fossil fuels (e.g., soot, coal tar). A variety of potential PAH sources exist along the Gowanus Canal, including urban runoff, former MGPs, bulk petroleum storage, and coal yards. Urban runoff contains a mixture of PAHs of both petrogenic and pyrogenic origin (e.g., spilled petroleum, dust, soot, fuel and wood combustion products, degraded asphalt).

A subset of sediment samples collected by National Grid in 2005 were analyzed for an expanded list of PAHs and other hydrocarbons to facilitate identification of the likely origins of PAHs in Gowanus Canal sediments (NewFields, 2007). Figure 15 presents high resolution hydrocarbon fingerprints for shallow sediment samples in the upper reach of the canal (0-1.5 ft interval) and for native sediment samples. The NewFields analysis concludes that the shallow sediments are dominated by an unresolved complex mixture (UCM) with multiple sources of PAHs. The UCM fingerprint is consistent with impacts from urban runoff in CSO discharges. The fingerprints of the native sediment samples shown in Figure 14 are characteristic of coal tar.

SECTION 4

Summary

Multiple lines of evidence indicate that CSOs to the Gowanus Canal adversely affect canal sediment quality and are contributing to unacceptable risks that must be addressed under CERCLA. CSO impacts are most apparent in the upper reach of the canal because most of the outfalls are located within or near this reach. The influence of CSO discharges on sediment quality is greatest in the upper reach because (1) the outfall at head of canal (RH-034) has the single largest contribution to annual discharge; (2) the shallow sediments are less influenced by impacts from former MGPs or historical industrial discharges, and (3) the sediments in the upper reach are less susceptible to resuspension by propeller wash from vessel traffic or from tidal forces.

Shallow sediments (i.e., 0-2 foot depth interval) in the upper reach were deposited after the period of greatest industrial activity in the canal. The following lines of evidence indicate that CSOs have a substantial negative impact on surface sediments in the upper reach of the canal:

- Bathymetric differences over a 5 to 7 year time frame measured independently by USEPA and National Grid indicate that sediment accumulation is greatest in the upper reach of the canal. The bathymetric differences translate to net sediment accumulation rates on the order of 1.5 to 5 in/year.
- Radioisotope profiles of Cesium-137 and Lead-210 in sediment cores from the upper reach of the canal show evidence of disturbance consistent with episodic deposition of solids from CSOs rather than the ideal profiles characteristic of continuous settlement of suspended sediments from the water column.
- CSO solids have high organic carbon content (NYCDEP, 2008). Average TOC concentrations in shallow sediments in the upper reach of the canal are approximately two times higher than TOC concentrations in sediments from Gowanus Bay and Upper New York Bay.
- Concentrations of total PAHs, lead and copper on CSO solids, surface sediments (0-0.5 feet), and shallow sediments (0-2 feet) in the upper reach of the canal are similar, whereas concentrations in reference area surface sediment samples and suspended solids are similar to each other and substantially lower. Total PAH, lead and copper concentrations in surface sediment (0-0.5 foot interval) and shallow sediment (0-2 foot interval) are significantly higher than concentrations in reference area sediment. These relationships indicate that solids from CSO discharges have a greater influence on surface sediment quality in the upper reach of the Gowanus Canal than the suspended sediment contributions from Gowanus Bay and Upper New York Bay.
- Relative concentrations of the four most frequently detected individual PAHs (acenaphthene, benzo(b)fluoranthene, benzo(k)fluoranthene, and pheneanthrene) show the same pattern as total PAHs: concentrations in CSO solids and surface sediments from the upper reach of the canal are similar and are substantially higher than reference area

concentrations. The concentrations for all four PAHs in surface sediments in the upper reach of the canal are significantly higher than concentrations in the reference area.

- Longitudinal profiles of total PAH, lead, and copper concentrations in surface sediment samples and average concentrations on CSO solids from each outfall along the length of the canal are variable, but concentrations are consistently higher than reference concentrations along the entire length of the canal.
- A geochemical evaluation based on the analysis of Pb/Al and Pb/Fe ratios in surface sediments from the upper canal and reference area indicate that the canal sediments are enriched in lead by a factor of about 3.7 above regional background (reference) levels.
- Pathogens have been detected in surface sediments collected throughout the Gowanus Canal. Fecal coliform concentrations are highest in the upper reach of the canal adjacent to CSO outfalls.
- High resolution hydrocarbon fingerprints of shallow sediment samples from the upper reach of the canal are characterized by an UCM fingerprint consistent with urban runoff.

These data-based lines of evidence are consistent with descriptions of CSO impacts described in NYCDEP technical reports (NYCDEP, 2007 and 2008).

The relative sediment source contributions in the upper canal have been prioritized qualitatively. Establishing a precise baseline is not feasible because CSO discharge events vary greatly in terms of the size, frequency and intensity. In addition, sewer system changes will occur as a result of current and planned upgrades (e.g., flushing tunnel and localized sewer separation) and major redevelopment projects (e.g., Whole Foods Market, Lightstone Group development plans and Barclay Arena). Relative sediment contributions, however, are likely to remain unchanged in the upper canal. As a result, further study would delay rather than contribute to remedial progress. Additional sampling and modeling will be performed during remedial design to reduce uncertainty and ensure remedy effectiveness.

SECTION 5

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ATTACHMENT 1

Data sets used in this technical memorandum are summarized in the table below.

Sample Type	Parameters	Description	Number of Data Points
Upper reach – surface sediment (0-0.5 feet)	TOC Lead Copper Total PAHs Iron Aluminum	Samples collected for the Gowanus Canal RI; field duplicate concentrations averaged	10
Upper reach – sediment core (0-2 feet)	TOC Lead Copper Total PAHs	Samples collected for RI; field duplicate concentrations averaged	40
Reference area surface sediment (0-0.5 feet)	TOC Lead Copper Total PAHs Iron Aluminum	Samples collected for RI; field duplicate concentrations averaged	10
CSO solids	Lead Copper Total PAHs Iron Aluminum	Wet weather CSO water samples collected for RI from the four major outfalls (RH-034, RH-035, OH-007 and RH-031); solids concentrations estimated using whole water contaminant and TSS data	7
CSO sediment	Lead Copper Total PAHs	Residual sediment samples collected from RH-035, OH-007 and RH-031 sewers for the RI; field duplicate concentrations averaged	3
Reference area suspended sediments	Lead Total PAHs	Wet and dry weather surface water samples collected for RI; solids concentrations estimated using whole water contaminant and TSS data	Lead – 20 Total PAHs - 22

TOC – total organic carbon, PAH – polycyclic aromatic hydrocarbon, HPAH – high molecular weight PAH, RI – remedial investigation, CSO – combined sewer overflow, TSS – total suspended solids

Non-detected PAHs included as 0 in sums of total PAH and HPAH

ATTACHMENT 2

Lead-Iron and Lead-Aluminum Ratios in Surface Sediments

Gowanus Canal

Brooklyn, New York

METHOD:

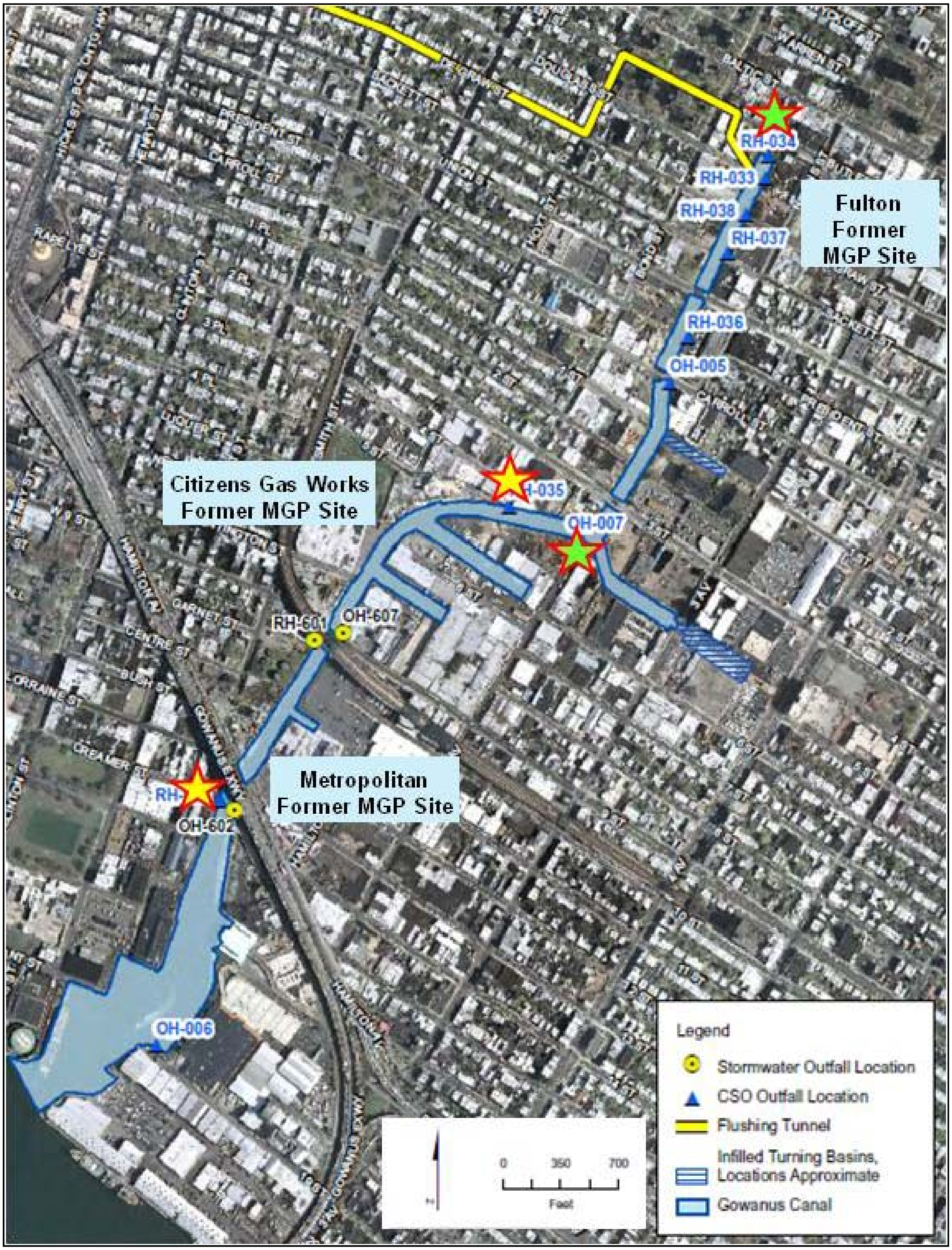
Calculated Pb/Fe and Pb/Al ratio for each sample

Excluded reference station 326 due to lead enrichment and canal station 308A due to iron enrichment

Calculated average Pb/Fe and Pb/Al ratios for canal and reference

Calculated enrichment factor for canal (average canal ratio / average reference ratio)

Station	Sample ID		Aluminum	Iron	Lead	Pb/Fe	Pb/Al
Upper Reach - Gowanus Canal							
301	GC-SD301-0.0-0.5	N	5,710	12,400	201	0.0162	0.0352
302	GC-SD302-0.0-0.5	N	13,600	25,600	239	0.0093	0.0176
303	GC-SD303-0.0-0.5	N	16,200	29,600	201	0.0068	0.0124
304	GC-SD304-0.0-0.5	N	16,100	29,500	247	0.0084	0.0153
305	GC-SD305-0.0-0.5	N	16,300	28,000	230	0.0082	0.0141
306	GC-SD306-0.0-0.5	N	16,700	29,300	238	0.0081	0.0143
307A	GC-SD307A-0.0-0.5	N	15,900	27,700	776	0.0280	0.0488
307B	GC-SD307B-0.0-0.5	N	18,200	28,800	216	0.0075	0.0119
308A	GC-SD308A-0.0-0.5	N	4,760	53,200	4,220	Excluded	
308A	D-062310-01	FD	4,870	87,000	2,710		
308B	GC-SD308B-0.0-0.5	N	13,500	27,100	312	0.0115	0.0231
Average						0.0116	0.0214
Reference Area							
326	GC-SD326-0.0-0.5	N	17,900	34,400	244	Excluded	
327	GC-SD327-0.0-0.5	N	19,400	35,500	95.5	0.0027	0.0049
328	GC-SD328-0.0-0.5	N	9,890	18,200	61.7	0.0034	0.0062
329	GC-SD329-0.0-0.5	N	15,500	31,600	90	0.0028	0.0058
330	GC-SD330-0.0-0.5	N	18,000	33,300	93.5	0.0028	0.0052
331	GC-SD331-0.0-0.5	N	12,800	26,600	93.1	0.0035	0.0073
332	GC-SD332-0.0-0.5	N	8,330	15,400	53.4	0.0035	0.0064
333	GC-SD333-0.0-0.5	N	16,800	29,900	87.5	0.0029	0.0052
334	GC-SD334-0.0-0.5	N	4,750	10,700	25.5	0.0024	0.0054
335	GC-SD335-0.0-0.5	N	15,300	26,800	86.3	0.0032	0.0056
Average						0.0030	0.0058
Enrichment Factor						3.8	3.7



Major CSO Outfalls*

Reductions Planned

No Reductions Planned

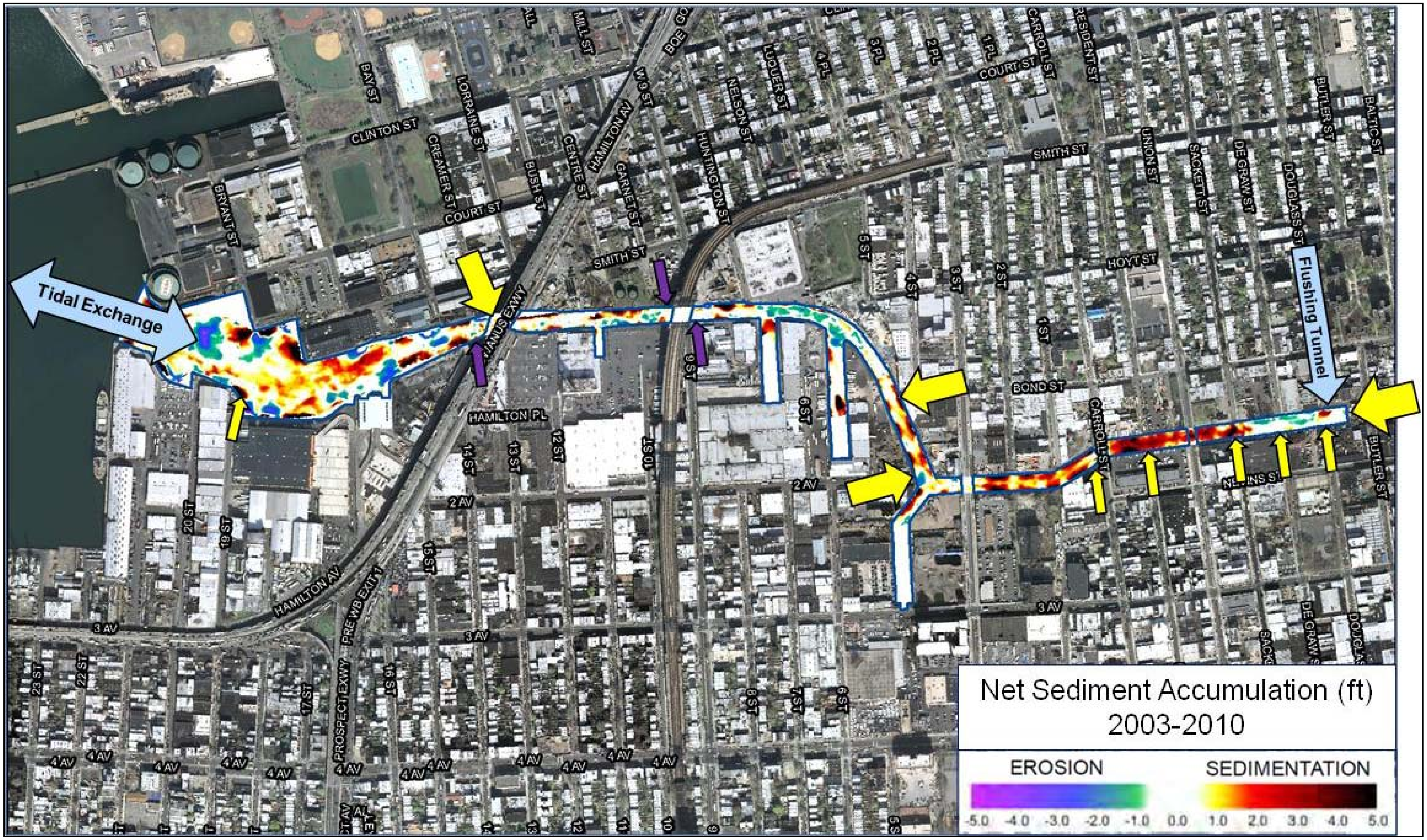
FIGURE 1
CSO and Stormwater Outfall Locations
Gowanus Canal, Brooklyn, NY

* Reductions planned under NYCDEP's Long Term CSO Control Planning Project

CH2MHILL.

http://www.youtube.com/watch?v=HzWOOqPAEgs

FIGURE 2
CSO Discharge from RH-034 and Sediment Mound
Gowanus Canal, Brooklyn, New York



Legend

Water and suspended sediment from Upper New York Bay

Freshwater and solids (wet weather)

CSO outfall

Stormwater outfall

FIGURE 3
Surface Water Hydrology and Sources of Solids
Gowanus Canal, Brooklyn, New York

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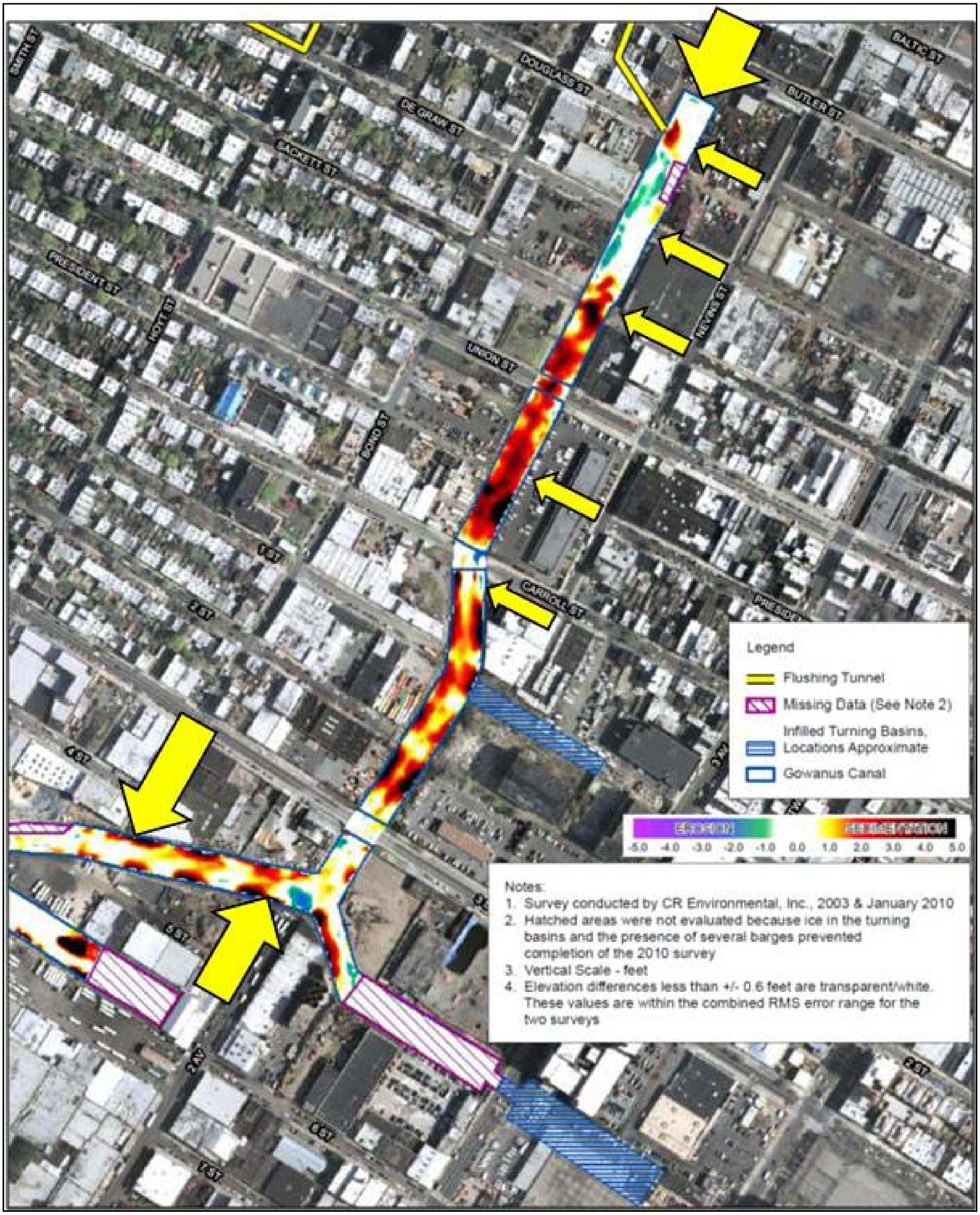

FIGURE 4
Bathymetric Differences in Upper Canal
Gowanus Canal, Brooklyn, New York

CH2MHILL.

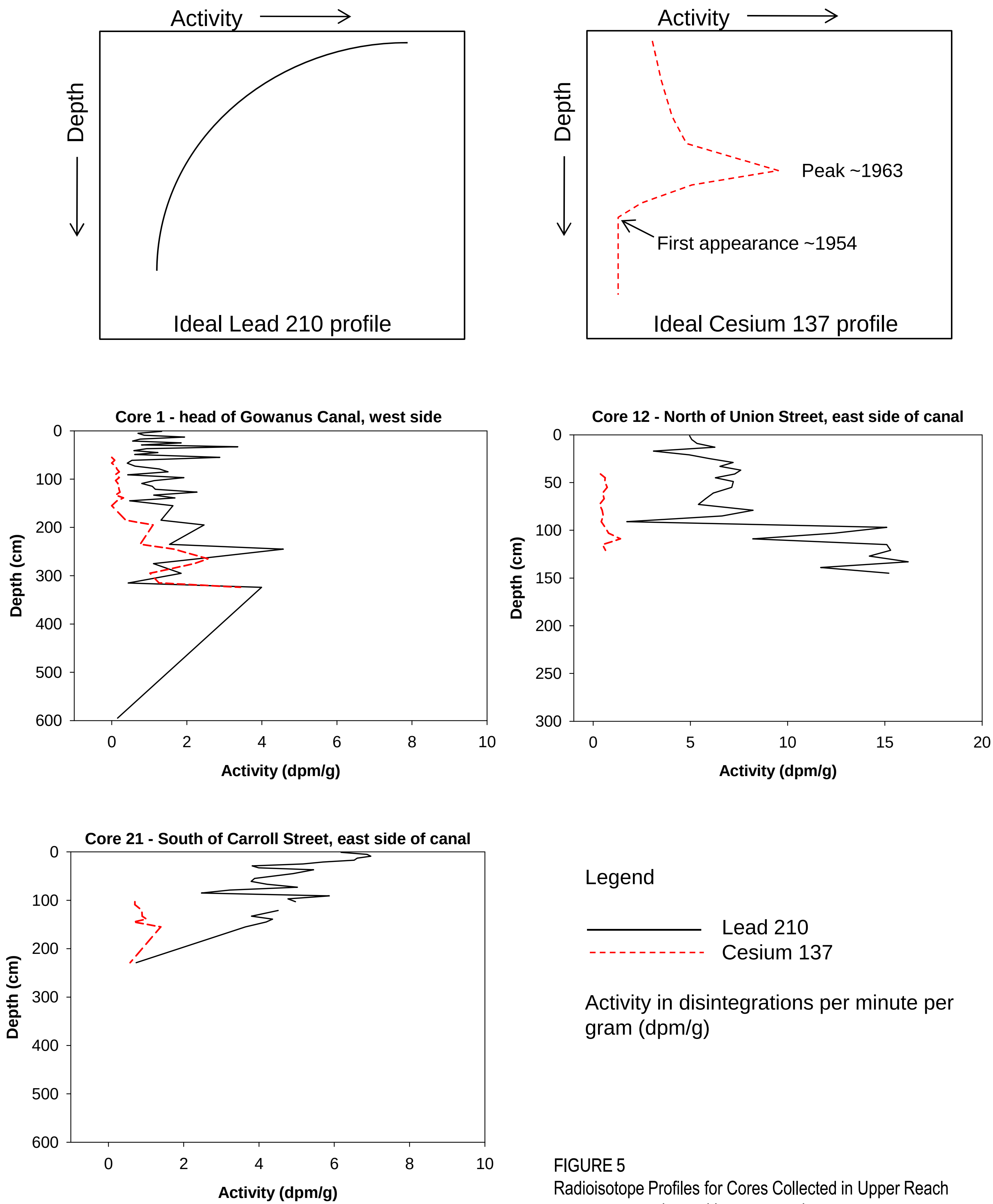

FIGURE 5
Radioisotope Profiles for Cores Collected in Upper Reach
Gowanus Canal, Brooklyn, New York

Core data from NewFields (2007)

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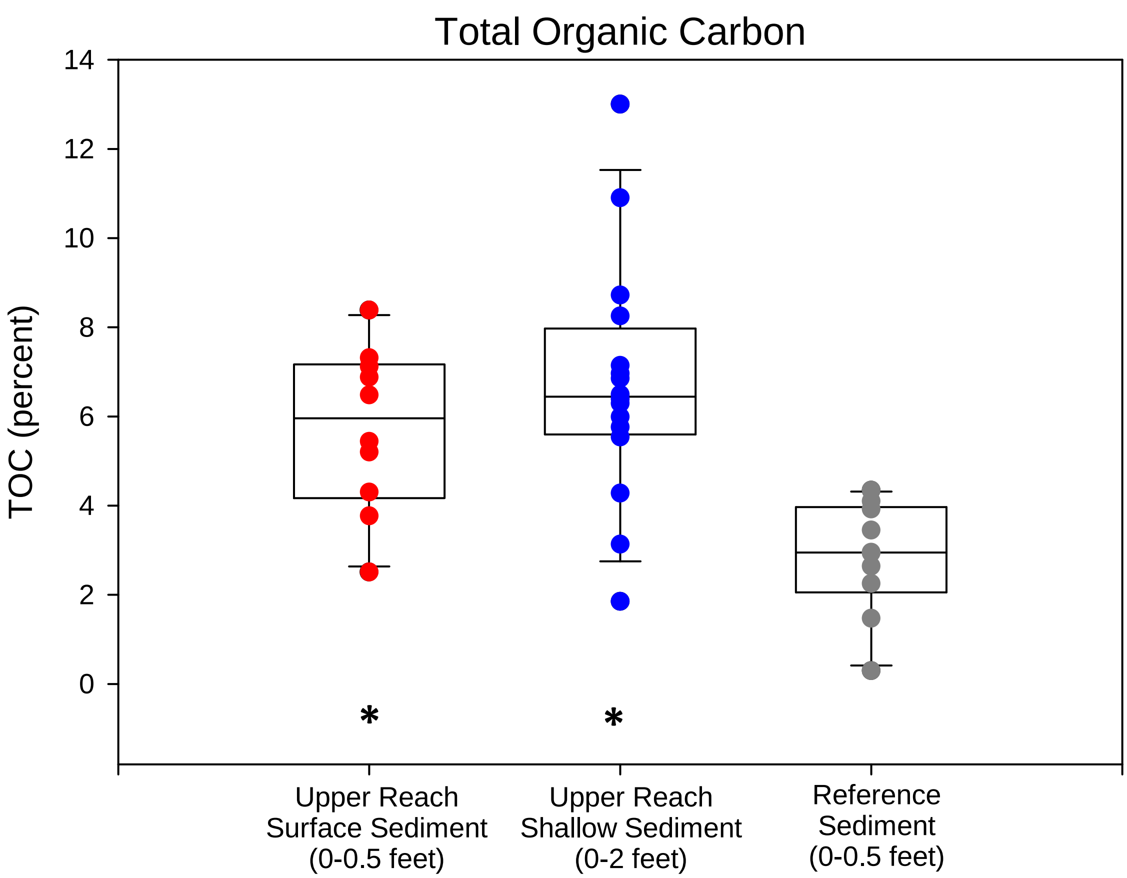

* Statistically significantly higher than reference (α = 0.05)
The box shows the 25th, median, and 75th percentiles, and the whiskers show the 10th and 90th percentiles. Whiskers are not shown if n<9.

FIGURE 6
Total Organic Carbon Concentrations in Upper Canal and Reference Area
Gowanus Canal, Brooklyn, New York

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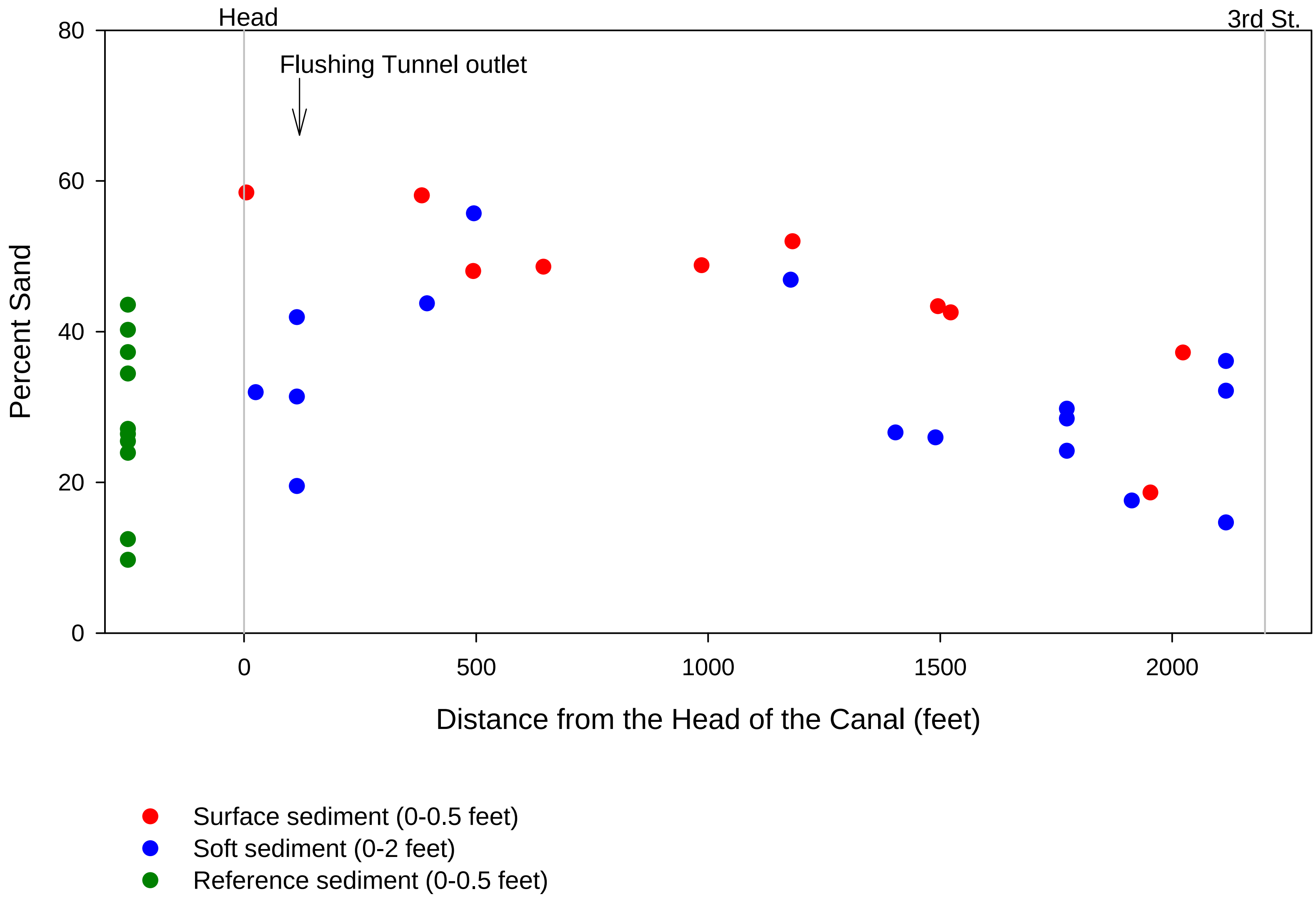
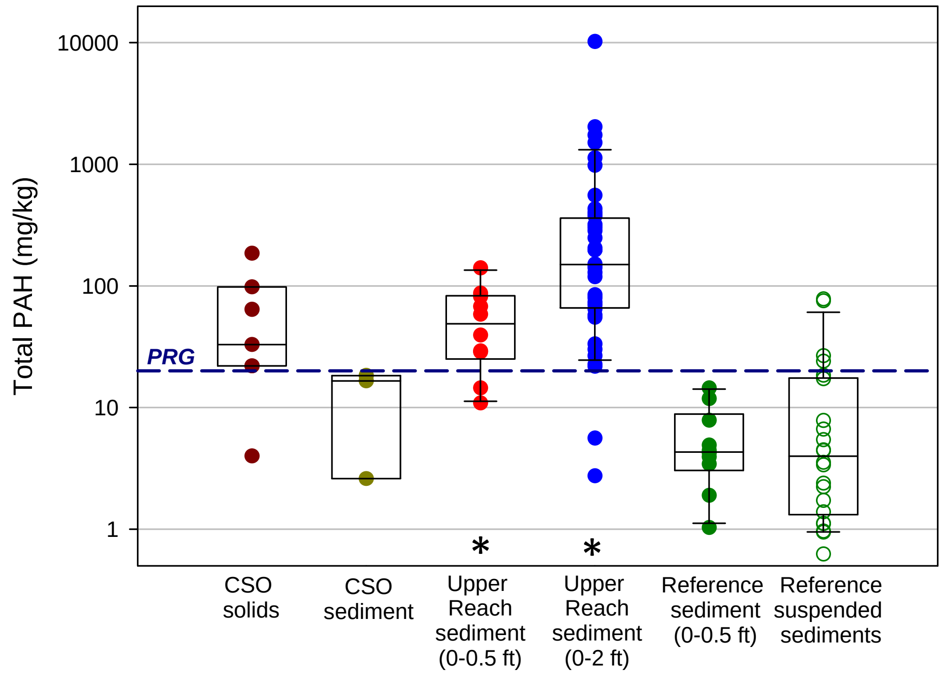
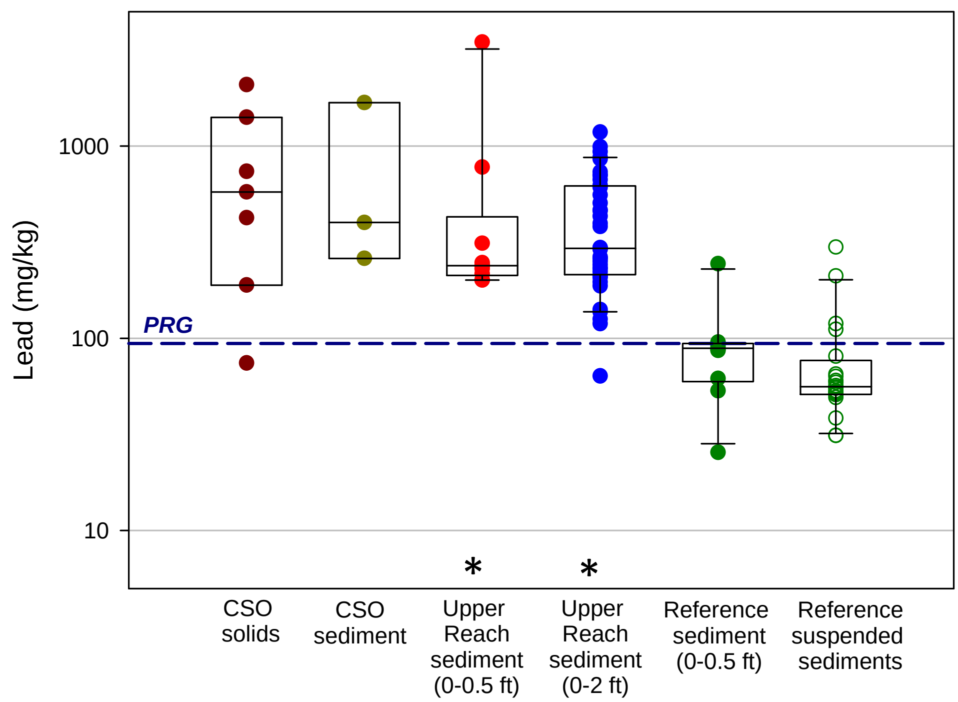


FIGURE 7
Longitudinal Profile of Sand Content in Upper Reach of Canal
Gowanus Canal, Brooklyn, New York

CH2MHILL



a. Total PAH



b. Lead

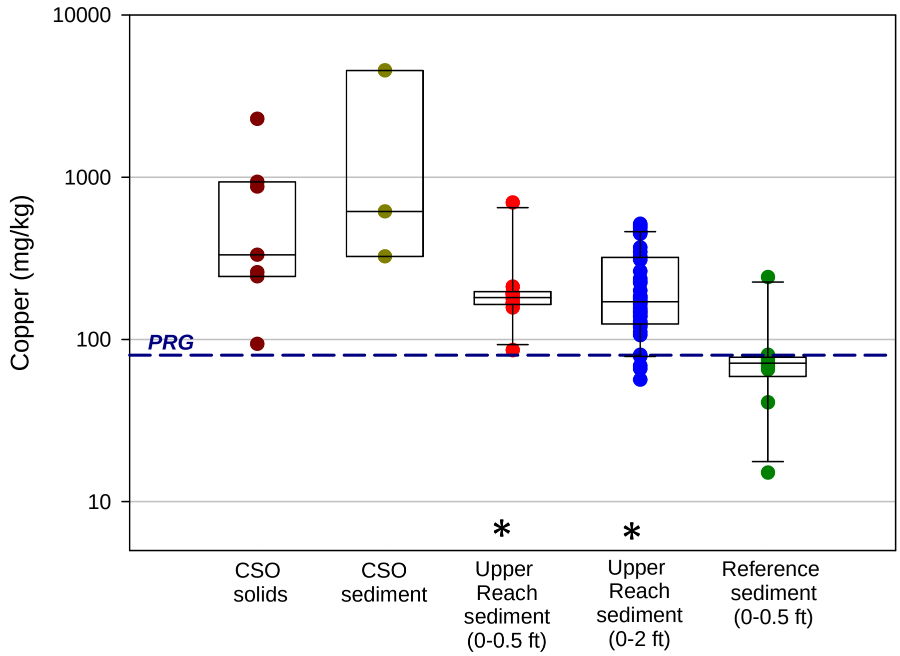
PRG – preliminary remediation goal

* Statistically significantly higher than reference (α = 0.05)

The box shows the 25th, median, and 75th percentiles, and the whiskers show the 10th and 90th percentiles. Whiskers are not shown if n<9.

FIGURE 8
Contaminant Concentrations in Upper Canal and Reference Area
Gowanus Canal, Brooklyn, New York

CH2MHILL.



c. Copper

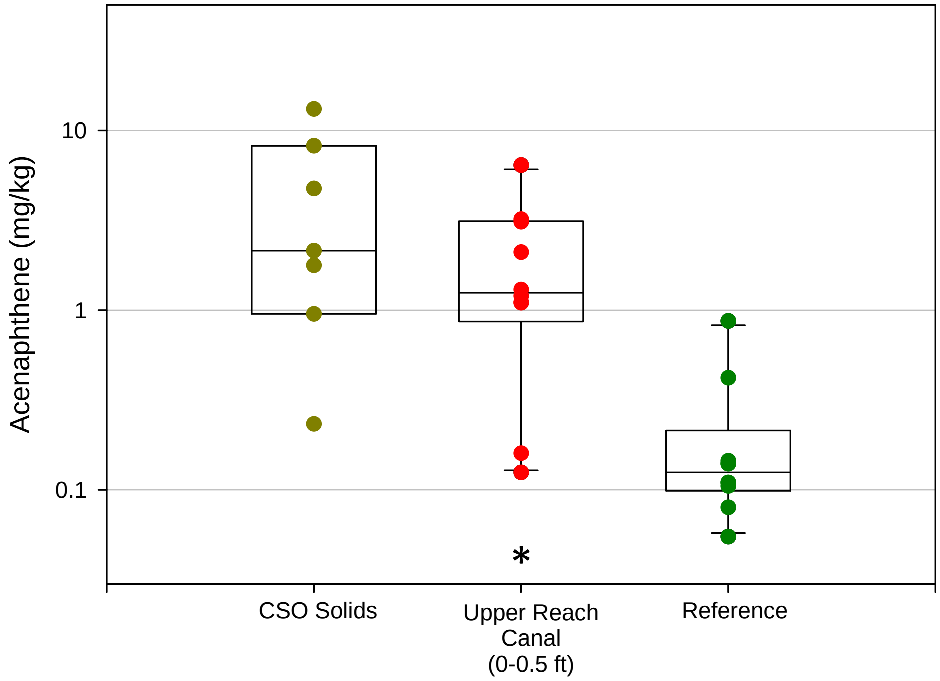
PRG – preliminary remediation goal

* Statistically significantly higher than reference (α = 0.05)

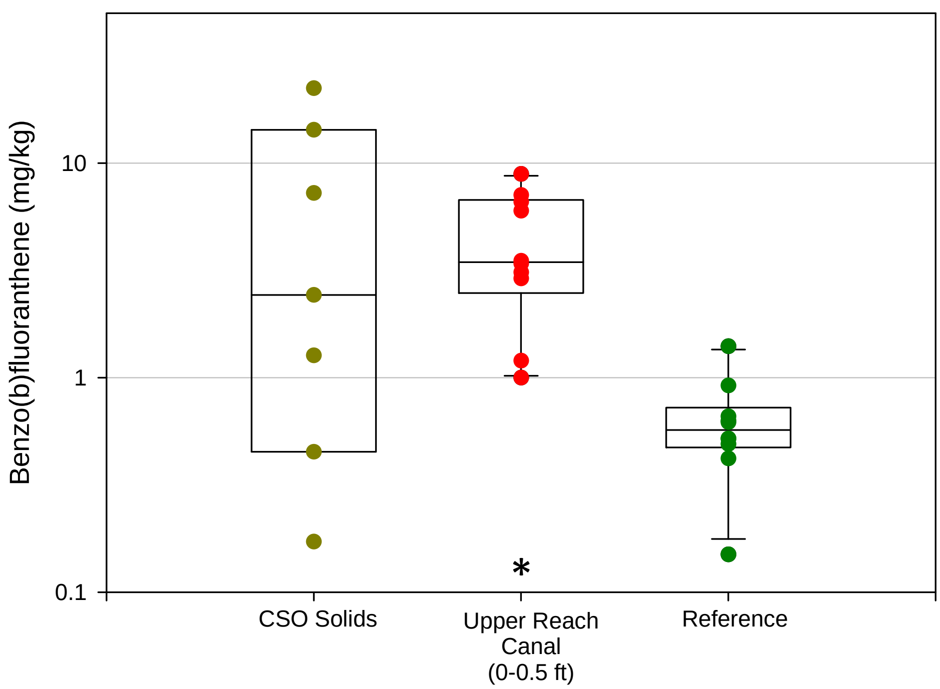
The box shows the 25th, median, and 75th percentiles, and the whiskers show the 10th and 90th percentiles. Whiskers are not shown if n<9.

FIGURE 8 (contd.)
Contaminant Concentrations in Upper Canal and Reference Area
Gowanus Canal, Brooklyn, New York

CH2MHILL



a. Acenaphthene

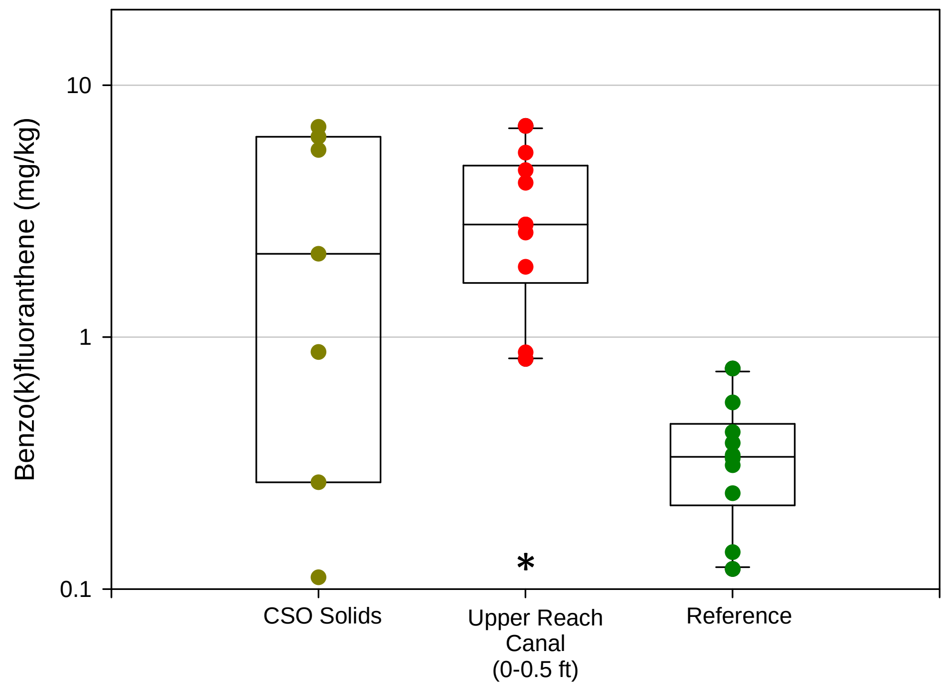


b. Benzo(b)fluoranthene

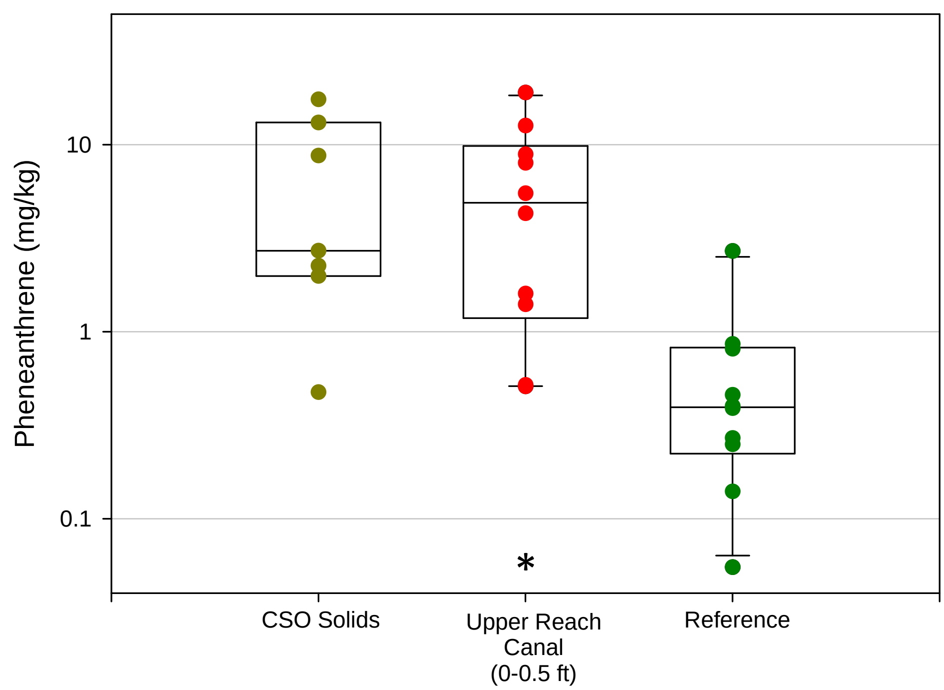
* Statistically significantly higher than reference (α = 0.05)
The box shows the 25th, median, and 75th percentiles, and the whiskers show the 10th and 90th percentiles. Whiskers are not shown if n<9.

FIGURE 9
Individual PAH Concentrations in Upper Canal and Reference Area
Gowanus Canal, Brooklyn, New York

CH2MHILL.



c. Benzo(k)fluoranthene



d. Pheneanthrene

* Statistically significantly higher than reference (α = 0.05)
The box shows the 25th, median, and 75th percentiles, and the whiskers show the 10th and 90th percentiles. Whiskers are not shown if n<9.

FIGURE 9 (contd.)
Individual PAH Concentrations in Upper Canal and Reference Area
Gowanus Canal, Brooklyn, New York

CH2MHILL.

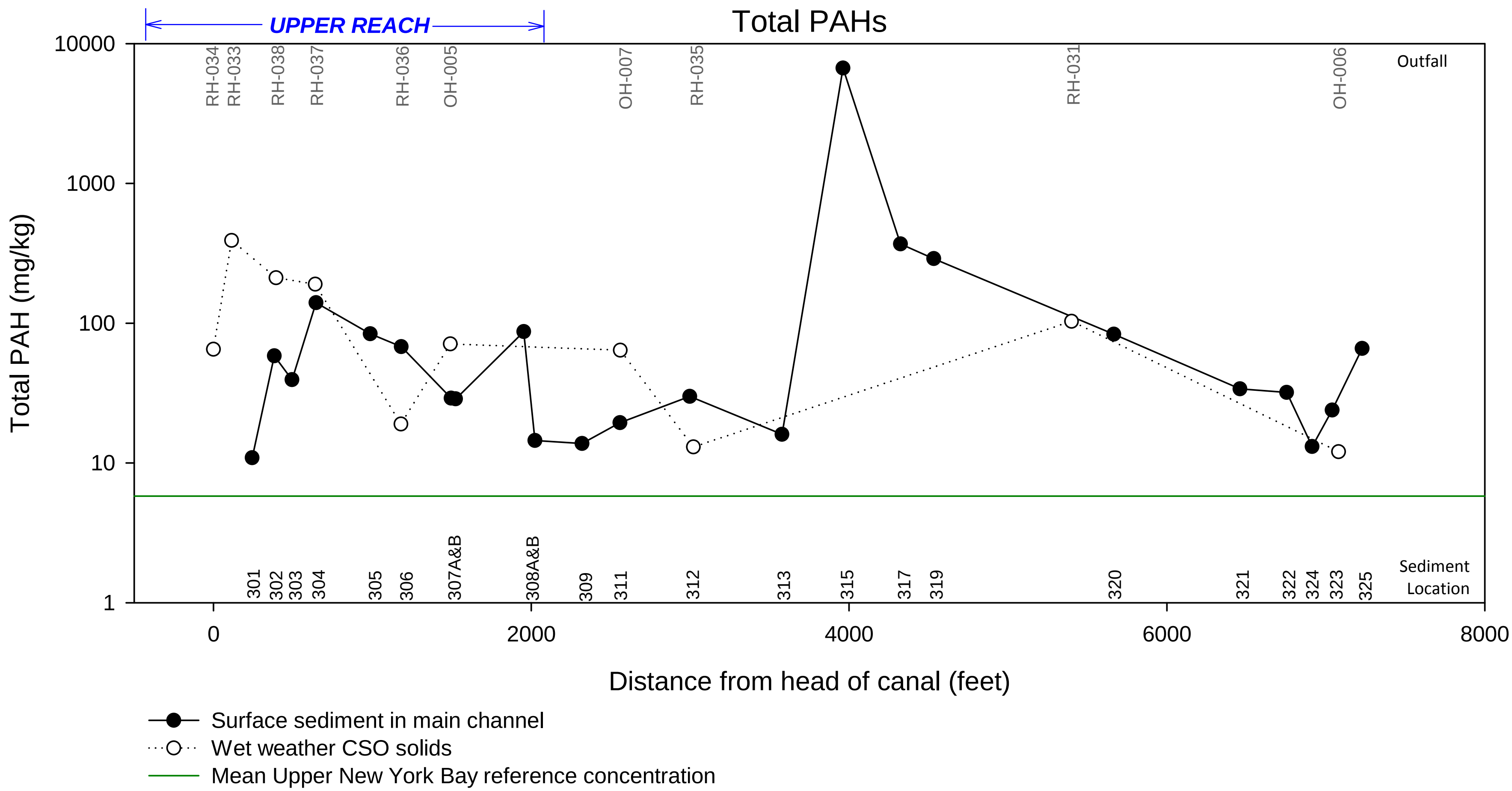


FIGURE 10a
Longitudinal Contaminant Trends - PAHs
Gowanus Canal, Brooklyn, New York

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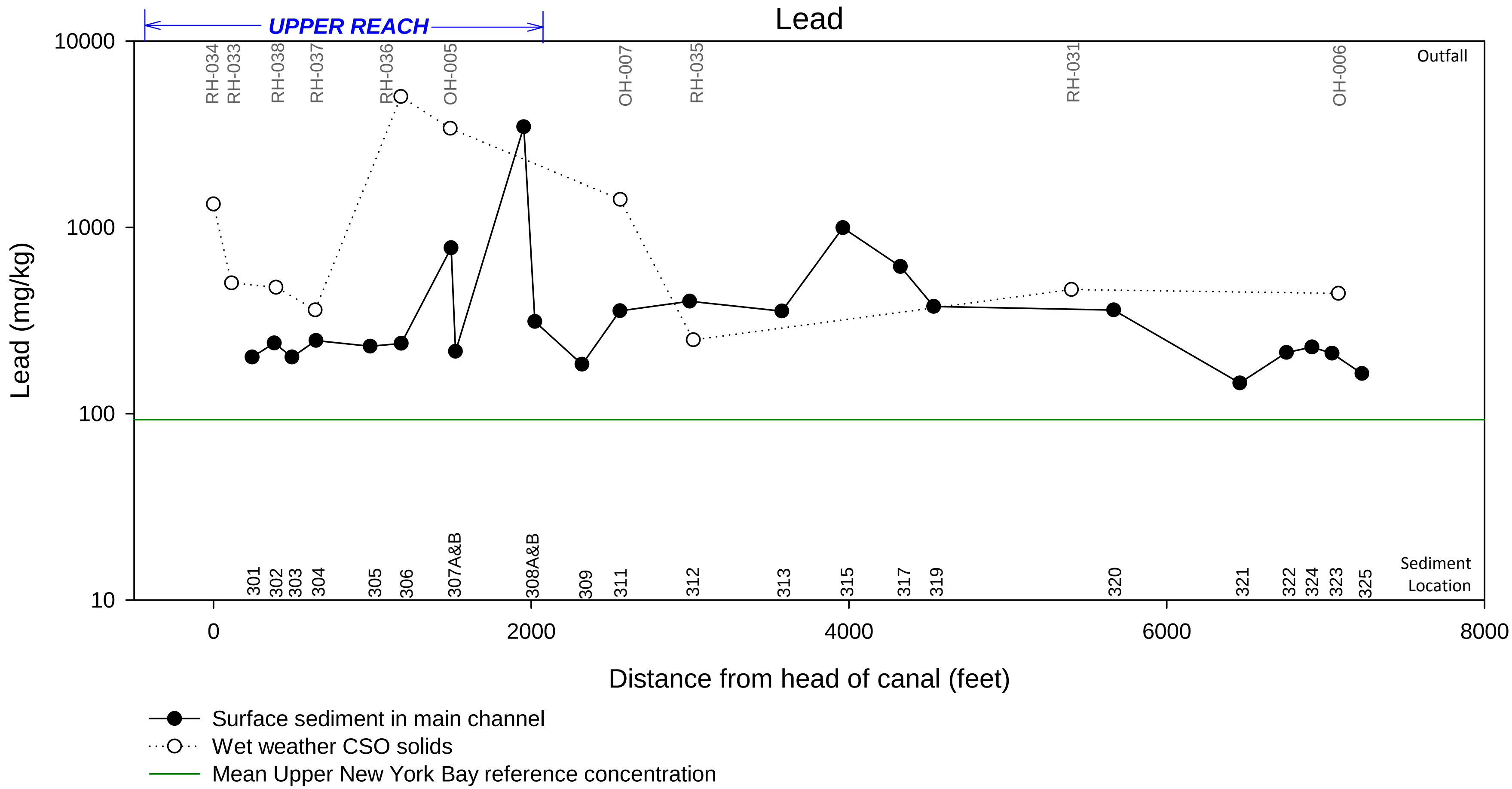

FIGURE 10b
Longitudinal Contaminant Trends - Lead
Gowanus Canal, Brooklyn, New York

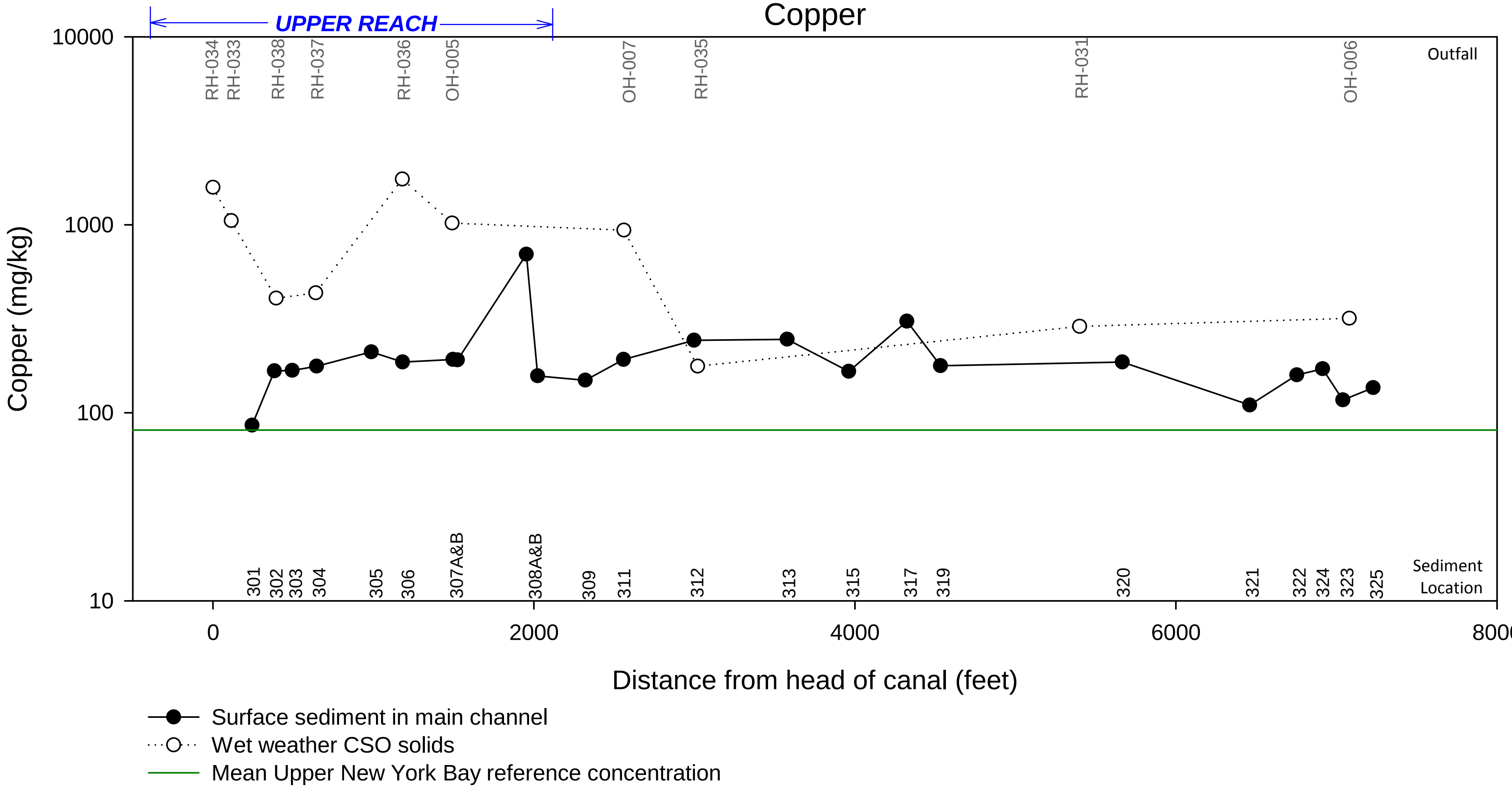

FIGURE 10c
Longitudinal Contaminant Trends - Copper
Gowanus Canal, Brooklyn, New York

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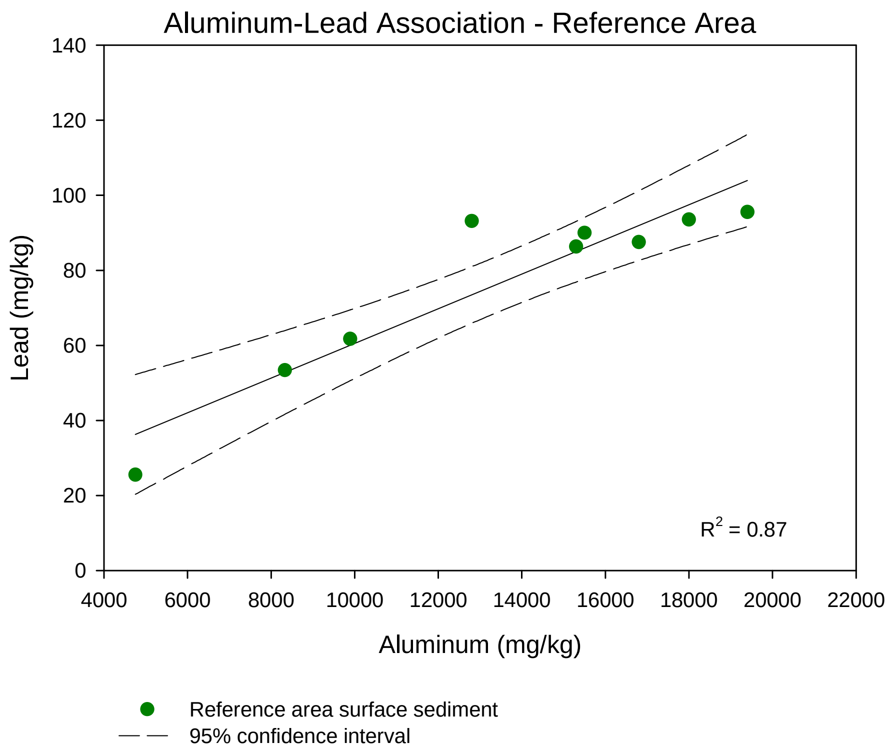

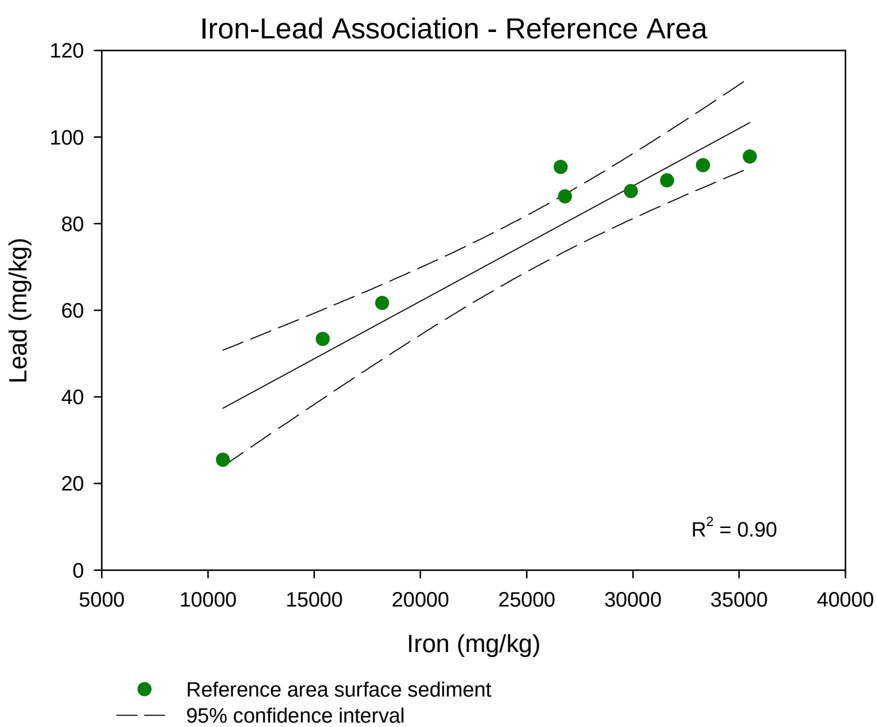

FIGURE 11
Lead/Aluminum and Lead/Iron Relationships in Reference Area Sediment
Gowanus Canal, Brooklyn, New York

CH2MHILL.

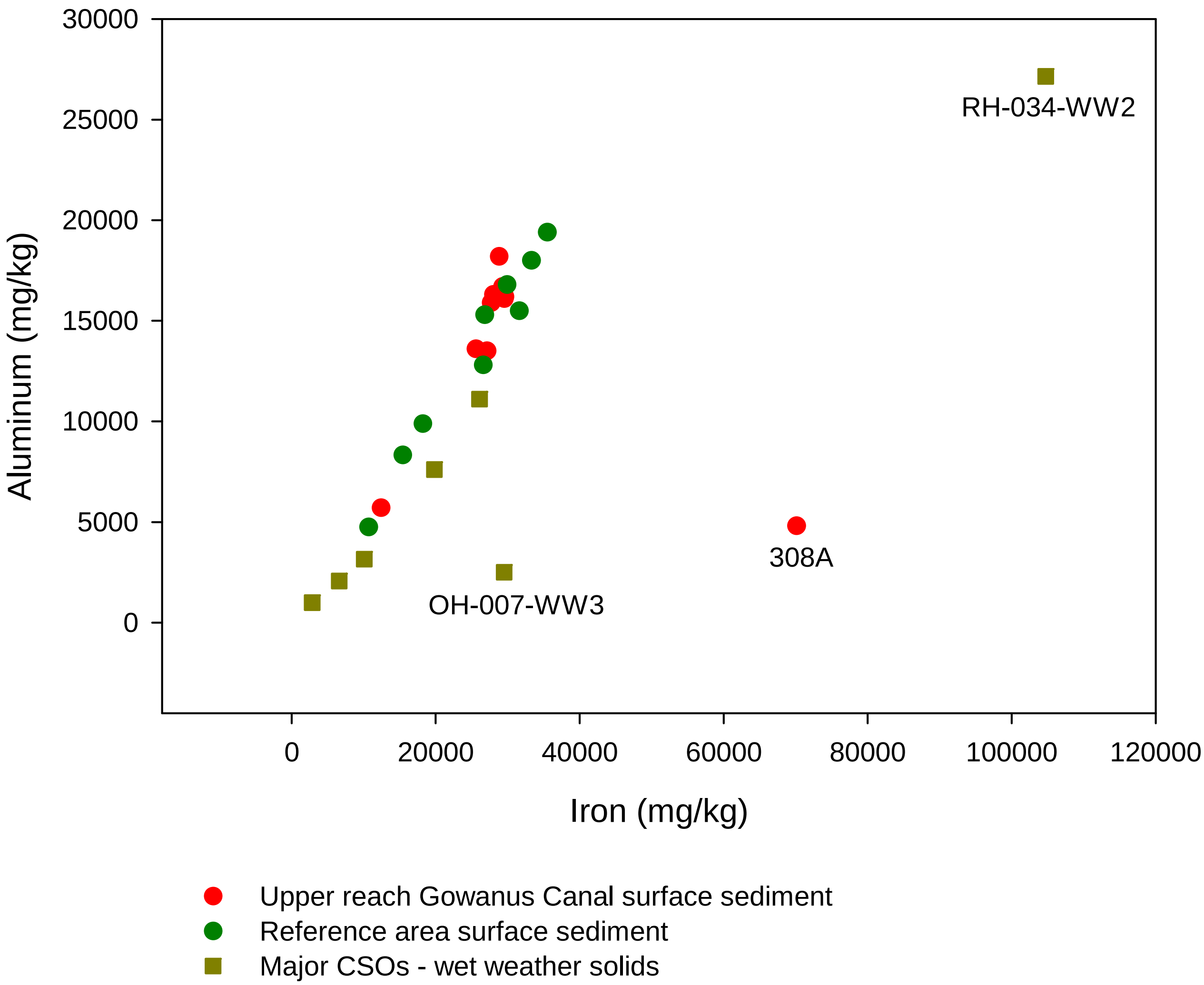

FIGURE 12
Iron and Aluminum Concentrations in Canal and Reference Area Samples
Gowanus Canal, Brooklyn, New York

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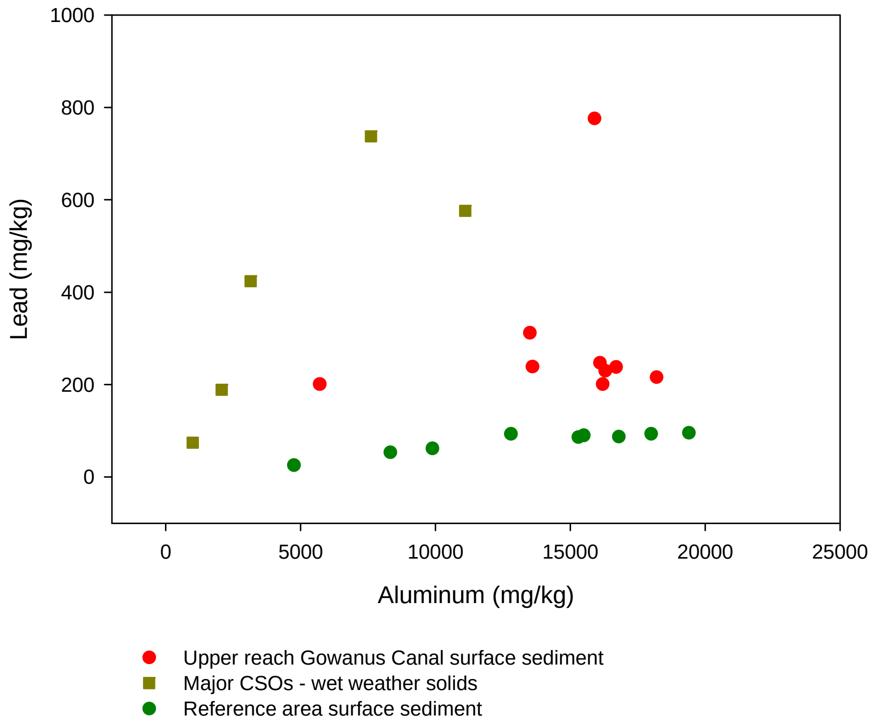

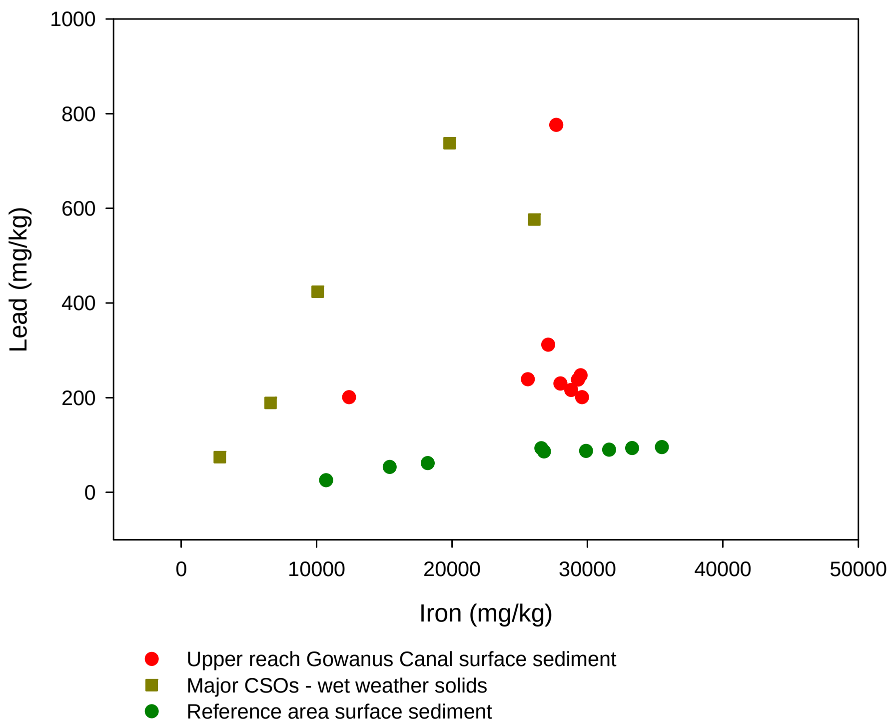

FIGURE 13
Lead/Aluminum and Lead/Iron Relationships in Canal and Reference Area Samples
Gowanus Canal, Brooklyn, New York

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Data from GEI, 2011a and 2011b

FIGURE 14a
Fecal Coliform Distribution in Surface Sediment – Upper Canal
Gowanus Canal, Brooklyn, New York

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Data from GEI, 2011a and 2011b

FIGURE 14b
Fecal Coliform Distribution in Surface Sediment – Lower Canal
Gowanus Canal, Brooklyn, New York

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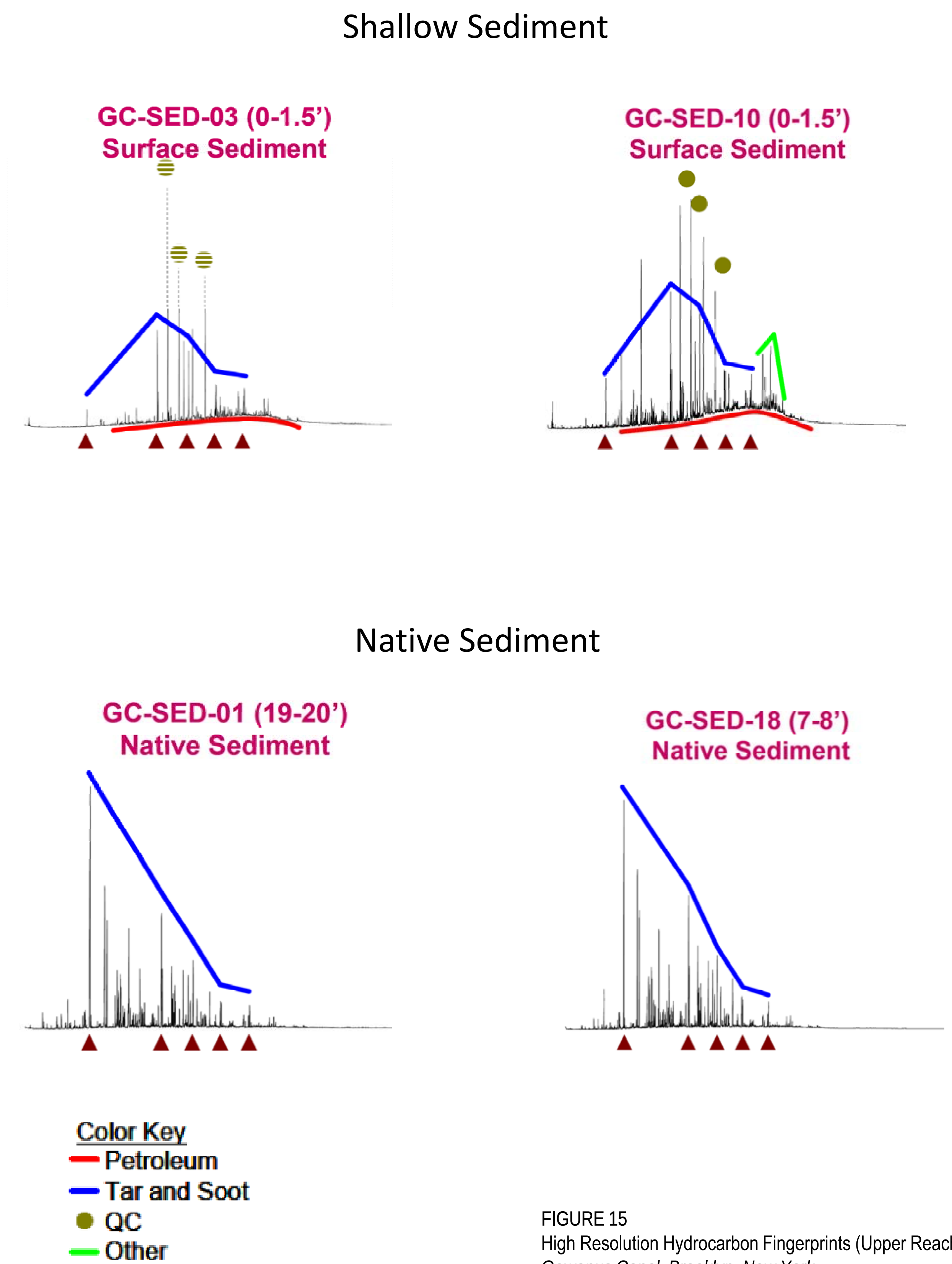

FIGURE 15
High Resolution Hydrocarbon Fingerprints (Upper Reach)
Gowanus Canal, Brooklyn, New York

Supplemental Evaluation of Remediation Goals Gowanus Canal, Brooklyn, New York

Prepared for

U.S. Environmental Protection Agency Region 2

Prepared under contract
AES10 Task Order 072-RI-FS-02ZP
Architect and Engineering Services Contract
Contract No. 68-S7-04-01

Prepared by

CH2MHILL

Supplemental Evaluation of Remediation Goals Gowanus Canal, Brooklyn, New York

Contents

SECTION 1

Introduction

The Feasibility Study (FS) report for the Gowanus Canal, Brooklyn, New York (USEPA, 2011a), presented the remedial action objectives (RAOs), preliminary remediation goals (PRGs), and remediation target areas for cleanup of the canal. The RAOs are narrative descriptions of what the cleanup is expected to accomplish. The RAOs provide the basis for developing site-specific PRGs, which are used to identify the extent of the cleanup needed to achieve the RAOs. This technical memorandum presents revised RAOs and PRGs that were developed based on recommendations provided by the U.S. Environmental Protection Agency's (USEPA) National Remedy Review Board and Contaminated Sediment Technical Advisory Group (the Boards) and discussions with other stakeholders. This memorandum also presents an approach that can be used to evaluate remedy success and protectiveness after the remedy has been implemented, and includes other supplemental evaluations that were requested by the Boards.

Section 1 presents an overview of the revised RAOs and PRGs, and an approach for evaluating remedy effectiveness. Sections 2 and 3 provide the supplemental human health and ecological risk evaluations respectively, including detailed descriptions of the revised PRGs. Section 4 discusses expected post-remediation sediment quality conditions in the canal (i.e., chemical concentrations in sediment after the source control actions and sediment remedy are completed). References are provided in Section 5. Supporting information is provided in attachments.

SECTION 2

Revised Remediation Goals

RAOs for the Gowanus Canal have been revised to incorporate benchmarks that will be used to assess remedy success and protectiveness. Discussion of each RAO is followed by an overview of the associated PRGs and the approach for evaluating remedy effectiveness. The RAOs and PRGs are based on the findings of the human health risk assessment (HHRA) and ecological risk assessment (ERA) (USEPA, 2011b) and specify (1) the contaminant(s) of concern (COCs), (2) the exposure route(s) and receptor(s), and (3) an acceptable contaminant level (or range of levels) for each exposure route. Detailed descriptions of the development of the revised human health and ecological PRGs are provided in Sections 3 and 4, respectively.

The approach for evaluating remedy effectiveness will be presented in the long-term monitoring plan that will be developed before the remedy is implemented so that baseline monitoring data can be collected as appropriate.

2.1 Protection of Human Health

The FS report included human health RAOs for direct contact with surface water and sediment in the canal, and ingestion of fish and shellfish. As detailed in Section 2.1.1, the direct contact RAO has been revised to address sediment only because concentrations of the human health COCs in surface water in the Gowanus Canal are not significantly different than concentrations in the surface water in the Gowanus Bay and Upper New York Bay reference area.

2.1.1 Direct Contact with Sediment

The revised RAO for direct contact with sediment is as follows:

- Reduce the cancer risk to human health from the incidental ingestion of and dermal contact with polycyclic aromatic hydrocarbons (PAHs) in sediment during recreational use of the canal or from exposure to canal overflow to levels that are within or below USEPA's excess lifetime cancer risk range of 10^{-6} (one per one million) to 10^{-4} (one per ten thousand).

The site-specific risk-based sediment PRGs associated with this RAO were presented in the FS report and are provided in Table 2-1. Human health COCs are defined as any chemical of potential concern (COPC) that contributes a cancer risk greater than 10^{-6} and/or a noncancer hazard quotient (HQ) greater than 0.1 to a cumulative cancer risk that is greater than 10^{-4} and/or a cumulative hazard index (HI) that is greater than 1. In the FS report, six carcinogenic PAHs were identified as human health COCs for sediment, and five carcinogenic PAHs were identified as human health COCs for surface water. As shown in Table 2-2, concentrations of carcinogenic PAHs in Gowanus Canal surface water generally are not significantly different than the Gowanus Bay and Upper New York Bay reference area concentrations.[1] Therefore, the sediment remedy is unlikely to have a substantial effect on carcinogenic PAH concentrations in surface water.

The PRGs for individual PAHs provided in the FS report are based on a target risk level of 10^{-5} so that cumulative risk from exposure to all carcinogenic PAHs would not exceed 10^{-4}. As requested by the Boards, these PRGs have been supplemented by PRGs based on a more-protective cumulative risk level of 10^{-6}. The development of these PRGs is described in more detail in Section 3.1. These PRGs are also provided in Table 2-1. Mean PAH concentrations in sediment samples from the Gowanus Bay and Upper New York Bay reference area are also provided for comparison.

The sediment PRGs based on the 10^{-6} cumulative risk level are similar to mean reference area concentrations for three PAHs and lower than mean reference area concentrations for one PAH. The sediment PRGs based on the 10^{-4} cumulative risk level are higher than the mean reference area concentrations. The PRGs based on the 10^{-4} cumulative risk level will be used for remediation because the PRGs based on the 10^{-6} cumulative risk level may not be achievable given the regional background (i.e., reference area) carcinogenic PAH concentrations.

The approach that will be used to evaluate whether this RAO has been achieved is as follows:

- Compare the concentrations of individual carcinogenic PAHs in exposed and near-shore sediment to the PRGs based on the 10^{-4} cumulative risk level.
- If any individual PAH exceeds the PRG, then calculate the cumulative risk for all detected carcinogenic PAHs; the cumulative risk should be within or below the risk management range of 10^{-4} to 10^{-6}.

2.1.2 Ingestion of Fish and Shellfish

The RAO related to the ingestion of fish and shellfish caught in the canal has been revised as follows:

- Reduce the contribution of polychlorinated biphenyls (PCBs) from the Gowanus Canal to fish and shellfish 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 HHRA concluded that carcinogenic risks and non-carcinogenic hazards from ingestion of PCB-contaminated fish and shellfish from the Gowanus Canal exceed USEPA acceptable risk levels. Average PCB concentrations in fish and crab tissue samples from the canal were about two times higher than concentrations in samples collected from the Gowanus Bay and Upper New York Bay reference area; however, the PCB concentrations in the reference area samples also result in carcinogenic risks and non-carcinogenic hazards that exceed acceptable levels. The New York State Department of Health (NYSDOH) has fish consumption advisories for Gowanus Bay and Upper New York Bay that identify PCBs as a

[1] Concentrations of some non-carcinogenic PAHs in surface water were significantly higher in the canal than in the reference area.

COC in fish (NYSDOH, 2010). Because PCB contamination in fish is a regional problem, remediation of the sediments in the canal is unlikely to reduce PCB concentrations in fish tissue to acceptable levels. Additionally, the species targeted in the HHRA (striped bass, white perch, American eel and blue crab) inhabit areas that are larger than the Gowanus Canal, and the PCB concentrations in their tissue reflect contributions from all of the areas in which they forage. Therefore, the PCB concentrations in fish and shellfish caught in the canal cannot be directly linked to PCB concentrations in the canal sediments alone.

Site-specific risk-based PRGs were not developed for PCBs in sediment or tissue because it is unlikely that the canal remedy will reduce the risk from ingesting PCB-contaminated fish and shellfish to acceptable levels, and PCB concentrations in sediment cannot be directly linked to the target species that were caught in the canal. However, PCBs co-occur with PAHs in the soft sediment and, therefore, they will be addressed through the remediation of the PAHs. The maximum Gowanus Bay and Upper New York Bay reference area concentration for PCBs in sediment was selected as the PRG. This PRG is 0.48 mg/kg.

The remedy selected for the Gowanus Canal is expected to result in a clean capped surface on the canal bottom. New sediments and solids that accumulate on this clean surface will reflect the background conditions that exist at th[2]e time that the remedy is completed. Expected future background conditions for the Gowanus Canal are discussed further in Section 4. The approach for evaluating the fish and shellfish ingestion RAO will be as follows:

- Compare PCB concentrations in Gowanus Canal surface sediment to concentrations in the Gowanus Bay and Upper New York Bay reference area sediments.
- During long-term monitoring, collect and evaluate fish and shellfish tissue data for risk communication purposes; compare concentrations in fish and shellfish tissue samples from the Gowanus Canal and the Gowanus Bay and Upper New York Bay reference area to Safe Tissue Levels (STLs).

STLs have been developed based on the results of the HHRA and are described further in Section 3.4.

2.2 Protection of Ecological Receptors

The FS report included ecological RAOs for the protection of the benthic community and herbivorous birds.

2.2.1 Benthic Community

The RAO for the protection of the benthic community has been revised as follows:

- Reduce the risks to benthic organisms in the canal from direct contact with PAHs, PCBs, and metals in sediment by reducing sediment toxicity to levels that are comparable to reference conditions in Gowanus Bay and Upper New York Bay.

---

2 The sample from station 326 was not included in the reference area data set because the total PCB congener concentration was more than three times higher than the concentrations in the other reference area samples.

As discussed in the FS report, PAHs were identified as the most likely cause of the toxicity observed in laboratory tests performed during the Remedial Investigation (RI) (USEPA, 2011b). The COCs contributing to risk to benthic organisms were identified as chemicals with concentrations that exceeded both risk-based screening levels and were statistically higher than reference area concentrations. The following chemicals were identified as COCs: PAHs, PCBs, lead, copper, barium, cadmium, mercury, nickel and silver. Lead and copper concentrations were elevated to a greater degree than the other metals, and correlation analysis indicated that barium, cadmium, nickel, and silver were significantly and positively correlated (i.e., co-occur) with either lead or copper (Table 2-3). Although mercury was not positively correlated with either lead or copper, average mercury concentrations in surface sediment and tissue samples from the Gowanus Canal and reference area are similar. Therefore, lead and copper were carried forward as the metals of concern. PCB concentrations exceeded sediment quality values, although the magnitude of exceedances was low. Therefore, the potential contribution of PCBs to observed toxicity relative to PAHs is considered to be low. PCBs co-occur with PAHs and therefore will be addressed through the remediation of the PAHs.

A revised site-specific risk-based PRG for total PAHs for protection of the benthic community has been developed based on the toxicity test results; details are provided in Section 4.1.1. This PRG is provided in Table 2-4. Site-specific risk-based PRGs were not developed for copper and lead because they are not likely to be bioavailable (see Section 4.2). The remediation that has been defined based on the PAH PRG includes all of the soft sediments within the canal and therefore will address all sediments with high concentrations of metals and PCBs.

PRGs for lead and copper are based on Gowanus Bay and Upper New York Bay reference area concentrations (Section 4.2) so that potential recontamination of the canal bottom can be monitored after the remedy is completed. The approach for assessing whether the RAO for the protection of the benthic community has been achieved will be as follows:

- Perform toxicity testing and compare the toxicity of Gowanus Canal sediments to Gowanus Bay and Upper New York Bay reference area sediments.
- Compare PAH concentrations in Gowanus Canal surface sediments to the site-specific risk-based PRG.
- Determine whether metals are bioavailable, and if so, compare concentrations in canal sediments to the highest non-toxic reference area concentrations.

The monitoring approach will be developed and presented in the long-term monitoring plan.

2.2.2 Protection of Herbivorous Birds

The RAO and PRG for the protection of herbivorous birds is the same as presented in the FS report, and is included here for completeness:

- Reduce to acceptable levels the risk to herbivorous birds from dietary exposure to PAHs.

The site-specific risk-based PRG of 230 milligrams per kilogram (mg/kg) for total PAHs for the protection of herbivorous birds was derived from a food web model developed for the ERA (Table 2-4). The approach for evaluating whether this RAO has been achieved will be as follows:

- Compare PAH concentrations in Gowanus Canal surface sediments to the PRG for the protection of herbivorous birds.

SECTION 3

Supplemental Human Health Evaluation

The supplemental human health evaluation that was performed to support the development of revised RAOs and PRGs consisted of the following activities:

- Development of supplemental PRGs for PAHs in sediment
- Assessment of potential risk from ingestion of PAHs in fish tissue[3]
- Calculation of risk and hazard estimates for a subsistence fishing scenario[4]
- Calculation of STLs for fish and shellfish that can be used for risk communication purposes

3.1 Supplemental Human Health PRGs

Human health-based PRGs for the direct contact pathway were presented in Appendix C of the FS report. These PRGs were based on a cumulative cancer risk of 10^{-4}, which is the upper bound of the USEPA risk management range. Supplemental human health-based PRGs have been developed based on a cumulative cancer risk of 10^{-6}, which is the lower bound of the risk management range.

Human health-based PRGs for sediment were calculated where COCs were identified for a particular use scenario (i.e., receptor type). A human health COC for the direct contact pathway is defined as any COPC that contributes a cancer risk greater than 10^{-6} and/or a noncancer HQ greater than 0.1 to a cumulative cancer risk that is greater than 10^{-4} and/or a cumulative HI that is greater than 1. Therefore, PRGs were calculated for carcinogenic PAHs based on exposure to exposed and nearshore surface sediment during recreational use of the canal by adults, adolescents, and children. PRGs were calculated only for carcinogenic constituents because the carcinogenic PAHs were the only COCs identified for the canal.

PRGs were not reported for carcinogenic PAHs for exposure to sediment that overtops the canal during significant storm events for lifetime (child/adult) residents because the PRGs based on the recreational use scenario are lower (more conservative). Therefore, sediment remediation based on the recreational use scenario will also address potential risks from exposure to sediment during a canal overflow event.

The PRGs for the recreational use scenario were calculated based on the site-specific exposure data presented in the HHRA (Appendix L of the RI report). The ratio between the target risk and the calculated risk due to a specific chemical (from the HHRA) was used to calculate the PRG. The ratio was multiplied by the exposure point concentration (EPC) (from the HHRA) to calculate the PRG.

The PRG for each COC was calculated using the following equation:

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[3] Evaluation performed in response to Boards' recommendation.

[4] Evaluation performed in response to Boards' recommendation.

$$PRG = \frac{EPC\ X\ Target\ Risk\ Level}{Calculated\ Risk}$$

Where:

EPC = exposure point concentration

$Target\ Risk\ Level$ = a target risk level of $1.67x10^{-7}$ was chosen so that the cumulative risk from exposure to all six PAHs in sediment would not exceed 10^{-6}, which is the lower bound of USEPA's risk management range

$Calculated\ Risk$ = the risk from exposure to the individual PAH through all exposure pathways (ingestion and dermal contact)

The supplemental PRGs for surface sediment based on a target cumulative risk level of 10^{-6} are provided in Table 3-1.

3.2 Risk from Exposure to PAHs in Fish

The potential human health risks from the consumption of fish and crab caught in the Gowanus Canal were evaluated in the RI. The risk calculations for the angler associated with ingestion of fish caught in the Gowanus Canal have been updated. Although the crab tissue samples collected from the canal were analyzed for PAHs, the fish tissue samples were not. Therefore, the PAH data from the crab tissue samples were used to represent potential PAH concentrations in fish tissue, and cumulative risks associated with ingestion of fish were calculated using the PAH crab data and fish tissue data for all other analytes. The three fish species evaluated in the HHRA were striped bass, white perch, and American eel. Edible tissue (filet only) samples were analyzed to assess potential human health risks associated with ingestion of striped bass, white perch, and eel. For blue crab, edible portion samples and hepatopancreas samples were analyzed separately, and the results were combined and used to estimate human health risks.

The only update to the calculations and risk methodology presented in the HHRA is the addition of the crab PAH data for each fish species. The same fraction ingested for each of the fish species was applied to the crab data for that fish species risk calculation. For example, for the striped bass it was assumed that of the total amount of recreational fish ingested, 47 percent would be striped bass; therefore, this fraction was applied to the crab PAH calculations added to the striped bass risk calculations.

The results of the risk calculations are provided as Attachment 1. The Risk Assessment Guidance for Superfund (RAGs) Part D Tables 7.8.RME through 7.10.RME and 7.7.CTE through 7.9.CTE from the attachment to the HHRA have been updated to reflect the use of the crab PAH data as a surrogate for fish tissue PAH concentrations. Additionally, the summarized risks are presented in updated versions of Table 7-4 and 7-5 from the HHRA. Because the PAHs are carcinogenic and do not have any non-carcinogenic toxicity or toxicity factors, the only changes associated with adding the crab PAH data to the fish tissue risk calculations are associated with carcinogenic risk. The risks from PAH are one to three orders of magnitude lower than the risks from PCBs. The addition of the PAH data to the fish ingestion risk calculations does not change the conclusions of the HHRA.

3.3 Subsistence Fishing Risk Calculations

This section presents additional risk calculations conducted using fish and crab tissue data collected from the Gowanus Canal. Risk calculations were performed for a subsistence fishermen (adult, adolescent, and child) associated with ingestion of fish and crab caught in the canal. The methodologies used to calculate cancer risk and noncancer hazards presented in the HHRA were used for the subsistence fisherman scenario. Edible tissue (filet only) samples were analyzed to assess potential human health risks associated with ingestion of striped bass, white perch, and eel. For blue crab, edible portion samples and hepatopancreas samples were analyzed separately and the results were combined and used to estimate human health risks. The PAH data for the crab tissue samples were used to represent potential PAH concentrations in fish tissue because fish tissue samples were not analyzed for PAHs, and cumulative risks associated with ingestion of fish were calculated using the PAH crab data and fish tissue data for all other analytes. The same fraction ingested for each of the fish species was applied to the crab data for that fish species risk calculations. For example, for the striped bass it was assumed that of the total amount of recreational fish ingested, 47 percent would be striped bass; therefore, this fraction was applied to the crab PAH calculations added to the striped bass risk calculations.

The exposure parameters (e.g., exposure frequency and duration) for the subsistence fisherman scenario were assumed to be the same as those of the angler scenario, with the exception of the fish ingestion rate. The fish ingestion rate was based on the assumption that subsistence fishermen and their families eat two fish meals/per week. This assumption is based on information obtained from a 2010 Fish Consumption Education Project in Brooklyn (Going Coastal Inc., 2010). The purpose of the project was to identify who is fishing and what is being caught and eaten along the shores of Brooklyn in order to reduce the consumption of contaminated fish and lessen potential health problems among the local subsistence and recreational fishing population. Of the respondents, 57 percent said they were trying to catch striped bass, and more than half responded that they were trying to catch bluefish. The survey showed that most of the fish caught were consumed. The median number of fish taken home ("keepers") during the month-long survey was 3.5, but the range was large and appeared to be correlated to how often an angler fished. Almost all of the keepers are eaten either by the anglers themselves (62 percent), shared with their family and friends, and/or given to other anglers. More than a quarter of respondents explicitly said that children under the age of 15 eat the fish they catch. In a comparison of the population of anglers who feed self-caught fish to children under the age of 15 to those who do not, the former consume much more fish per month than the latter; those who feed their catch to children have a median consumption value of 8 fish meals per month and the latter has a median value of 3 fish meals per month (statistically different according to the independent samples median test) (Going Coastal, Inc., 2010). The fish ingestion rate for the subsistence fishermen risk calculations was based on the median consumption value of 8 fish meals per month for those who feed their catch to children.

Table 4.7.RME in Attachment 2 presents the exposure parameters that were used for the subsistence fisherman exposure. The table numbers in the attachment sequentially follow

the tables presented in the HHRA. The reasonable maximum exposure (RME) risk calculations for the subsistence fisherman who ingest fish and crab caught from the canal are presented in Attachment 2, Tables 7.11.RME through 7.13.RME. A summary of the cancer risks and noncancer hazards are presented in Tables 3-2 and 3-3, respectively.

Adult Subsistence Fishermen

- Total Fish ELCR (RME) = 1 x 10^{-3}, above USEPA's target risk range. The risk from ingestion of eel (bottom feeders) and striped bass (top level predators) each exceed USEPA's target risk range. The risk is associated primarily with ingestion of eel (71 percent). The primary risk drivers for ingestion of eel and striped bass are PCBs, with smaller contributions from pesticides (eel only), PAHs, and metals. The dioxin-like PCBs and nondioxin-like PCBs contributed similar levels of risk. The average concentration of non-dioxin-like PCBs and dioxin-like PCB Toxic Equivalents (TEQs) in the eel from the canal is almost two times higher than the average concentrations in the reference samples (see Table 7-3 in the RI report for average concentrations in canal and reference fish and crab tissue samples).
- Total white perch (middle level predators) ELCR (RME) is within the target risk range.
- Total Crab ELCR (RME) = 4 x 10^{-4}, above USEPA's target risk range. The primary risk drivers are PCBs, with smaller contributions from PAHs and arsenic. The average concentration of non-dioxin-like PCBs and dioxin-like PCB TEQ in blue crab from the canal (see Table 7-3 in the RI report for average concentrations in canal and reference fish and crab tissue samples) is almost twice the average concentration of PCBs in blue crab from the reference samples.
- Total Fish HI (RME) = 42, above USEPA's target HI. The HIs for ingestion of striped bass, white perch, and eel exceed USEPA's target HI. The hazard is associated with PCBs, with smaller contributions from mercury (HI below 1 for base and perch, HI equal to 1 for eel). About 70 percent of the total HI is contributed by assumed consumption of American eel. The average concentration of total PCBs in the eel from the canal is about two times higher than the average concentration of total PCBs in the reference samples (see Table 7-3 in the RI report for average concentrations in canal and reference fish tissue samples). The average concentration of mercury in the eel from the canal samples is slightly lower than the average concentration in the eel from the reference samples.
- Total Crab HI (RME) = 10, above USEPA's target HI. The hazard is associated with PCBs, with smaller contributions from mercury (HI equal to 1). The average concentration of PCBs in blue crab from the canal is almost twice the average concentration of PCBs in blue crab from the reference samples (Table 7-3 in the RI report); however, the average concentrations of mercury in blue crab from the reference samples are slightly higher than the average concentrations in the canal samples.

Adolescent Subsistence Fishermen

- Total Fish ELCR (RME) = 2 x 10^{-4}, above USEPA's target risk range. The risk from ingestion of eel (bottom feeders) exceeds USEPA's target risk range. The primary risk drivers are PCBs and chromium, with smaller contributions from pesticides,

PAHs, and arsenic. The dioxin-like PCBs and nondioxin-like PCBs contributed similar levels of risk.
- Total striped bass (top level predators) ELCR (RME) is within the target risk range.
- Total white perch (middle level predators) ELCR (RME) is within the target risk range.
- Total Crab ELCR (RME) = 1 x 10^{-4}, equal to USEPA's upper target risk range. The primary risk drivers are PCBs, PAHs, and arsenic.
- Total Fish HI (RME) = 34, above USEPA's target HI. The HIs for ingestion of striped bass, white perch, and eel exceed USEPA's target HI. The hazard is associated with PCBs, with smaller contributions from mercury (HI below 1). About 70 percent of the total HI is contributed by assumed consumption of American eel.
- Total Crab HI (RME) = 8, above USEPA's target HI. The hazard is associated with PCBs, with smaller contributions from mercury (HI below 1).

Children of Subsistence Fishermen

- Total Fish ELCR (RME) = 6 x 10^{-4}, above USEPA's target risk range. The risk from ingestion of eel (bottom feeders) exceeds USEPA's target risk range. The primary risk drivers are PCBs and chromium, with smaller contributions from pesticides, PAHs, and arsenic. The dioxin-like PCBs and nondioxin-like PCBs contributed similar levels of risk.
- Striped bass (top level predators) ELCR (RME) is equal to USEPA's upper target risk range.
- Total white perch (middle level predators) ELCR (RME) is within the target risk range.
- Total Crab ELCR (RME) = 2 x 10^{-4}, above USEPA's upper target risk range. The primary risk drivers are PCBs, PAHs, and arsenic.
- Total Fish HI (RME) = 63, above USEPA's target HI. The HIs for ingestion of striped bass, white perch, and eel exceed USEPA's target HI. The hazard is associated with PCBs, with smaller contributions from mercury (HI less than 1 for perch). About 70 percent of the total HI is contributed by assumed consumption of American eel.
- Total Crab HI (RME) = 14, above USEPA's target HI. The hazard is associated with PCBs, with smaller contributions from mercury.

3.4 Safe Tissue Levels for Fish and Crab Ingestion

Human health risk-based STLs were calculated for fish and crab tissue for COCs that were identified for the recreational angler and subsistence fishermen scenarios. A COC is defined as any COPC that contributes significant risks to a pathway in a use scenario for a receptor. Any COPC with a cancer risk greater than 1 x 10^{-6} and/or a noncarcinogenic HQ greater than 0.1 where the USEPA target thresholds (cumulative cancer risk greater than 1 x 10^{-4} and/or the HI for a target organ is greater than 1) are exceeded is considered a COC. The COCs for the three fish species evaluated in the HHRA and the crab are:

- Striped Bass – PCBs, arsenic, and mercury; and benzo(a)pyrene and dibenzo(a,h)anthracene (from crab tissue PAH data)

- White Perch – PCBs; benzo(a)pyrene (from crab tissue PAH data)

- American Eel – PCBs, arsenic, chromium, mercury, dieldrin, p,p'-DDT; and benzo(a)pyrene and dibenz(a,h)anthracene (from crab tissue PAH data)
- Blue Crab – PCBs, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene, arsenic, and mercury

For carcinogenic COCs, the STLs were calculated as follows:

$$STL = \frac{EPC\ X\ Target\ Cancer\ Risk}{Total\ Cancer\ Risk}$$

Where:

EPC = exposure point concentration from the HHRA (mg/kg)

Target Cancer Risk = target cancer risk, set at 10^{-6} and 10^{-4}

Total Cancer Risk = total risk to receptor from the fish or crab, from the HHRA for the recreational angler or Section 3.3 of this memorandum for the subsistence fisherman

For noncarcinogenic COCs, the STLs were calculated as follows:

$$STL = \frac{EPC\ X\ Target\ HI}{Total\ HI}$$

Where:

EPC = exposure point concentration from the HHRA (mg/kg)

Target HI = target hazard index, set at 1 and also based on the number of COCs affecting the target organ (e.g., if two COCs have the same target organ then the target HI was set at 0.5)

Total HI = total hazard to receptor from the HHRA for the recreational angler or Section 3.3 of this memorandum for the subsistence fisherman

The detailed STL calculations are provided in Attachment 3, Tables 12.1 and 12.2; these calculations show the STLs for all COPCs. Human health risk-based STLs for fish and crab tissue COCs for the recreational angler and subsistence fisherman are summarized in Tables 3-4 and 3-5, respectively. The target risk levels for the STLs were set at 10^{-6} and 10^{-4}. The target HIs were set so that the total target organ HIs do not exceed 1.

Table 3-7 compares the EPC for each species and COC in the Gowanus Canal and Upper New York Bay reference areas to the STLs. At the 10^{-6} risk level, almost all of the fish and crab EPCs in the canal and reference area exceed the STLs. At the 10^{-4} risk level, dioxin-like and non-dioxin like PCBs in the Gowanus Canal exceed the STLs for one or more fish species or crab based on the recreational angler or subsistence fisherman. Arsenic also exceeds the STLs for some species to a smaller degree. For noncarcinogens, total PCBs exceed the STLs for all species in the Gowanus Canal and reference area.

SECTION 4

Supplemental Ecological Evaluation

The supplemental ecological evaluation that was performed to support development of revised RAOs and PRGs included the following elements:

- Development of a revised PRG for total PAHs
- Supplemental evaluation of metals
- Evaluation of risk to avian wildlife from PAHs in fish[5]

4.1 Approach for PAHs

4.1.1 Revised PRG

Revised potential PRGs for total PAHs were derived through an analysis of the toxicity test results and co-located sediment chemistry results. Sediment toxicity data are available from the RI 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, 5 of which represented reference conditions in Gowanus Bay and Upper New York Bay. Laboratory control sediment was also used in each test. Test results are summarized in Table 4-1. Because greater responses were seen in the amphipod tests, only those results were used to derive PRGs.

Two samples, 326 and 313, were excluded from any further analysis. As documented in the RI, sample 326, a reference station, had a greater number and magnitude of exceedances of screening values for metals and was not considered appropriate for use in characterizing reference toxicity. As documented in RI, sample 313 was considered a potential outlier and was excluded from the analysis.

Two approaches were used to derive potential PRGs for total PAHs. First, graphical plots of each toxicity test endpoint versus total PAH concentrations were prepared (Figures 4-1 to 4-3). For these plots, all results were normalized to the laboratory control, and presented as the fraction of control.[6] On each plot, a horizontal line (green) represents the lowest toxicity test result for a reference sample (considered the lower bound of the reference envelope). Also included on each plot is a line (red) representing a 20 percent reduction relative to the control. A statistical comparison was also made between each canal station response and the pooled reference station responses. Canal station responses that were statistically different from the mean reference response are highlighted in red.[7]

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[5] Evaluation in response to Boards' recommendation.

[6] If the result for a station was greater than the result for the laboratory control, then the fraction of control value is greater than 1.

[7] Pair-wise t-tests were used to compare a canal sample response to the pooled reference station response. Statistical significance was set at $\alpha = 0.05$.

Two alternative PRGs were identified to represent different levels of protection. The first potential PRG was selected by identifying the lowest concentration that was outside the lower of the two horizontal lines, which is the lowest observed adverse effect concentration (LOAEC). The second potential PRG was selected by identifying the concentration immediately below the LOAEC, which is the greatest no observed adverse effect concentration (NOAEC). The stations representing the LOAEC and NOAEC are circled on the plots.

The second approach for deriving potential PRGs used the data to estimate total PAH concentrations associated with a various percent reductions in response. Toxicity Response Analysis Program (TRAP) software, version 1.2 [8], was used to attempt to fit a model to the data so that effects concentrations could be determined. Because the polychaete had lower test responses than the amphipod, this analysis focused on the amphipod test data alone. A 20 percent effects concentration (EC20) is typically considered a chronic response threshold and could be appropriate as a PRG.

The potential PRGs for total PAHs are presented in Table 4-2. The potential PRGs based on the NOAEC ranged from 39 mg/kg for amphipod survival to 7.8 mg/kg for growth and reproduction. In all cases, the sample that represents the NOAEC is either a reference station or a canal station with a test response that was not statistically different from the reference response. Potential PRGs based on the LOAEC for total PAHs ranged from 67 mg/kg for amphipod survival to 14 mg/kg for growth and reproduction. In the case of the LOAEC for survival, the station is the second lowest total PAH concentration that was statistically different from the reference response. The LOAECs for growth and reproduction are the station with the lowest total PAH concentration that was statistically different from reference.

TRAP estimates of EC20s are presented in Table 4-3. The potential PRGs for total PAHs ranged from 72 mg/kg for amphipod survival to 12 mg/kg for growth. The TRAP estimates were similar to the graphical estimates. However, the 95 percent confidence intervals around these estimates were large, indicating high variability of the dose-response relationships. Most relationships were not statistically significant. Therefore, the TRAP results were used only to verify the PRGs developed using the graphical approach.

Based on the above information, the site-specific toxicity test data are appropriate for use in selecting a PRG for total PAHs. 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 started can be assumed to fall between those two concentrations. This threshold is commonly calculated at the geometric mean of the NOAEC and LOAEC. This approach has been used in USEPA Region 1 at other sites. A recent example is the Area A wetland operable unit at the New London Submarine Base in Groton, Connecticut. The 2010 Record of Decision for Site 2B states: "The geometric means of the NOECs and LOECs were then selected as the [remediation goals]" (NAVFAC, 2010).

Because of the sample size and the variability of the site-specific dose-response relationships, there is uncertainty in the identified NOAECs and LOAECs presented in

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[8] http://www.epa.gov/med/Prods_Pubs/trap.htm

Table 4-2. One way to address that uncertainty is to identify all potential NOAECs and LOAECs from the series and then calculate a measure of their central tendency, such as the geometric mean. In addition, there is some variability in the total organic carbon (TOC) content of the samples from key stations included in each calculation. TOC is a key parameter influencing PAH bioavailability. Therefore, the calculations were performed on an organic carbon (OC) normalized basis to address this variation. The geometric means of the potential OC-normalized NOAECs and LOAECs were calculated and then converted to a dry weight basis assuming the mean canal-wide surface sediment TOC concentration of 6 percent. Figure 4-4 identifies the potential LOAECs (circled in red) and NOAECs (circled in blue) for amphipod growth. Tables 4-4 and 4-5 present the geometric mean of the LOAECs and NOAECs normalized to the canal mean TOC of 6 percent, respectively. The recommended PRG for total PAHs is 20 mg/kg at 6 percent TOC.

4.1.2 Supporting Information

Additional data and analyses from the RI were considered in selecting PRGs. Site-specific bioavailability of PAHs is important in interpreting sediment toxicity tests results. The bioavailability and potential toxicity of total PAHs were evaluated using the Equilibrium-partitioning Sediment Benchmark Toxic Unit (ESBTU) approach described in USEPA (2003). The ESBTU method estimates the bioavailable and potentially toxic fraction of the total PAHs in the bulk sediment. ESBTUs were calculated using dry weight concentrations of individuals PAHs, site-specific levels of OC, and an adjustment factor to account for the toxicological contribution of unmeasured PAHs (for this analysis, the factor for adjusting from 13 measured PAHs to 34 PAHs, at 50 percent certainty, was used because a factor for adjusting from 16 measured PAHs was not available). An attempt was made to quantify the alkylated PAHs from the sample chromatograms; however, they were only identified in a subset of the samples of interest. Because alkylated PAH data were not available for all of the toxicity test stations, the analysis of PAH bioavailability and potential toxicity used the adjustment factor instead.

Sediment samples with ESBTUs of less than 1.0 indicate that the PAHs are not bioavailable in concentrations that pose risk and are acceptable for the protection of benthic organisms. If the ESTBU is greater than 1.0, then PAHs may be bioavailable in concentrations that pose risk and sensitive benthic organisms may be unacceptably affected. The likelihood of adverse effects increases with increasing ESBTU.

Calculated ESBTUs for canal and reference samples ranged from 0.14 to 377 (Table 4-6). Figure 4-5 shows the relationship between amphipod survival in a sample and the calculated ESBTU. Figure 4-6 shows the same relationship for amphipod growth. The results indicate that the PAHs are generally bioavailable and potentially toxic in the canal samples. The samples associated with the NOAEC and LOAEC are circled. The ESBTU results show that total PAH concentrations less than the LOAEC and NOAEC should not be toxic, and that increased toxicity should be expected at concentrations greater than the LOAEC and NOAEC.

These results are consistent with the porewater results presented in sediment and surface water sampling winter and summer reports for the Gowanus Canal prepared for National Grid (GEI, 2011 and 2012). Tables 18 and 19 of the winter and summer reports respectively present toxic units (TUs) based on PAHs measured in sediment porewater samples from the canal. The calculated TUs show that PAHs are bioavailable and potentially toxic throughout the site.

4.2 Approach for Metals

As noted in Section 2.2.1, 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. USEPA has developed a model to evaluate the toxicity of divalent metals (cadmium, copper, lead, nickel, silver, zinc) to sediment-dwelling organisms (USEPA, 2005). The model is based on the assumption that divalent metals can only cause or contribute to sediment toxicity when the sum of the molar concentrations of cadmium, copper, lead, nickel, silver, and zinc (simultaneously extracted metals, or SEM) exceeds the molar concentration of the binding phase, acid-volatile sulfides (or AVS). Under such conditions, insufficient AVS are available to bind all of the divalent metals (SEM) in the particulate (precipitated) matrix which is not bioavailable, and metals can accumulate (dissolved) in pore water to levels that may be toxic to sediment-dwelling organisms.

Because metals also can bind to OC in sediment, the reliability of the model has been improved by incorporating the site-specific fraction of TOC in sediment (foc) into the model (i.e., ∑(SEM-AVS)/foc). The model predicts that toxicity is likely when the (∑SEM-AVS/foc) is greater than 3,000 micromoles (µmol) per grams organic carbon (goc), uncertain when the concentration is between 130 and 3,000 µmol/goc, and not likely when the concentration is less than 130 µmol/goc (USEPA, 2005).

The results of the AVS and SEM analyses provided in the RI report were used to calculate SEM-AVS/foc for each toxicity test sample. The results are reported in Table 4-7. The results strongly suggest that the metals currently are not 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, the maximum Gowanus Bay and Upper New York Bay concentrations for the reference stations that showed no toxicity were selected as PRGs for copper and lead. These concentrations are as follows:

- Copper – 80 mg/kg
- Lead – 94 mg/kg

4.3 Evaluation of Risk to Avian Wildlife from Exposure to PAHs in Fish

Risk to fish-eating avian wildlife from PAHs was not assessed in the ERA. Vertebrates metabolize PAHs, and it is generally assumed that they would not bioaccumulate significantly in fish tissue. However, no data for PAHs in fish tissue were collected to verify this assumption. Therefore, a supplemental risk evaluation was performed to investigate whether fish-eating avian wildlife are at risk. Crab tissue samples collected from the canal and analyzed for PAHs were used as a surrogate for fish tissue. Crab tissue samples used in the evaluation are presented in Table 4-8. The 95 percent upper confidence limit of the mean (UCL) was used as EPC.

Dietary exposure of PAHs to fish-eating avian wildlife was estimated using a food-web modeling approach. For receptor species used in food-web modeling, the dietary intake (dose) of each constituent (in mg of chemical per kg of body weight per day) was calculated by using species-specific life history information, where available, and the following formula (modified from USEPA, 1993):

$$DI_x = \frac{[[\sum_i (FIR)(FC_{xi})(PDF_i)] + [(FIR)(SC_x)(PDS)]]}{BW}\left(AUF\right)$$

Where:

DI_x	=	Dietary intake for constituent x (mg constituent/kg body weight/day)
FIR	=	Food ingestion rate (kg/day, dry-weight)
FC_{xi}	=	Concentration of constituent x in food item i (mg/kg, dry-weight)
PDF_i	=	Proportion of diet composed of food item i (dry-weight basis)
SC_x	=	Concentration of constituent x in sediment (mg/kg, dry-weight)
PDS	=	Proportion of diet composed of sediment (dry-weight basis)
BW	=	Body weight (kg)
AUF	=	Area use factor; percent (decimal) of habitat used by receptor relative to the size of the site

Receptor-specific values used as inputs to this equation are provided in Table 4-9. Potential risk was then evaluated using the HQ approach, which compares the estimated dose to a toxicity reference value (TRV) (Table 4-9). All dietary inputs and the TRV were the same as those used in the ERA. The calculated HQs were less than 1, indicating there is no unacceptable risk to fish eating avian wildlife (Table 4-9).

SECTION 5

Future Sediment Quality in the Gowanus Canal

The sediment remedy selected for the Gowanus Canal will most likely include a capped, clean surface on the canal bottom. The cap is expected to experience some level of recontamination as new sediments are deposited on top of the cap given the urban site setting. "Anthropogenic background" in sediments in urban waterways generally refers to contaminant contributions from stormwater discharges and runoff, surface runoff and direct atmospheric deposition that are either directly deposited or transported in from upstream or downstream areas.

The sediments and solids that will accumulate in the canal after the remedy is completed will be derived mainly from combined sewer overflow (CSO) discharges that are not controlled as part of Superfund or Clean Water Act actions, and to a lesser degree, by (1) storm sewers; (2) direct runoff to the canal; and (3) suspended sediments transported into the canal from the Gowanus Bay and Upper New York Bay via tides and from the flushing tunnel. Only 2 percent of the Gowanus Canal watershed is drained by storm sewers and 6 percent is drained by direct runoff (NYCDEP, 2009). Therefore, the relative contributions of CSO solids (more prominently in the upper reach of the canal) and the suspended sediments from the Gowanus Bay and Upper New York Bay (mainly in the lower reach) will largely influence the anthropogenic background levels that will be established in the canal in the future. The concentrations of PAHs, PCBs and metals in the newly deposited sediments will depend on the level of CSO reductions that are achieved.

The conditions that govern sediment and contaminant transport and deposition in the canal will change after implementation of the New York City Department of Environmental Protection's (NYCDEP) Gowanus Canal Waterbody/Watershed Facility Plan (Facility Plan; NYCDEP, 2009). Improvements under the Facility Plan are scheduled to be completed in 2014. The technical memorandum *Preliminary Estimate of Solids Reductions Needed to Achieve Remediation Goals, Gowanus Canal, Brooklyn New York* (USEPA, 2012) describes current and expected future conditions after implementation of the Facility Plan. Rehabilitating the Flushing Tunnel will increase its average capacity by 40 percent, and reconstructing the Gowanus Pump Station and replacing the force main will reduce the annual volume of CSO discharges to the entire canal by 34 percent in a typical precipitation year, although the CSO solids load at the head of the canal (outfall RH-034) will increase by approximately 5 percent and still contribute 97 percent of the CSO solids load to the upper reach of the canal. The net effect of these changes cannot be precisely quantified until after the improvements are completed. Nevertheless, a preliminary estimate (USEPA, 2012) indicates that additional CSO reductions of 58 to 74 percent should be sufficient to achieve the PRGs for the PAHs and for lead, copper and PCBs.

SECTION 6

References

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TABLE 2-1

Summary of Human Health Preliminary Remediation Goals for Sediment

Gowanus Canal, Brooklyn, New York

Chemical	Preliminary Remediation Goal (mg/kg) 10^{-4} risk level[1]	Preliminary Remediation Goal (mg/kg) 10^{-6} risk level[2]	Reference Area Mean (mg/kg)
Benzo(a)anthracene	24	0.40	0.51
Benzo(a)pyrene	2.4	0.040	0.46
Benzo(b)fluoranthene	24	0.40	0.63
Benzo(k)fluoranthene	240	4.0	0.36
Dibenz(a,h)anthracene	2.4	0.040	ND
Indeno(1,2,3-c,d)pyrene	24	0.40	0.34

[1] Target risk level of 10^{-5} for individual PAHs so that cumulative risk will not exceed 10^{-4}

[2] Target risk level of 1.67×10^{-7} for individual PAHs so that cumulative risk will not exceed 10^{-6}

ND - not detected

mg/kg - milligrams per kilogram

PAH - polycyclic aromatic hydrocarbon

TABLE 2-2

Comparison of Surface Water Concentrations in Gowanus Canal and Reference Area

Gowanus Canal, Brooklyn, New York

Human Health Contaminant of Concern	Comparison of Gowanus Canal to Reference Area Surface Water Samples [1]	
	Dry Weather Samples	Wet Weather Samples
Benzo(a)anthracene	nsd	nsd
Benzo(a)pyrene	nsd	nsd
Benzo(b)fluoranthene	Canal > Reference	nsd
Dibenz(a,h)anthracene	ND	nsd
Indeno(1,2,3-c,d)pyrene	nsd	nsd

[1] From Table 4-11 of the RI Report (USEPA, 2011b); 0.05 significance level

nsd - no significant difference

ND - not detected in Canal samples

TABLE 2-3

Correlation Analysis of Metals in Surface Sediment Samples

Gowanus Canal, Brooklyn, New York

	Correlation Coefficient	
Metal	Copper	Lead
Barium	0.68	0.77
Cadmium	0.42	0.43
Mercury	ns	ns
Nickel	0.68	0.43
Silver	0.47	ns

0.05 significance level

ns - not significant

TABLE 2-4

Summary of Revised Ecological Preliminary Remediation Goals for Sediment

Gowanus Canal, Brooklyn, New York

Endpoint	Total PAH (mg/kg)	Comment
Protection of the benthic community	20	At 6% TOC; geomean of TOC-normalized potential NOAECs and LOAECs for amphipod growth
Protection of herbivorous birds	230	Not revised

TOC - total organic carbon
NOAEC - no observable adverse effects concentration
LOAEC - lowest observable adverse effects concentration
PAH - polycyclic aromatic hydrocarbon
mg/kg - milligrams per kilogram

TABLE 3-1

Calculation of Additional Human Health Preliminary Remediation Goals for Sediment

Gowanus Canal, Brooklyn, New York

Surface Sediment—exposed and nearshore sediment in Gowanus Canal; Recreational Adult/Adolescent/Child						
	Exposure Point	Carcinogenic Risk				PRG - 1.67x10^{-7}
Chemical	Concentration (mg/kg)	Inh	Ing	Der	Total	(mg/kg)
Benzo(a)anthracene	1.3E+02	--	2.3E-05	3.0E-05	5.3E-05	4.0E-01
Benzo(a)pyrene	1.1E+02	--	1.9E-04	2.5E-04	4.4E-04	4.0E-02
Benzo(b)fluoranthene	1.1E+02	--	2.0E-05	2.6E-05	4.7E-05	4.0E-01
Benzo(k)fluoranthene	6.5E+01	--	1.2E-06	1.5E-06	2.7E-06	4.0E+00
Dibenz(a,h)anthracene	6.2E+00	--	1.1E-05	1.4E-05	2.6E-05	4.0E-02
Indeno(1,2,3-c,d)pyrene	4.9E+01	--	8.8E-06	1.1E-05	2.0E-05	4.0E-01

For carcinogens: PRG = (Exposure Point Concentration x Target Risk Level)/ Calculated Cancer Risk
Inh - inhalation; Ing - ingestion, Der - dermal; PRG - Preliminary Remediation Goal
Target risk of 1.67 x10^{-7} for each chemical would result in cumulative risk of 10^{-6}.
mg/kg - milligrams per kilogram

TABLE 3-2

Summary of Total RME Cancer Risks for Subsistence Fisherman

Gowanus Canal, Brooklyn, New York

		Receptor			
Media	Exposure Pathway	**Subsistence Fisherman Adult Cancer Risk**	**Subsistence Fisherman Adolescent Cancer Risk**	**Subsistence Fisherman Child Cancer Risk**	**Total Subsistence Fisherman Cancer Risk**
Striped Bass in Gowanus Canal (top-level predator fish)	Ingestion	3E-04	6E-05	1E-04	4E-04
	Total	3E-04	6E-05	1E-04	4E-04
White Perch in Gowanus Canal (middle-level predator fish)	Ingestion	5E-05	1E-05	3E-05	9E-05
	Total	5E-05	1E-05	3E-05	9E-05
Eel in Gowanus Canal (bottom feeder fish)	Ingestion	8E-04	2E-04	4E-04	1E-03
	Total	8E-04	2E-04	4E-04	1E-03
Blue Crab in Gowanus Canal	Ingestion	4E-04	1E-04	2E-04	8E-04
	Total	4E-04	1E-04	2E-04	8E-04
Fish Total Risk		1E-03	2E-04	6E-04	2E-03
Crab Total Risk		4E-04	1E-04	2E-04	8E-04

Risk associated with fish also includes PAH concentrations from crab data.
PAH - polycyclic aromatic hydrocarbon
RME - reasonable maximum estimate

TABLE 3-3

Summary of Total RME Noncancer Hazards for Subsistence Fisherman

Gowanus Canal, Brooklyn, New York

		Receptor		
Media	Exposure Pathway	Subsistence Fisherman Adult Noncancer Hazard	Subsistence Fisherman Adolescent Noncancer Hazard	Subsistence Fisherman Child Noncancer Hazard
Striped Bass in Gowanus Canal (top-level predator fish)	Ingestion	11	9	16
	Total	11	9	16
White Perch in Gowanus Canal (middle-level predator fish)	Ingestion	2	2	3
	Total	2	2	3
Eel in Gowanus Canal (bottom feeder fish)	Ingestion	29	24	44
	Total	29	24	44
Blue Crab in Gowanus Canal	Ingestion	10	8	14
	Total	10	8	14
Fish Total Risk		42	34	63
Crab Total Risk		10	8	14

Risk associated with fish also includes PAH concentrations from crab data.
PAH - polycyclic aromatic hydrocarbon
RME - reasonable maximum estimate

TABLE 3-4

Summary of Safe Chemical Concentration Levels in Biota - Recreational Angler

Gowanus Canal, Brooklyn, New York

Biota: Striped Bass

COCs	Carcinogenic Risk-Based			Non-carcinogenic Risk-Based				
	Target Risk		Basis	Target Hazard	Basis	Target Organ	Target-organ-specific	
	ELCR=10^{-6}	ELCR=10^{-4}		HQ=1			Note[1]	Target Hazard
Dioxin-Like PCB TEQ	1.1E-07	1.1E-05	adult	NA			NA	
Nondioxin-Like	8.4E-03	8.4E-01	adult	NA			NA	
Total PCB	NA	NA		7.1E-02	child	Ocular, Finger and Toe Nails	7.1E-02	HQ=1
Arsenic	1.1E-02	1.1E+00	adult	1.1E+00	child	Skin, Vascular	1.1E+00	HQ=1
Mercury	NA	NA		3.5E-01	child	Developmental Neurological	3.5E-01	HQ=1
Benzo(a)pyrene	1.1E-03	1.1E-01	child	NA			NA	
Dibenz(a,h)anthracene	1.1E-03	1.1E-01	child	NA			NA	

Biota: White Perch

COCs	Carcinogenic Risk-Based			Non-carcinogenic Risk-Based				
	Target Risk		Basis	Target Hazard	Basis	Target Organ	Target-organ-specific	
	ELCR=10^{-6}	ELCR=10^{-4}		HQ=1			Note[1]	Target Hazard
Dioxin-Like PCB TEQ	5.6E-07	5.6E-05	adult	NA			NA	
Nondioxin-Like	4.4E-02	4.4E+00	adult	NA			NA	
Total PCB	NA	NA		3.7E-01	child	Ocular, Finger and Toe Nails	3.7E-01	HQ=1

Biota: Eel

COCs	Carcinogenic Risk-Based			Non-carcinogenic Risk-Based				
	Target Risk		Basis	Target Hazard	Basis	Target Organ	Target-organ-specific	
	ELCR=10^{-6}	ELCR=10^{-4}		HQ=1			Note[1]	Target Hazard
Dieldrin	1.1E-03	1.1E-01	adult	1.9E-01	child	Liver	1.9E-01	HQ=1
Dioxin-Like PCB TEQ	1.1E-07	1.1E-05	adult	NA			NA	
Nondioxin-Like	8.9E-03	8.9E-01	adult	NA			NA	
Total PCB	NA	NA		7.6E-02	child	Ocular, Finger and Toe Nails	7.6E-02	HQ=1
Arsenic	1.2E-02	1.2E+00	adult	1.1E+00	child	Skin, Vascular	1.1E+00	HQ=1
Chromium	1.7E-02	1.7E+00	child	1.1E+01	child	Not identified	1.1E+01	HQ=1
Mercury	NA	NA		3.8E-01	child	Developmental Neurological	3.8E-01	HQ=1
Benzo(a)pyrene	1.1E-03	1.1E-01	child	NA			NA	
Dibenz(a,h)anthracene	1.1E-03	1.1E-01	child	NA			NA	

Biota: Blue Crab

COCs	Carcinogenic Risk-Based			Non-carcinogenic Risk-Based				
	Target Risk		Basis	Target Hazard	Basis	Target Organ	Target-organ-specific	
	ELCR=10^{-6}	ELCR=10^{-4}		HQ=1			Note[1]	Target Hazard
Benzo(a)pyrene	5.6E-04	5.6E-02	child	NA			NA	
Dibenz(a,h)anthracene	5.6E-04	5.6E-02	child	NA			NA	
Dioxin-Like PCB TEQ	5.7E-08	5.7E-06	adult	NA			NA	
Nondioxin-Like	4.4E-03	4.4E-01	adult	NA			NA	
Total PCB	NA	NA	adult	3.8E-02	child	Ocular, Finger and Toe Nails	3.8E-02	HQ=1
Arsenic	5.9E-03	5.9E-01	adult	5.6E-01	child	Skin, Vascular	5.6E-01	HQ=1
Mercury	NA	NA	adult	1.9E-01	child	Developmental Neurological	1.9E-01	HQ=1

Units are in mg (chem)/kg (biota tissue)

Note 1 - when more than one COPC has the same target organ, non-carcinogenic risk-based PRG is divided by the number of COPCs with that target organ to address cumulative effects.

COCs - contaminants of concern

ELCR - expected lifetime cancer risk

HQ - hazard quotient

NA - not applicable

PCB - polychlorinated biphenyl

TEQ - toxic equivalent

TABLE 3-5

Summary of Safe Chemical Concentration Levels in Biota - Subsistence Fisherman

Gowanus Canal, Brooklyn, New York

Biota: Striped Bass

COCs	Carcinogenic Risk-Based			Non-carcinogenic Risk-Based				
	Target Risk		Basis	Target Hazard	Basis	Target Organ	Target-organ-specific	
	ELCR=10^{-6}	ELCR=10^{-4}		HQ=1			Note[1]	Target Hazard
Dioxin-Like PCB TEQ	4.3E-08	4.3E-06	adult	NA			NA	
Nondioxin-Like	3.3E-03	3.3E-01	adult	NA			NA	
Total PCB	NA	NA		3.0E-02	child	Ocular, Finger and Toe Nails	3.0E-02	HQ=1
Arsenic	4.5E-03	4.5E-01	adult	4.6E-01	child	Skin, Vascular	4.6E-01	HQ=1
Mercury	NA	NA		1.5E-01	child	Developmental Neurological	1.5E-01	HQ=1
Benzo(a)pyrene	4.6E-04	4.6E-02	child	NA			NA	
Dibenz(a,h)anthracene	4.6E-04	4.6E-02	child	NA			NA	

Biota: White Perch

COCs	Carcinogenic Risk-Based			Non-carcinogenic Risk-Based				
	Target Risk		Basis	Target Hazard	Basis	Target Organ	Target-organ-specific	
	ELCR=10^{-6}	ELCR=10^{-4}		HQ=1			Note[1]	Target Hazard
Dioxin-Like PCB TEQ	2.2E-07	2.2E-05	adult	NA			NA	
Nondioxin-Like	1.7E-02	1.7E+00	adult	NA			NA	
Total PCB	NA	NA		1.6E-01	child	Ocular, Finger and Toe Nails	1.6E-01	HQ=1
Mercury	NA	NA		7.9E-01	child	Developmental Neurological	7.9E-01	HQ=1
Benzo(a)pyrene	2.4E-03	2.4E-01	child	NA			NA	

Biota: Eel

COCs	Carcinogenic Risk-Based			Non-carcinogenic Risk-Based				
	Target Risk		Basis	Target Hazard	Basis	Target Organ	Target-organ-specific	
	ELCR=10^{-6}	ELCR=10^{-4}		HQ=1			Note[1]	Target Hazard
Dieldrin	4.5E-04	4.5E-02	adult	8.1E-02	child	Liver	4.1E-02	HQ=0.5
p,p'-DDT	2.1E-02	2.1E+00	adult	8.1E-01	child	Liver	4.1E-01	HQ=0.5
Dioxin-Like PCB TEQ	4.6E-08	4.6E-06	adult	NA			NA	
Nondioxin-Like	3.6E-03	3.6E-01	adult	NA			NA	
Total PCB	NA	NA		3.2E-02	child	Ocular, Finger and Toe Nails	3.2E-02	HQ=1
Arsenic	4.8E-03	4.8E-01	adult	4.9E-01	child	Skin, Vascular	4.9E-01	HQ=1
Chromium	7.1E-03	7.1E-01	child	4.9E+00	child	Not identified	4.9E+00	HQ=1
Mercury	NA	NA		1.6E-01	child	Developmental Neurological	1.6E-01	HQ=1
Benzo(a)pyrene	4.9E-04	4.9E-02	child	NA			NA	
Dibenz(a,h)anthracene	4.9E-04	4.9E-02	child	NA			NA	

Biota: Blue Crab

COCs	Carcinogenic Risk-Based			Non-carcinogenic Risk-Based				
	Target Risk		Basis	Target Hazard	Basis	Target Organ	Target-organ-specific	
	ELCR=10^{-6}	ELCR=10^{-4}		HQ=1			Note[1]	Target Hazard
Benzo(a)anthracene	2.1E-03	2.1E-01	child	NA			NA	
Benzo(a)pyrene	2.1E-04	2.1E-02	child	NA			NA	
Dibenz(a,h)anthracene	2.1E-04	2.1E-02	child	NA			NA	
Indeno(1,2,3-cd)pyrene	2.1E-03	2.1E-01	child	NA			NA	
Dioxin-Like PCB TEQ	2.0E-08	2.0E-06	adult	NA			NA	
Nondioxin-Like	1.6E-03	1.6E-01	adult	NA			NA	
Total PCB	NA	NA	adult	1.4E-02	child	Ocular, Finger and Toe Nails	1.4E-02	HQ=1
Arsenic	2.1E-03	2.1E-01	adult	2.1E-01	child	Skin, Vascular	2.1E-01	HQ=1
Mercury	NA	NA	adult	7.1E-02	child	Developmental Neurological	7.1E-02	HQ=1

Units are in mg (chem)/kg (biota tissue)

Note 1 - when more than one COPC has the same target organ, non-carcinogenic risk-based PRG is divided by the number of COPCs with that target organ to address cumulative effects.

ELCR - expected lifetime cancer risk

HQ - hazard quotient

NA - not applicable

TEQ - toxic equivalent

TABLE 3-6

Summary of Fish and Shellfish Tissue Concentrations and Safe Tissue Levels

Gowanus Canal, Brooklyn, New York

				Safe Tissue Level					
				Recreational Angler			Subsistence Fisherman		
				Cancer Risk Level		Hazard Level	Cancer Risk Level		Hazard Level
Contaminants of Concern	Unit (wet weight)	Gowanus Canal EPC	Reference Area EPC	10^{-4}	10^{-6}	1	10^{-4}	10^{-6}	1
Striped Bass [1]									
Chemicals with Cancer Risk > 10^{-6}			Weakfish						
Dioxin-like PCBs	µg/kg	0.00431	0.0026	0.011	0.00011	--	0.0043	0.000043	--
Non-dioxin like PCBs	µg/kg	409	99	840	8.4	--	330	3.3	--
Arsenic	mg/kg	0.68	ND	1.1	0.011	--	0.45	0.0045	--
Benzo(a)pyrene [2]	µg/kg	11.8	3.8	110	1.1	--	46	0.46	--
Dibenz(a,h)anthracene [2]	µg/kg	3.94	3.8	110	1.1	--	46	0.46	--
Chemicals with Hazard Index > 1									
Total PCB	µg/kg	435	107	--	--	71	--	--	30
White Perch [1]									
Chemicals with Cancer Risk > 10^{-6}			Scup						
Dioxin-like PCBs	µg/kg	0.00508	0.00071	0.056	0.00056	--	0.022	0.00022	--
Non-dioxin like PCBs	µg/kg	437	40	4400	44	--	1700	17	--
American Eel									
Chemicals with Cancer Risk > 10^{-6}									
Dioxin-like PCBs	µg/kg	0.0141	0.0072	0.011	0.00011	--	0.0046	0.000046	--
Non-dioxin like PCBs	µg/kg	1220	424	890	8.9	--	360	3.6	--
Dieldrin	µg/kg	17	4.9	110	1.1	--	45	0.45	--
Chromium	mg/kg	0.67	ND	1.7	0.017	--	0.71	0.0071	--
Arsenic	mg/kg	0.5	ND	1.2	0.012	--	0.48	0.0048	--
Benzo(a)pyrene [2]	µg/kg	11.8	3.8	110	1.1	--	49	0.49	--
Dibenz(a,h)anthracene [2]	µg/kg	3.94	3.8	110	1.1	--	49	0.49	--
Chemicals with Hazard Index > 1									
Total PCB	µg/kg	1350	480	--	--	76	--	--	32
Blue Crab									
Chemicals with Cancer Risk > 10^{-6}									
Dioxin-like PCBs	µg/kg	0.00504	0.0032	0.0057	0.000057	--	0.002	0.00002	--
Non-dioxin like PCBs	µg/kg	143	90	440	4.4	--	160	1.6	--
Arsenic	mg/kg	1.31	1.5	0.59	0.0059	--	0.21	0.0021	--
Benzo(a)pyrene	µg/kg	11.8	3.8	56	0.56	--	21	0.21	--
Dibenz(a,h)anthracene	µg/kg	3.94	3.8	56	0.56	--	21	0.21	--
Chemicals with Hazard Index > 1									
Total PCB	µg/kg	166	105	--	--	38	--	--	14

Notes:

[1] Striped bass and white perch were not caught in the reference area

[2] Crab tissue PAH data were used to represent PAH concentrations in fish tissue because fish tissues were not analyzed for PAHs.

EPC - exposure point concentration

HI - hazard index

ND - not detected

red shading - recreational angler risk > 10^{-4} or HI > 1

blue shading - subsistence fisherman risk > 10^{-4}

mg/kg - milligrams per kilogram

µg/kg - micrograms per kilogram

TABLE 4-1

Results of Whole Sediment Toxicity Tests and Chemical Analyses to Support Preliminary Remediation Goal Development

Gowanus Canal, Brooklyn, New York

							Fraction of Control							
		Polychaete		Amphipod			Polychaete		Amphipod					
Category	Station	Survival (%)	Growth (Wet Biomass - g/organism)	Survival (%)	Growth (Dry Biomass - mg/organism)	Reproduction (# of juveniles/ female)	Survival	Growth	Survival	Growth	Reproduction	Total PAHs (mg/kg)	Copper[a] (mg/kg)	Lead[a] (mg/kg)
Site	315	71.3	1.79	0	NA	NA	0.73	0.63	0.00	0.00	0.00	6670	151	1600
Site	314	75	2.24	0	NA	NA	0.80	0.79	0.00	0.00	0.00	3559	349	488
Site	319	97.5	2.76	53.8	0.175	0	1.00	0.97	0.66	0.17	0.00	289	178	376
Site	318	86.3	2.53	35.6	0.105	0	0.89	0.89	0.44	0.10	0.00	236	349	669
Site	310	83.8	2.67	27.5	0.13	0	0.86	0.94	0.34	0.12	0.00	66.9	314	600
Site	303	87.5	2.668	81.3	0.886	1.58	0.90	0.94	1.00	0.84	0.33	39.4	168	201
Site	321	92.5	2.66	68.8	0.418	0.47	0.95	0.94	0.85	0.40	0.10	33.9	110	146
Site	307A	93.8	3.21	79.4	0.576	0.87	0.96	1.13	0.98	0.54	0.18	29.1	192	776
Site	307B	87.5	2.58	70	0.645	2.2	0.90	0.91	0.90	0.61	0.45	28.7	191	216
Site	324	87.5	2.82	85.6	0.666	0.88	0.90	0.99	1.05	0.63	0.18	16.4	167	216
Site	309	85	2.65	86.3	0.643	0.96	0.90	0.93	1.06	0.61	0.20	13.8	149	184
Reference	328	85	2.582	75	0.797	3.56	0.90	0.91	0.90	0.75	0.73	7.8	80.2	61.7
Reference	333	85	2.756	76.8	0.673	2.45	0.90	0.97	0.95	0.64	0.50	4.4	76.9	87.5
Reference	330	87.5	2.689	91.9	1.096	5.24	0.90	0.95	1.13	1.04	1.08	4.2	70.7	93.5
Reference	329	85	2.251	90.6	0.791	2.12	0.90	0.79	1.12	0.75	0.44	3.4	65.2	90
Excluded	326	85	2.772	71	0.475	0.51	0.87	0.98	0.87	0.45	0.10	1890.0	242	244
Excluded	313	61.3	1.88	0.6	0.003	0	0.60	0.66	0.01	0.00	0.00	15.8	246	355

[a] For values reported as non-detected, the reporting limit was used as the assumed value.

NA - not applicable

mg/kg - milligram per kilogram

TABLE 4-2

Potential Preliminary Remediation Goals for Total PAHs based on Graphical Estimation Approach

Gowanus Canal, Brooklyn, New York

	Graphical Estimated PRG (mg/kg) Amphipod		
Total PAH PRG Basis	Survival	Growth	Reproduction
No Observable Adverse Effects Concentration (NOAEC) approach	39	7.8	7.8
Lowest Observable Adverse Effects Concentration (LOAEC) approach	67	14	14

PAH - polycyclic aromatic hydrocarbon

PRG - preliminary remediation goal

mg/kg - milligram per kilogram

TABLE 4-3

Potential Preliminary Remediation Goals for Total PAHs Based on TRAP Estimation Approach

Gowanus Canal, Brooklyn, New York

Contaminant of Concern	TRAP Estimated PRG (mg/kg) Amphipod		
	Survival	Growth	Reproduction
Total PAHs	72	12	15

PAH - polycyclic aromatic hydrocarbon

PRG - preliminary remediation goal

TRAP - Toxicity Respons Analysis Program

mg/kg - milligram per kilogram

TABLE 4-4

Potential LOAECs Normalized to Mean Canal TOC Content

Gowanus Canal, Brooklyn, New York

	Uncertainty in LOAECs			
Station	Total PAH (mg/kg)	TOC (mg/kg)	Total PAH (mg/kg OC)	Amphipod Growth as Fraction of Control
321	33.9	51100	663	0.40
307A	29.1	43000	677	0.54
307B	28.7	54400	528	0.61
324	16.4	35000	469	0.63
309	13.8	45000	307	0.61
Geomean	23.0	45181	509	
LOAEC normalized to mean canal TOC content			31	

LOAEC - lowest observable adverse effects concentration

OC - organic carbon

PAH - polycyclic aromatic hydrocarbon

TOC - total organic carbon

mg/kg - milligram per kilogram

TABLE 4-5

Potential NOAECs Normalized to Mean Canal TOC Content

Gowanus Canal, Brooklyn, New York

	Uncertainty in NOAECs			
Station	Total PAH (mg/kg)	TOC (mg/kg)	Total PAH (mg/kg OC)	Amphipod Growth as Fraction of Control
303	39.4	73100	539	0.84
328	7.8	22500	348	0.75
333	4.4	26400	167	0.64
330	4.2	34500	122	1.04
329	3.4	29500	116	0.75
Geomean	7.2	33812	214	
NOAEC normalized to mean canal TOC content			13	

NOAEC - no observable adverse effects concentration

OC - organic carbon

PAH - polycyclic aromatic hydrocarbon

TOC - total organic carbon

mg/kg - milligram per kilogram

TABLE 4-6

Equilibrium Partitioning Sediment Benchmark Toxic Units for PAH Mixtures Based on the Final Chronic Value

Gowanus Canal, Brooklyn, New York

		Location ID	324	TOC=	0.035	315	TOC=	0.0818	314	TOC=	0.109	319	TOC=	0.0493	318	TOC=	0.094
PAH	$C_{OC, PAHi, FCVi}$ (ug/g_{OC})	$C_{OC, PAHi, Maxi}$ (ug/g_{OC})															
Naphthalene	385	61,700	0.28	8.0	0.0208	1600	19559.9	50.8049	5.6	51.4	0.1334	9.1	184.6	0.4794	2	21.3	0.0553
C1 Naphthalene	444	165,700															
Acenaphthylene	452	24,000	0.00	0.0	0.0000	130	1589.2	3.5160	150	1376.1	3.0446	10	202.8	0.4488	13	138.3	0.3060
Acenaphthene	491	33,400	0	0.0	0.0000	580	7090.5	14.4409	460	4220.2	8.5951	20	405.7	0.8262	6.1	64.9	0.1322
C2 Naphthalenes	510	--															
Fluorene	538	26,000	0	0.0	0.0000	540	6601.5	12.2704	130	1192.7	2.2168	11	223.1	0.4147	3.2	34.0	0.0633
C3 Naphthalenes	581	--															
Anthracene	594	1,300	0.45	12.9	0.0216	610	7457.2	2.1886	350	3211.0	2.1886	21	426.0	0.7171	9.7	103.2	0.1737
Phenanthrene	596	34,300	0.47	13.4	0.0225	1100	13447.4	22.5628	470	4311.9	7.2348	37	750.5	1.2592	8.8	93.6	0.1571
C1 Fluorenes	611	--															
C4 Naphthalenes	657	--															
C1 Phenanthrenes	670	--															
C2 Fluorenes	686	--															
Pyrene	697	9,090	0	0.0	0.0000	630	7701.7	11.0498	670	6146.8	8.8189	47	953.3	1.3678	44	468.1	0.6716
Fluoranthene	707	23,870	0	0.0	0.0000	530	6479.2	9.1644	630	5779.8	8.1751	29	588.2	0.8320	31	329.8	0.4665
C2 Phenanthrenes	746	--															
C3 Fluorenes	769	--															
C1 Fluoranthenes	770	--															
C3 Phenanthrenes	829	--															
Benzo(a)anthracene	841	4,153	0.94	26.9	0.0319	490	5990.2	4.9382	320	2935.8	3.4908	21	426.0	0.5065	25	266.0	0.3162
Chrysene	844	826	0.74	21.1	0.0251	490	5990.2	0.9787	320	2935.8	0.9787	22	446.2	0.5287	24	255.3	0.3025
C4 Phenanthrenes	913	--															
C1 Chrysenes	929	--															
Benzo(a)pyrene	965	3,840	1.8	51.4	0.0533	140	1711.5	1.7736	200	1834.9	1.9014	14	284.0	0.2943	15	159.6	0.1654
Perylene	967	431															
Benzo(e)pyrene	967	4,300															
Benzo(b)fluoranthene	979	2,169	1.9	54.3	0.0555	98	1198.0	1.2237	210	1926.6	1.9679	13	263.7	0.2693	17	180.9	0.1847
Benzo(k)fluoranthene	981	1,220	0.52	14.9	0.0151	67	819.1	0.8349	120	1100.9	1.1222	8.8	178.5	0.1820	11	117.0	0.1193
C2 Chrysenes	1,008	--															
Benzo(g,h,i)perylene	1,095	648	1.1	31.4	0.0287	53	647.9	0.5917	74	678.9	0.5918	7.4	150.1	0.1371	9	95.7	0.0874
C3 Chrysenes	1,112	--															
Indeno(1,2,3-cd)pyrene	1,115	--	1.2	34.3	0.0307	63	770.2	0.6907	120	1100.9	0.9874	11	223.1	0.2001	11	117.0	0.1050
Dibenzo(a,h)anthracene	1,123	2,389	0.44	12.6	0.0112	10	122.2	0.1089	14	128.4	0.1144	2.5	50.7	0.0452	3.1	33.0	0.0294
C4 Chrysenes	1,214	--															
Sum total of $ESBTU_{FCVi}$			**9.8**		**0.32**	**7131**		**137**	**4244**		**52**	**284**		**8.5**	**233**		**3.3**
Adjusted $ESBTU_{FCVi}$[1]					**0.87**			**377**			**142**			**23**			**9.2**

Notes

Non detected PAHs were set at 0 for the purposes of the ESB TU Calculations

[1] - Adjusted with an uncertainty factor at a 50% confidence level associated with using 13 PAHs (uncertainty factor = 2.75).

ESBTU - Equilibrium Partitioning Sediment Benchmark Toxic Units

FCV - final chronic value

OC - organic carbon

PAH - polycyclic aromatic hydrocarbon

TOC - total organic carbon

ug/g_{OC} - micrograms (ug) per gram organic carbon (g_{OC})

TABLE 4-6

Equilibrium Partitioning Sediment Benchmark Toxic Units for PAH Mixtures Based on the Final Chronic Value

Gowanus Canal, Brooklyn, New York

		Location ID	310	TOC=	0.0946	303	TOC=	0.0731	321	TOC=	0.0511	307A	TOC=	0.043
PAH	$C_{OC, PAHi, FCVi}$ (ug/g_{OC})	$C_{OC, PAHi, Maxi}$ (ug/g_{OC})												
Naphthalene	385	61,700	0	0.0	0.0000	0.28	3.8	0.0099	0.46	9.0	0.0234	0	0.0	0.0000
C1 Naphthalene	444	165,700												
Acenaphthylene	452	24,000	0	0.0	0.0000	0	0.0	0.0000	0	0.0	0.0000	0	0.0	0.0000
Acenaphthene	491	33,400	0	0.0	0.0000	1.3	17.8	0.0362	0.37	7.2	0.0147	1.1	25.6	0.0521
C2 Naphthalenes	510	--												
Fluorene	538	26,000	0	0.0	0.0000	0	0.0	0.0000	0.43	8.4	0.0156	0.36	8.4	0.0156
C3 Naphthalenes	581	--												
Anthracene	594	1,300	0	0.0	0.0000	1.8	24.6	0.0415	1.1	21.5	0.0362	1	23.3	0.0392
Phenanthrene	596	34,300	2	21.1	0.0355	4.3	58.8	0.0987	1.3	25.4	0.0427	1.6	37.2	0.0624
C1 Fluorenes	611	--												
C4 Naphthalenes	657	--												
C1 Phenanthrenes	670	--												
C2 Fluorenes	686	--												
Pyrene	697	9,090	13	137.4	0.1972	5.9	80.7	0.1158	5.5	107.6	0.1544	5	116.3	0.1668
Fluoranthene	707	23,870	8.2	86.7	0.1226	4.2	57.5	0.0813	3.5	68.5	0.0969	3.6	83.7	0.1184
C2 Phenanthrenes	746	--												
C3 Fluorenes	769	--												
C1 Fluoranthenes	770	--												
C3 Phenanthrenes	829	--												
Benzo(a)anthracene	841	4,153	4.8	50.7	0.0603	3.4	46.5	0.0553	3	58.7	0.0698	1.9	44.2	0.0525
Chrysene	844	826	4.4	46.5	0.0551	2.9	39.7	0.0470	2.8	54.8	0.0649	2.3	53.5	0.0634
C4 Phenanthrenes	913	--												
C1 Chrysenes	929	--												
Benzo(a)pyrene	965	3,840	8.7	92.0	0.0953	3.6	49.2	0.0510	4.1	80.2	0.0831	2.8	65.1	0.0675
Perylene	967	431												
Benzo(e)pyrene	967	4,300												
Benzo(b)fluoranthene	979	2,169	11	116.3	0.1188	3.4	46.5	0.0475	3.4	66.5	0.0680	3.1	72.1	0.0736
Benzo(k)fluoranthene	981	1,220	5.4	57.1	0.0582	2.8	38.3	0.0390	2.4	47.0	0.0479	1.9	44.2	0.0450
C2 Chrysenes	1,008	--												
Benzo(g,h,i)perylene	1,095	648	4.1	43.3	0.0396	2.2	30.1	0.0275	2.4	47.0	0.0429	1.6	37.2	0.0340
C3 Chrysenes	1,112	--												
Indeno(1,2,3-cd)pyrene	1,115	--	5.3	56.0	0.0502	2.4	32.8	0.0294	2.1	41.1	0.0369	2.1	48.8	0.0438
Dibenzo(a,h)anthracene	1,123	2,389	0	0.0	0.0000	0.52	7.1	0.0063	0.65	12.7	0.0113	0.46	10.7	0.0095
C4 Chrysenes	1,214	--												
Sum total of $ESBTU_{FCVi}$			**67**		**0.83**	**39**		**0.69**	**34**		**0.81**	**29**		**0.84**
Adjusted $ESBTU_{FCVi}$[1]					**2.3**			**1.9**			**2.2**			**2.3**

Notes

Non detected PAHs were set at 0 for the purposes of the ESB TU Calculations

[1] - Adjusted with an uncertainty factor at a 50% confidence level associated with using 13 PAHs (uncertainty factor = 2.75).

ESBTU - Equilibrium Partitioning Sediment Benchmark Toxic Units

FCV - final chronic value

OC - organic carbon

PAH - polycyclic aromatic hydrocarbon

TOC - total organic carbon

ug/g_{OC} - micrograms (ug) per gram organic carbon (g_{OC})

TABLE 4-6

Equilibrium Partitioning Sediment Benchmark Toxic Units for PAH Mixtures Based on the Final Chronic Value

Gowanus Canal, Brooklyn, New York

		Location ID	307B	TOC=	0.054	324	TOC=	0.035	309	TOC=	0.045	328	TOC=	0.0225
PAH	$C_{OC, PAHi, FCVi}$ (ug/g_{OC})	$C_{OC, PAHi, Maxi}$ (ug/g_{OC})												
Naphthalene	385	61,700	0	0.0	0.0000	0.31	8.9	0.0230	0	0.0	0.0000	1.6	71.1	0.1847
C1 Naphthalene	444	165,700												
Acenaphthylene	452	24,000	0	0.0	0.0000	0	0.0	0.0000	0	0.0	0.0000	0	0.0	0.0000
Acenaphthene	491	33,400	1.2	22.2	0.0453	0	0.0	0.0000	0	0.0	0.0000	0.42	18.7	0.0380
C2 Naphthalenes	510	--												
Fluorene	538	26,000	0	0.0	0.0000	0	0.0	0.0000	0	0.0	0.0000	0.32	14.2	0.0264
C3 Naphthalenes	581	--												
Anthracene	594	1,300	1.5	27.8	0.0468	0.33	9.4	0.0159	0.61	13.6	0.0228	0.5	22.2	0.0374
Phenanthrene	596	34,300	1.4	25.9	0.0435	0.62	17.7	0.0297	1.3	28.9	0.0485	0.86	38.2	0.0641
C1 Fluorenes	611	--												
C4 Naphthalenes	657	--												
C1 Phenanthrenes	670	--												
C2 Fluorenes	686	--												
Pyrene	697	9,090	4.4	81.5	0.1169	0	0.0	0.0000	2.6	57.8	0.0829	0	0.0	0.0000
Fluoranthene	707	23,870	3.4	63.0	0.0891	2	57.1	0.0808	2.2	48.9	0.0691	0.64	28.4	0.0402
C2 Phenanthrenes	746	--												
C3 Fluorenes	769	--												
C1 Fluoranthenes	770	--												
C3 Phenanthrenes	829	--												
Benzo(a)anthracene	841	4,153	2.2	40.7	0.0484	1.5	42.9	0.0510	1.7	37.8	0.0449	0.53	23.6	0.0280
Chrysene	844	826	1.9	35.2	0.0417	1.1	31.4	0.0372	1.2	26.7	0.0316	0.38	16.9	0.0200
C4 Phenanthrenes	913	--												
C1 Chrysenes	929	--												
Benzo(a)pyrene	965	3,840	2.4	44.4	0.0461	0	0.0	0.0000	0	0.0	0.0000	0	0.0	0.0000
Perylene	967	431												
Benzo(e)pyrene	967	4,300												
Benzo(b)fluoranthene	979	2,169	2.9	53.7	0.0549	5.3	151.4	0.1547	0	0.0	0.0000	0.92	40.9	0.0418
Benzo(k)fluoranthene	981	1,220	2.6	48.1	0.0491	1.1	31.4	0.0320	0	0.0	0.0000	0.24	10.7	0.0109
C2 Chrysenes	1,008	--												
Benzo(g,h,i)perylene	1,095	648	2.3	42.6	0.0389	1.5	42.9	0.0391	1.3	28.9	0.0264	0.26	11.6	0.0106
C3 Chrysenes	1,112	--												
Indeno(1,2,3-cd)pyrene	1,115	--	1.5	27.8	0.0249	1.8	51.4	0.0461	2.5	55.6	0.0498	0.27	12.0	0.0108
Dibenzo(a,h)anthracene	1,123	2,389	0.99	18.3	0.0163	0.6	17.1	0.0153	0.34	7.6	0.0067	0	0.0	0.0000
C4 Chrysenes	1,214	--												
Sum total of $ESBTU_{FCVi}$			**29**		**0.66**	**16**		**0.52**	**14**		**0.38**	**6.9**		**0.51**
Adjusted $ESBTU_{FCVi}$[1]					**1.8**			**1.4**			**1.1**			**1.4**

Notes

Non detected PAHs were set at 0 for the purposes of the ESB TU Calculations

[1] - Adjusted with an uncertainty factor at a 50% confidence level associated with using 13 PAHs (uncertainty factor = 2.75).

ESBTU - Equilibrium Partitioning Sediment Benchmark Toxic Units

FCV - final chronic value

OC - organic carbon

PAH - polycyclic aromatic hydrocarbon

TOC - total organic carbon

ug/g_{OC} - micrograms (ug) per gram organic carbon (g_{OC})

TABLE 4-6

Equilibrium Partitioning Sediment Benchmark Toxic Units for PAH Mixtures Based on the Final Chronic Value

Gowanus Canal, Brooklyn, New York

		Location ID	333	TOC=	0.0264	330	TOC=	0.0345	329	TOC=	0.0295	326	TOC=	0.0434
PAH	$C_{OC, PAHi, FCVi}$ (ug/g_{OC})	$C_{OC, PAHi, Maxi}$ (ug/g_{OC})												
Naphthalene	385	61,700	0	0.0	0.0000	0.34	9.9	0.0256	0	0.0	0.0000	0	0.0	0.0000
C1 Naphthalene	444	165,700												
Acenaphthylene	452	24,000	0	0.0	0.0000	0	0.0	0.0000	0	0.0	0.0000	0	0.0	0.0000
Acenaphthene	491	33,400	0	0.0	0.0000	0	0.0	0.0000	0	0.0	0.0000	0	0.0	0.0000
C2 Naphthalenes	510	--												
Fluorene	538	26,000	0	0.0	0.0000	0	0.0	0.0000	0	0.0	0.0000	0	0.0	0.0000
C3 Naphthalenes	581	--												
Anthracene	594	1,300	0.27	10.2	0.0172	0	0.0	0.0000	0.14	4.7	0.0080	0	0.0	0.0000
Phenanthrene	596	34,300	0.46	17.4	0.0292	0.39	11.3	0.0190	0.25	8.5	0.0142	0	0.0	0.0000
C1 Fluorenes	611	--												
C4 Naphthalenes	657	--												
C1 Phenanthrenes	670	--												
C2 Fluorenes	686	--												
Pyrene	697	9,090	0	0.0	0.0000	0	0.0	0.0000	0	0.0	0.0000	0	0.0	0.0000
Fluoranthene	707	23,870	0.54	20.5	0.0289	0.51	14.8	0.0209	0.41	13.9	0.0197	0.41	9.4	0.0134
C2 Phenanthrenes	746	--												
C3 Fluorenes	769	--												
C1 Fluoranthenes	770	--												
C3 Phenanthrenes	829	--												
Benzo(a)anthracene	841	4,153	0.41	15.5	0.0185	0.38	11.0	0.0131	0.38	12.9	0.0153	0.35	8.1	0.0096
Chrysene	844	826	0.36	13.6	0.0162	0.4	11.6	0.0137	0.46	15.6	0.0185	0.39	9.0	0.0106
C4 Phenanthrenes	913	--												
C1 Chrysenes	929	--												
Benzo(a)pyrene	965	3,840	0.76	28.8	0.0298	0.6	17.4	0.0180	0.43	14.6	0.0151	0	0.0	0.0000
Perylene	967	431												
Benzo(e)pyrene	967	4,300												
Benzo(b)fluoranthene	979	2,169	0.62	23.5	0.0240	0.66	19.1	0.0195	0.49	16.6	0.0170	0.42	9.7	0.0099
Benzo(k)fluoranthene	981	1,220	0.34	12.9	0.0131	0.31	9.0	0.0092	0.33	11.2	0.0114	0	0.0	0.0000
C2 Chrysenes	1,008	--												
Benzo(g,h,i)perylene	1,095	648	0.3	11.4	0.0104	0.3	8.7	0.0079	0.3	10.2	0.0093	0	0.0	0.0000
C3 Chrysenes	1,112	--												
Indeno(1,2,3-cd)pyrene	1,115	--	0.35	13.3	0.0119	0.32	9.3	0.0083	0.24	8.1	0.0073	0.32	7.4	0.0066
Dibenzo(a,h)anthracene	1,123	2,389	0	0.0	0.0000	0	0.0	0.0000	0	0.0	0.0000	0	0.0	0.0000
C4 Chrysenes	1,214	--												
Sum total of $ESBTU_{FCVi}$			**4.4**		**0.20**	**4.2**		**0.16**	**3.4**		**0.14**	**1.9**		**0.05**
Adjusted $ESBTU_{FCVi}$[1]					**0.55**			**0.43**			**0.37**			**0.14**

Notes

Non detected PAHs were set at 0 for the purposes of the ESB TU Calculations

[1] - Adjusted with an uncertainty factor at a 50% confidence level associated with using 13 PAHs (uncertainty factor = 2.75).

ESBTU - Equilibrium Partitioning Sediment Benchmark Toxic Units

FCV - final chronic value

OC - organic carbon

PAH - polycyclic aromatic hydrocarbon

TOC - total organic carbon

ug/g_{OC} - micrograms (ug) per gram organic carbon (g_{OC})

TABLE 4-7

Surface Sediment (0-0.5 foot) AVS/SEM Summary

Gowanus Canal, Brooklyn, New York

Station	SEM/AVS ratio	(Sum SEM-AVS)/foc (µmol/goc)
Gowanus Canal Sample Locations		
GC-SD303-0.0-0.5	<0.1	-2596
GC-SD307A-0.0-0.5	<0.1	-2636
GC-SD307B-0.0-0.5	<0.1	-1565
GC-SD309-0.0-0.5	<0.1	-570
GC-SD310-0.0-0.5	9.6	372
GC-SD313-0.0-0.5	<0.1	-1956
GC-SD314-0.0-0.5	<0.1	-483
GC-SD315-0.0-0.5	<0.1	-1774
GC-SD318-0.0-0.5	0.1	-1274
GC-SD319-0.0-0.5	<0.1	-1368
GC-SD324-0.0-0.5	<0.1	-2838

Notes:

Toxicity unlikely for values <130 µmol/goc

Toxicity uncertain for values >130 and <3000 µmol/goc

Toxicity likely for values >3000 µmol/goc

AVS - acid volatile sulfide

SEM - simultaneously extracted metals

µmol/goc - micromoles (µmol) per grams organic carbon (goc)

TABLE 4-8

PAH Concentrations in Whole Body Crab Tissue – Calculated Values – Dry Weight

Gowanus Canal, Brooklyn, New York

Location ID	Study Loc	Species	Type	basis	Units	Total PAHs
GC-TI401-BC	Canal	Blue Crab	Whole Body	DRY	ug/kg	**6,020**
GC-TI401-BC	Canal	Blue Crab	Whole Body	DRY	ug/kg	**5,110**
GC-TI402-BC	Canal	Blue Crab	Whole Body	DRY	ug/kg	**5,580**
GC-TI402-BC	Canal	Blue Crab	Whole Body	DRY	ug/kg	**5,730**
GC-TI403-BC	Canal	Blue Crab	Whole Body	DRY	ug/kg	**5,100**
GC-TI403-BC	Canal	Blue Crab	Whole Body	DRY	ug/kg	**5,130**
GC-TI404-BC	Canal	Blue Crab	Whole Body	DRY	ug/kg	**5,730**
GC-TI404-BC	Canal	Blue Crab	Whole Body	DRY	ug/kg	**5,590**
GC-TI405-BC	Canal	Blue Crab	Whole Body	DRY	ug/kg	**5,710**
GC-TI405-BC	Canal	Blue Crab	Whole Body	DRY	ug/kg	**5,520**
GC-TI406-BC	Canal	Blue Crab	Whole Body	DRY	ug/kg	**3,000**
GC-TI406-BC	Canal	Blue Crab	Whole Body	DRY	ug/kg	**5,030**
					95% UCL	***5,676***

PAH - polycyclic aromatic hydrocarbon

UCL - upper confidence limit of mean

µg/kg - micrograms per kilogram

TABLE 4-9

Food Web Risk Calculations - Avian Wildlife

Gowanus Canal, Brooklyn, New York

Constituent	Sediment (mg/kg dw)	Prey Item Tissue: Fish (mg/kg dw)	Prey Item Tissue: Benthic Invertebrates (mg/kg dw)	Avian TRVs (mg/kg/day): NOAEL	Avian TRVs (mg/kg/day): LOAEL	Green Heron: Dietary Intake (mg/kg/day)	Green Heron: Hazard Quotients: NOAEL	Green Heron: Hazard Quotients: LOAEL	Double-Crested Cormorant: Dietary Intake (mg/kg/day)	Double-Crested Cormorant: Hazard Quotients: NOAEL	Double-Crested Cormorant: Hazard Quotients: LOAEL
Semivolatile Organics											
PAHs, total		5.7	5.7		1.43	0.670	--	0.5	0.225	--	0.2

Dietary Intake Equation[1] Component	Heron	Cormorant	Description
DI	*Chemical-specific*		Dietary intake for chemical (see above)
FIR	0.0250	0.0925	Food ingestion rate (kg/day dry weight)
FCx_{fish}	*Chemical-specific*		Concentration of chemical x in fish (see above)
PDF_{fish}	0.71	1.0	Proportion of diet composed of fish (percent)
FCx_{invert}	*Chemical-specific*		Concentration of chemical x in benthic invertebrates (see above)
PDF_{invert}	0.29	0	Proportion of diet composed of benthic invertebrates (percent)
FCx_{plant}	*Chemical-specific*		Concentration of chemical x in aquatic plants (see above)
PDF_{plant}	0	0	Proportion of diet composed aquatic plants (percent)
SCx	*Chemical-specific*		Concentration of chemical x in sediment (see above)
$PD_{sediment}$	0	0	Proportion of diet composed of sediment (percent)
BW	0.21	2.33	Body weight (kg wet weight)
AUF	1.0	1.0	Area Use Factor (Site Size/Home Range; Max. is 1.0)

1 - see text for dietary intake equation and description

LOAEL - lowest observable adverse effects level

NOAEL - no observable adverse effects level

PAH - polycyclic aromatic hydrocarbon

TRV - toxicity reference value

mg/kg - milligrams per kilogram

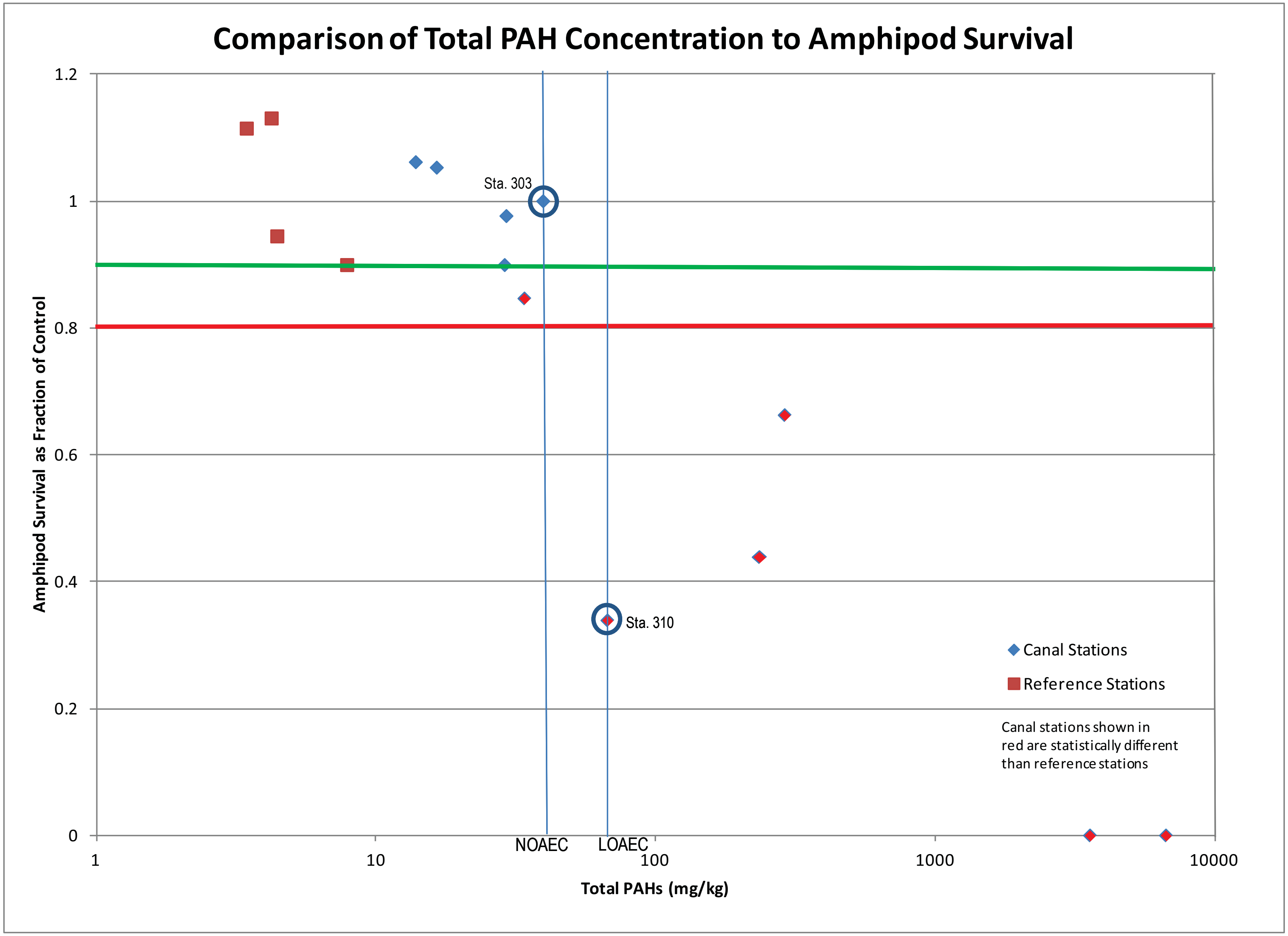

FIGURE 4-1
Comparison of Total PAH Concentrations to Amphipod Survival
Gowanus Canal, Brooklyn, New York

CH2MHILL.

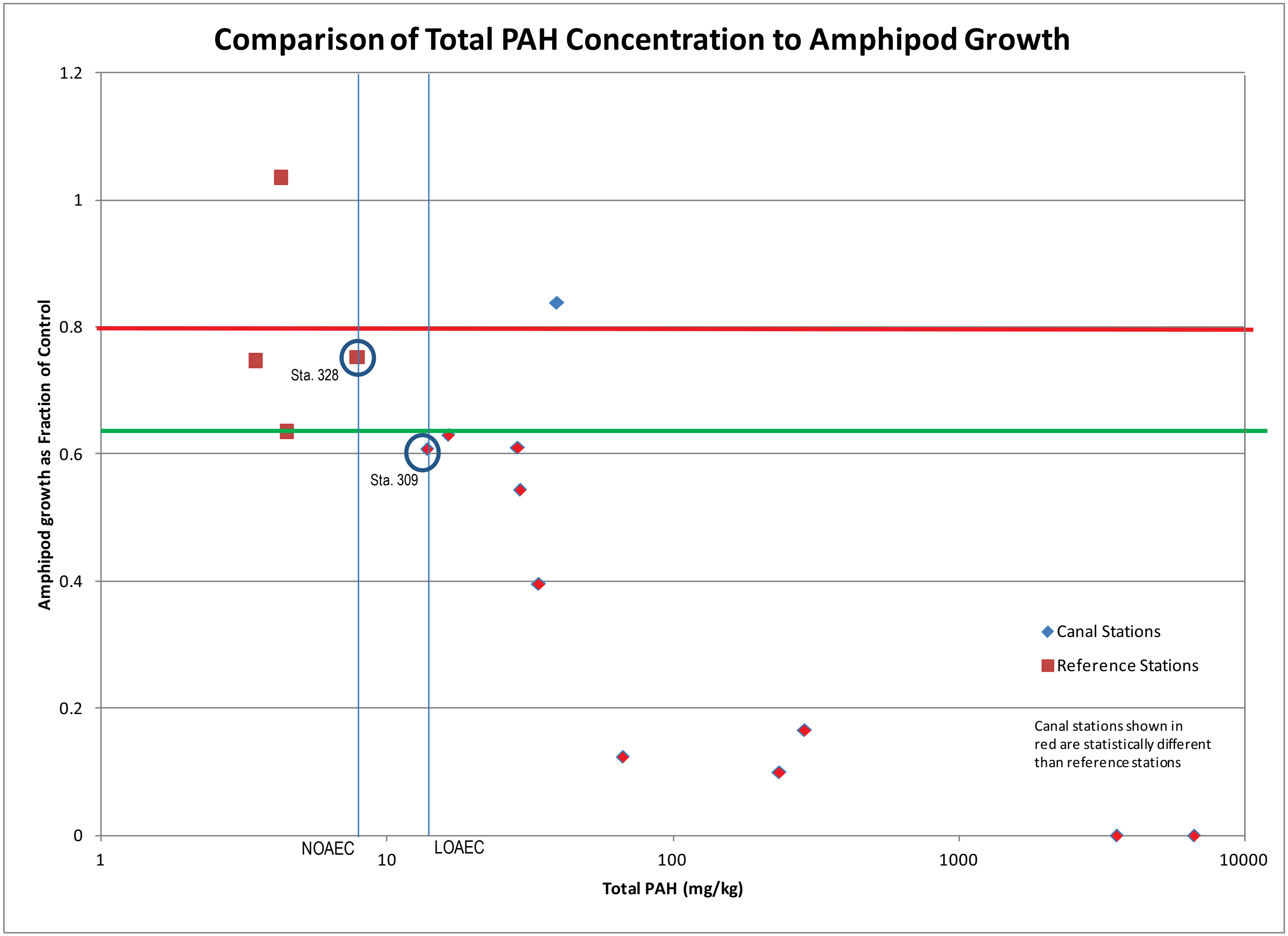

FIGURE 4-2
Comparison of Total PAH Concentration to Amphipod Growth
Gowanus Canal, Brooklyn, New York

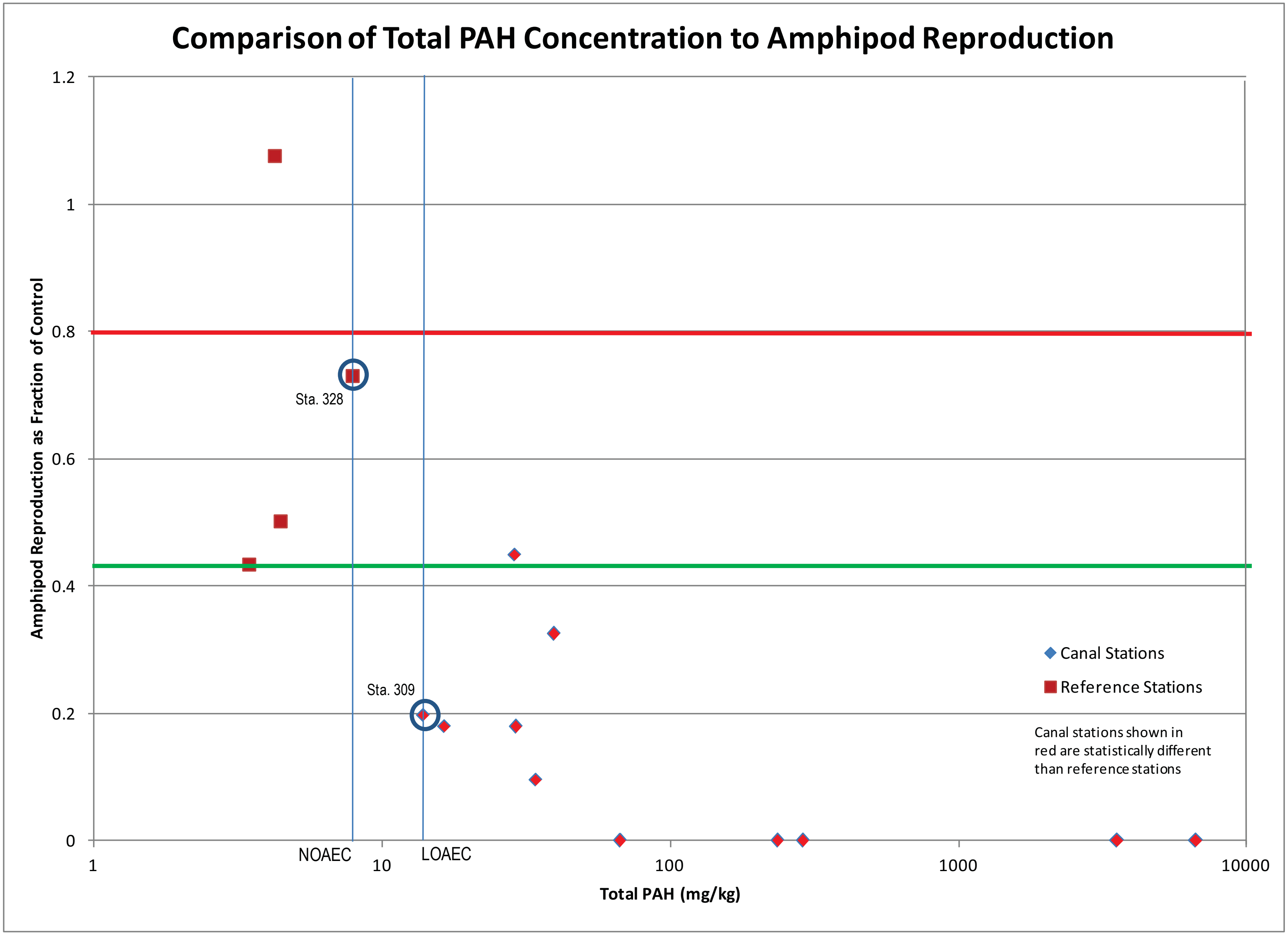

FIGURE 4-3
Comparison of Total PAH Concentration to Amphipod Reproduction
Gowanus Canal, Brooklyn, New York

CH2MHILL.

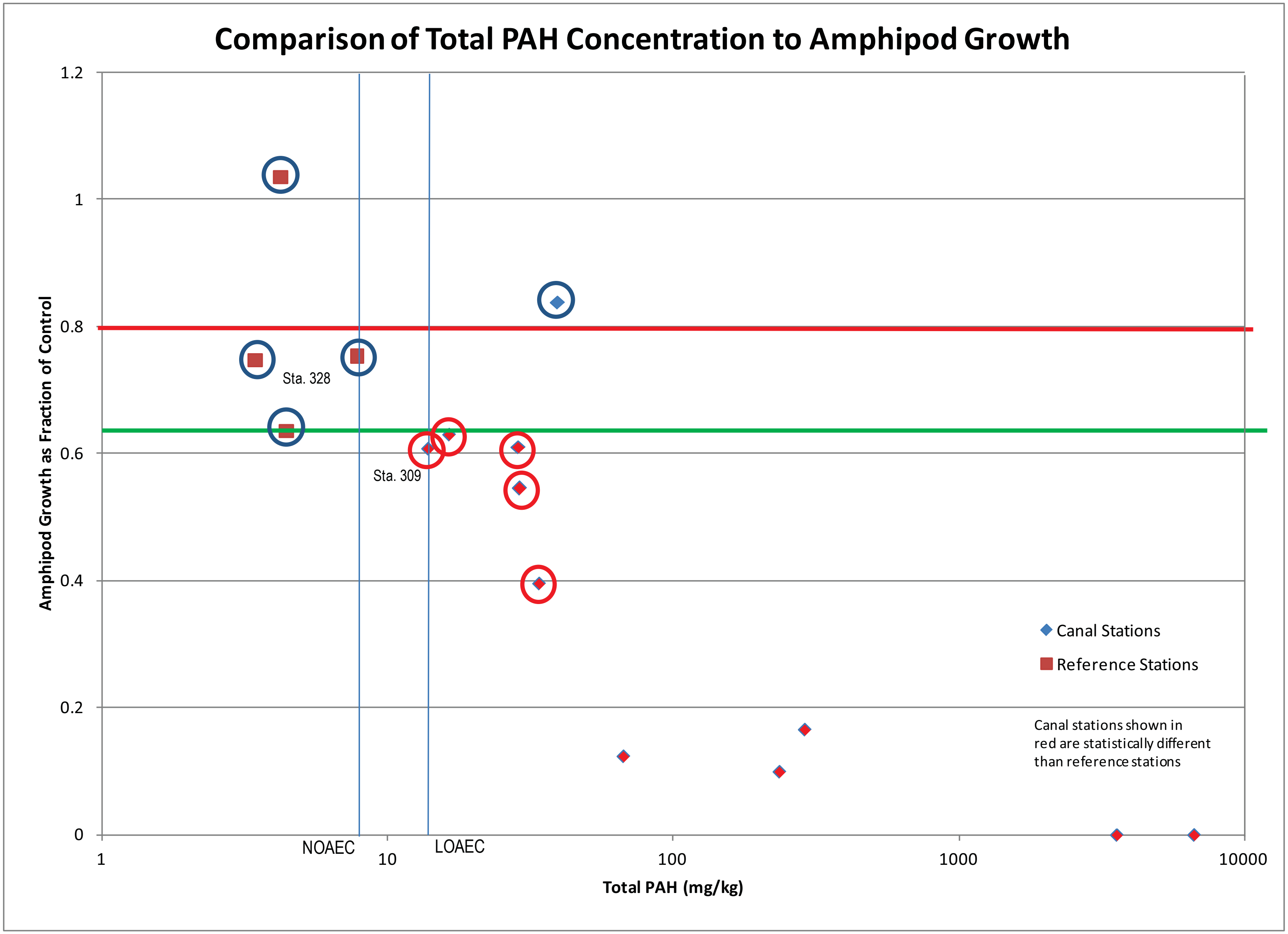

FIGURE 4-4
Comparison of Total PAH Concentration to Amphipod Growth
Gowanus Canal, Brooklyn, New York

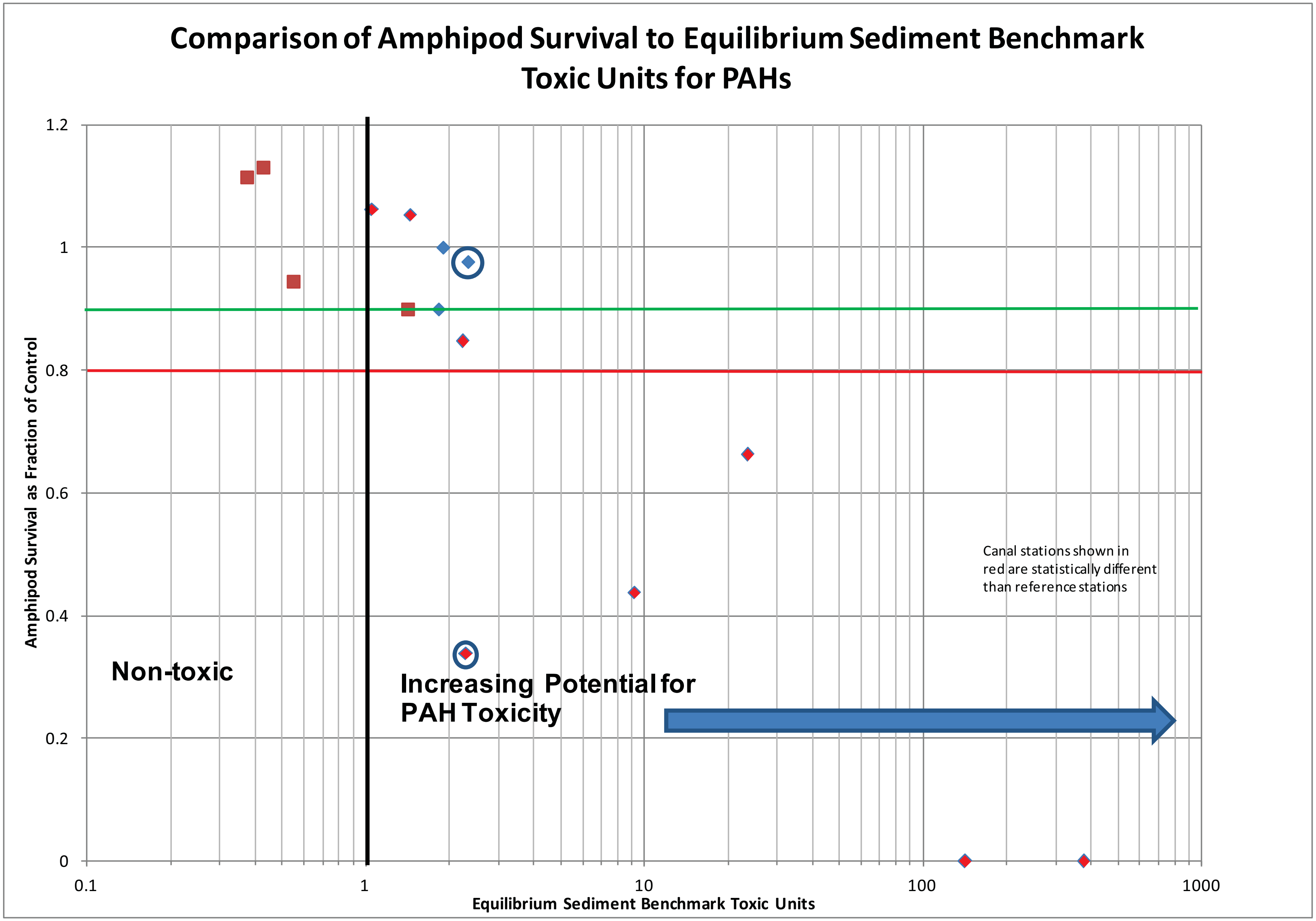

FIGURE 4-5
Comparison of Amphipod Survival to Equilibrium Benchmark Toxic Units for PAHs
Gowanus Canal, Brooklyn, New York

CH2MHILL.

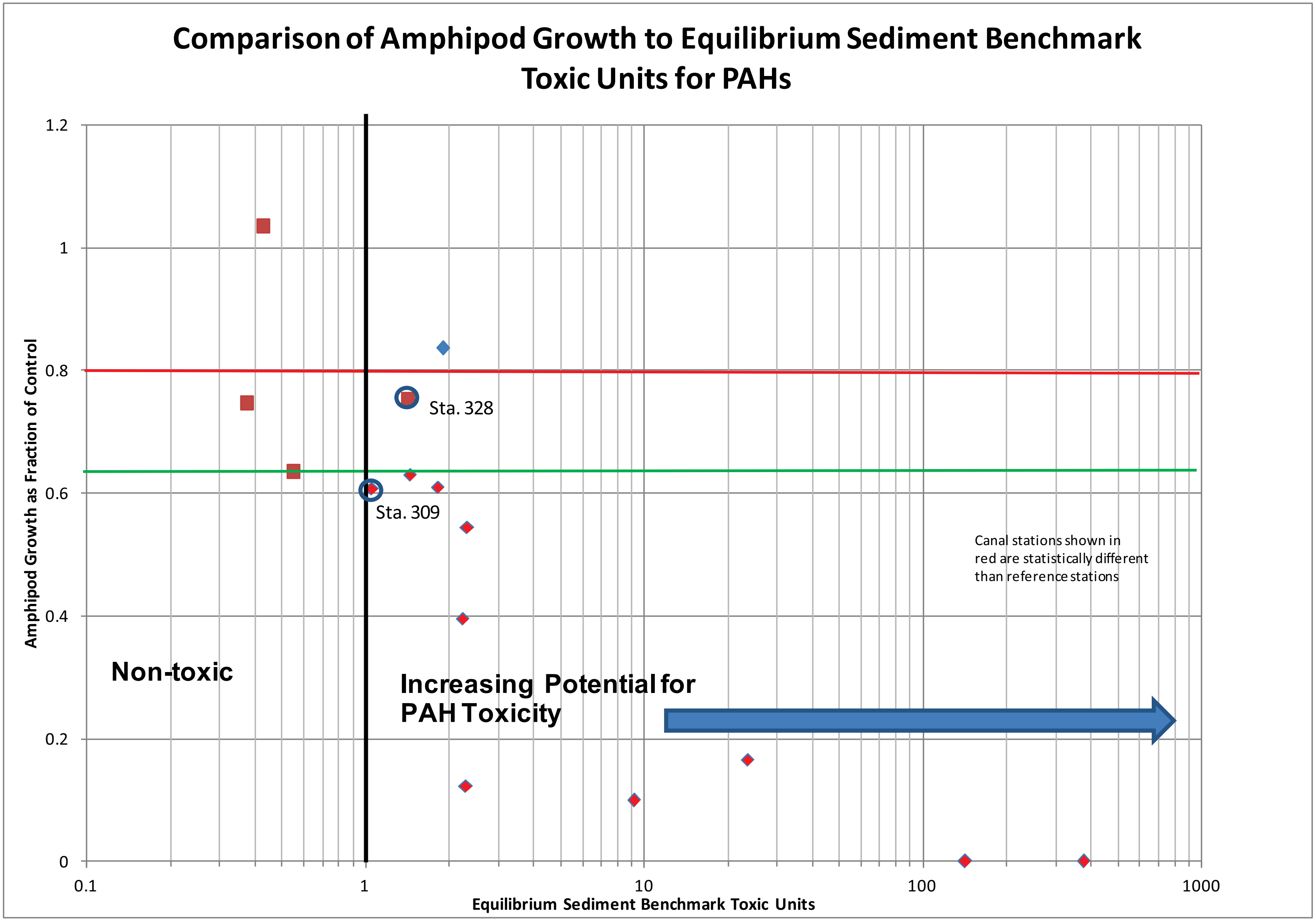

FIGURE 4-6
Comparison of Amphipod Growth to Equilibrium Sediment Benchmark Toxic Units for PAHs
Gowanus Canal, Brooklyn, New York

CH2MHILL.

Attachment 1

REVISED TABLE 7.8.RME

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

REASONABLE MAXIMUM EXPOSURE

Gowanus Canal Remedial Investigation, Brooklyn, New York

Scenario Timeframe: Current/Future
Receptor Population: Angler
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Surface Water/Sediment	Fish and Crab Tissue	Striped Bass in Gowanus Canal	Ingestion													
				p,p'-DDE	1.2E-02	mg/kg	7.2E-07	mg/kg-day	3.4E-01	1/(mg/kg-day)	2.4E-07	2.1E-06	mg/kg-day	NA		NA
				p,p'-DDT	9.6E-03	mg/kg	5.7E-07	mg/kg-day	3.4E-01	1/(mg/kg-day)	2.0E-07	1.7E-06	mg/kg-day	5.0E-04	mg/kg-day	3.4E-03
				Dioxin-Like PCB TEQ	4.3E-06	mg/kg	2.6E-10	mg/kg-day	1.6E+05	1/(mg/kg-day)	4.0E-05	7.5E-10	mg/kg-day	NA		NA
				Nondioxin-Like	4.1E-01	mg/kg	2.4E-05	mg/kg-day	2.0E+00	1/(mg/kg-day)	4.9E-05	7.1E-05	mg/kg-day	NA		NA
				Total PCB	4.4E-01	mg/kg	2.6E-05	mg/kg-day	NA		NA	7.6E-05	mg/kg-day	2.0E-05	mg/kg-day	3.8E+00
				Arsenic	6.8E-02	mg/kg	4.1E-06	mg/kg-day	1.5E+00	1/(mg/kg-day)	6.1E-06	1.2E-05	mg/kg-day	3.0E-04	mg/kg-day	4.0E-02
				Mercury	2.0E-01	mg/kg	1.2E-05	mg/kg-day	NA		NA	3.5E-05	mg/kg-day	1.0E-04	mg/kg-day	3.5E-01
				Selenium	1.2E+00	mg/kg	7.2E-05	mg/kg-day	NA		NA	2.1E-04	mg/kg-day	5.0E-03	mg/kg-day	4.2E-02
				Benzo(a)anthracene*	7.7E-03	mg/kg	4.6E-07	mg/kg-day	7.3E-01	1/(mg/kg-day)	3.4E-07	1.3E-06	mg/kg-day	NA		NA
				Benzo(a)pyrene*	1.2E-02	mg/kg	7.1E-07	mg/kg-day	7.3E+00	1/(mg/kg-day)	5.2E-06	2.1E-06	mg/kg-day	NA		NA
				Benzo(b)fluoranthene*	6.4E-03	mg/kg	3.8E-07	mg/kg-day	7.3E-01	1/(mg/kg-day)	2.8E-07	1.1E-06	mg/kg-day	NA		NA
				Dibenz(a,h)anthracene*	3.9E-03	mg/kg	2.4E-07	mg/kg-day	7.3E+00	1/(mg/kg-day)	1.7E-06	6.9E-07	mg/kg-day	NA		NA
				Indeno(1,2,3-cd)pyrene*	9.9E-03	mg/kg	5.9E-07	mg/kg-day	7.3E-01	1/(mg/kg-day)	4.3E-07	1.7E-06	mg/kg-day	NA		NA
			Exp. Route Total								1.0E-04					4.2E+00
		Exposure Point Total									1.0E-04					4.2E+00
	Exposure Medium Total - Striped Bass in Gowanus Canal										1.0E-04					4.2E+00
	Fish and Crab Tissue	White Perch in Gowanus Canal	Ingestion													
				Dioxin-Like PCB TEQ	5.8E-06	mg/kg	6.6E-11	mg/kg-day	1.6E+05	1/(mg/kg-day)	1.0E-05	1.9E-10	mg/kg-day	NA		NA
				Nondioxin-Like	4.4E-01	mg/kg	5.0E-06	mg/kg-day	2.0E+00	1/(mg/kg-day)	1.0E-05	1.5E-05	mg/kg-day	NA		NA
				Total PCB	4.6E-01	mg/kg	5.3E-06	mg/kg-day	NA		NA	1.5E-05	mg/kg-day	2.0E-05	mg/kg-day	7.7E-01
				Mercury	1.9E-01	mg/kg	2.2E-06	mg/kg-day	NA		NA	6.4E-06	mg/kg-day	1.0E-04	mg/kg-day	6.4E-02
				Selenium	1.4E+00	mg/kg	1.6E-05	mg/kg-day	NA		NA	4.7E-05	mg/kg-day	5.0E-03	mg/kg-day	9.4E-03
				Benzo(a)anthracene*	7.7E-03	mg/kg	8.8E-08	mg/kg-day	7.3E-01	1/(mg/kg-day)	6.4E-08	2.6E-07	mg/kg-day	NA		NA
				Benzo(a)pyrene*	1.2E-02	mg/kg	1.4E-07	mg/kg-day	7.3E+00	1/(mg/kg-day)	9.9E-07	3.9E-07	mg/kg-day	NA		NA
				Benzo(b)fluoranthene*	6.4E-03	mg/kg	7.3E-08	mg/kg-day	7.3E-01	1/(mg/kg-day)	5.3E-08	2.1E-07	mg/kg-day	NA		NA
				Dibenz(a,h)anthracene*	3.9E-03	mg/kg	4.5E-08	mg/kg-day	7.3E+00	1/(mg/kg-day)	3.3E-07	1.3E-07	mg/kg-day	NA		NA
				Indeno(1,2,3-cd)pyrene*	9.9E-03	mg/kg	1.1E-07	mg/kg-day	7.3E-01	1/(mg/kg-day)	8.3E-08	3.3E-07	mg/kg-day	NA		NA
			Exp. Route Total								2.2E-05					8.5E-01
		Exposure Point Total									2.2E-05					8.5E-01
	Exposure Medium Total - White Perch in Gowanus Canal										2.2E-05					8.5E-01

REVISED TABLE 7.8.RME

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

REASONABLE MAXIMUM EXPOSURE

Gowanus Canal Remedial Investigation, Brooklyn, New York

Scenario Timeframe: Current/Future
Receptor Population: Angler
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Surface Water/Sediment	Fish and Crab Tissue	Eel in Gowanus Canal	Ingestion													
				alpha-Chlordane	2.2E-02	mg/kg	1.2E-06	mg/kg-day	3.5E-01	1/(mg/kg-day)	4.3E-07	3.6E-06	mg/kg-day	5.0E-04	mg/kg-day	7.2E-03
				Dieldrin	1.7E-02	mg/kg	9.5E-07	mg/kg-day	1.6E+01	1/(mg/kg-day)	1.5E-05	2.8E-06	mg/kg-day	5.0E-05	mg/kg-day	5.6E-02
				gamma-Chlordane	1.3E-02	mg/kg	7.3E-07	mg/kg-day	3.5E-01	1/(mg/kg-day)	2.5E-07	2.1E-06	mg/kg-day	5.0E-04	mg/kg-day	4.2E-03
				p,p'-DDD	3.8E-02	mg/kg	2.1E-06	mg/kg-day	2.4E-01	1/(mg/kg-day)	5.1E-07	6.2E-06	mg/kg-day	NA		NA
				p,p'-DDE	2.5E-02	mg/kg	1.4E-06	mg/kg-day	3.4E-01	1/(mg/kg-day)	4.8E-07	4.1E-06	mg/kg-day	NA		NA
				p,p'-DDT	4.7E-02	mg/kg	2.6E-06	mg/kg-day	3.4E-01	1/(mg/kg-day)	9.0E-07	7.7E-06	mg/kg-day	5.0E-04	mg/kg-day	1.5E-02
				Dioxin-Like PCB TEQ	1.4E-05	mg/kg	7.9E-10	mg/kg-day	1.6E+05	1/(mg/kg-day)	1.2E-04	2.3E-09	mg/kg-day	NA		NA
				Nondioxin-Like	1.2E+00	mg/kg	6.8E-05	mg/kg-day	2.0E+00	1/(mg/kg-day)	1.4E-04	2.0E-04	mg/kg-day	NA		NA
				Total PCB	1.4E+00	mg/kg	7.6E-05	mg/kg-day	NA		NA	2.2E-04	mg/kg-day	2.0E-05	mg/kg-day	1.1E+01
				Arsenic	5.0E-02	mg/kg	2.8E-06	mg/kg-day	1.5E+00	1/(mg/kg-day)	4.2E-06	8.2E-06	mg/kg-day	3.0E-04	mg/kg-day	2.7E-02
				Chromium	6.7E-01	mg/kg	3.8E-05	mg/kg-day	5.0E-01	1/(mg/kg-day)	1.9E-05	1.1E-04	mg/kg-day	3.0E-03	mg/kg-day	3.6E-02
				Copper	7.4E+00	mg/kg	4.1E-04	mg/kg-day	NA		NA	1.2E-03	mg/kg-day	4.0E-02	mg/kg-day	3.0E-02
				Cyanide, total	3.1E+00	mg/kg	1.7E-04	mg/kg-day	NA		NA	5.1E-04	mg/kg-day	2.0E-02		2.5E-02
				Mercury	2.6E-01	mg/kg	1.5E-05	mg/kg-day	NA		NA	4.2E-05	mg/kg-day	1.0E-04		4.2E-01
				Selenium	1.4E+00	mg/kg	7.8E-05	mg/kg-day	NA		NA	2.3E-04	mg/kg-day	5.0E-03	mg/kg-day	4.6E-02
				Benzo(a)anthracene*	7.7E-03	mg/kg	4.3E-07	mg/kg-day	7.3E-01	1/(mg/kg-day)	3.1E-07	1.3E-06	mg/kg-day	NA		NA
				Benzo(a)pyrene*	1.2E-02	mg/kg	6.6E-07	mg/kg-day	7.3E+00	1/(mg/kg-day)	4.8E-06	1.9E-06	mg/kg-day	NA		NA
				Benzo(b)fluoranthene*	6.4E-03	mg/kg	3.6E-07	mg/kg-day	7.3E-01	1/(mg/kg-day)	2.6E-07	1.0E-06	mg/kg-day	NA		NA
				Dibenz(a,h)anthracene*	3.9E-03	mg/kg	2.2E-07	mg/kg-day	7.3E+00	1/(mg/kg-day)	1.6E-06	6.4E-07	mg/kg-day	NA		NA
				Indeno(1,2,3-cd)pyrene*	9.9E-03	mg/kg	5.6E-07	mg/kg-day	7.3E-01	1/(mg/kg-day)	4.1E-07	1.6E-06	mg/kg-day	NA		NA
			Exp. Route Total								3.1E-04					1.2E+01
		Exposure Point Total									3.1E-04					1.2E+01
	Exposure Medium Total - Eel in Gowanus Canal										3.1E-04					1.2E+01

REVISED TABLE 7.8.RME

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

REASONABLE MAXIMUM EXPOSURE

Gowanus Canal Remedial Investigation, Brooklyn, New York

Scenario Timeframe: Current/Future
Receptor Population: Angler
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Surface Water/Sediment	Fish and Crab Tissue	Blue Crab in Gowanus Canal	Ingestion													
				Benzo(a)anthracene	7.7E-03	mg/kg	8.7E-07	mg/kg-day	7.3E-01	1/(mg/kg-day)	6.3E-07	2.5E-06	mg/kg-day	NA		NA
				Benzo(a)pyrene	1.2E-02	mg/kg	1.3E-06	mg/kg-day	7.3E+00	1/(mg/kg-day)	9.7E-06	3.9E-06	mg/kg-day	NA		NA
				Benzo(b)fluoranthene	6.4E-03	mg/kg	7.2E-07	mg/kg-day	7.3E-01	1/(mg/kg-day)	5.3E-07	2.1E-06	mg/kg-day	NA		NA
				Dibenz(a,h)anthracene	3.9E-03	mg/kg	4.4E-07	mg/kg-day	7.3E+00	1/(mg/kg-day)	3.2E-06	1.3E-06	mg/kg-day	NA		NA
				Indeno(1,2,3-cd)pyrene	9.9E-03	mg/kg	1.1E-06	mg/kg-day	7.3E-01	1/(mg/kg-day)	8.1E-07	3.3E-06	mg/kg-day	NA		NA
				Dioxin-Like PCB TEQ	5.0E-06	mg/kg	5.7E-10	mg/kg-day	1.6E+05	1/(mg/kg-day)	8.9E-05	1.7E-09	mg/kg-day	NA		NA
				Nondioxin-Like	1.4E-01	mg/kg	1.6E-05	mg/kg-day	2.0E+00	1/(mg/kg-day)	3.2E-05	4.7E-05	mg/kg-day	NA		NA
				Total PCB	1.7E-01	mg/kg	1.9E-05	mg/kg-day	NA		NA	5.5E-05	mg/kg-day	2.0E-05	mg/kg-day	2.7E+00
				Arsenic	1.3E-01	mg/kg	1.5E-05	mg/kg-day	1.5E+00	1/(mg/kg-day)	2.2E-05	4.3E-05	mg/kg-day	3.0E-04	mg/kg-day	1.4E-01
				Copper	1.0E+01	mg/kg	1.1E-03	mg/kg-day	NA		NA	3.4E-03	mg/kg-day	4.0E-02	mg/kg-day	8.4E-02
				Mercury	1.2E-01	mg/kg	1.4E-05	mg/kg-day	NA		NA	4.1E-05	mg/kg-day	1.0E-04	mg/kg-day	4.1E-01
			Exp. Route Total								1.6E-04					3.4E+00
		Exposure Point Total									1.6E-04					3.4E+00
	Exposure Medium Total - Crab in Gowanus Canal										1.6E-04					3.4E+00
Total Fish							Total of Receptor Risks - Fish				4.3E-04	Total of Receptor Hazards - Fish				1.7E+01
Total Blue Crab							Total of Receptor Risks - Blue Crab				1.6E-04	Total of Receptor Hazards - Blue Crab				3.4E+00

Notes-

NA = Not available / Not applicable.

* PAH data included for fish is based on mearsued concentrations of PAHs in crab, not on actual fish tissue data

REVISED TABLE 7.9.RME

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

REASONABLE MAXIMUM EXPOSURE

Gowanus Canal Remedial Investigation, Brooklyn, New York

Scenario Timeframe: Current/Future
Receptor Population: Angler
Receptor Age: Adolescent

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Surface Water/Sediment	Fish and Crab Tissue	Striped Bass in Gowanus Canal	Ingestion													
				p,p'-DDE	1.2E-02	mg/kg	1.4E-07	mg/kg-day	3.4E-01	1/(mg/kg-day)	4.9E-08	1.7E-06	mg/kg-day	NA		NA
				p,p'-DDT	9.6E-03	mg/kg	1.2E-07	mg/kg-day	3.4E-01	1/(mg/kg-day)	3.9E-08	1.3E-06	mg/kg-day	5.0E-04	mg/kg-day	2.7E-03
				Dioxin-Like PCB TEQ	4.3E-06	mg/kg	5.2E-11	mg/kg-day	1.6E+05	1/(mg/kg-day)	8.1E-06	6.0E-10	mg/kg-day	NA		NA
				Nondioxin-Like	4.1E-01	mg/kg	4.9E-06	mg/kg-day	2.0E+00	1/(mg/kg-day)	9.8E-06	5.7E-05	mg/kg-day	NA		NA
				Total PCB	4.4E-01	mg/kg	5.2E-06	mg/kg-day	NA		NA	6.1E-05	mg/kg-day	2.0E-05	mg/kg-day	3.0E+00
				Arsenic	6.8E-02	mg/kg	8.2E-07	mg/kg-day	1.5E+00	1/(mg/kg-day)	1.2E-06	9.5E-06	mg/kg-day	3.0E-04	mg/kg-day	3.2E-02
				Mercury	2.0E-01	mg/kg	2.4E-06	mg/kg-day	NA		NA	2.8E-05	mg/kg-day	1.0E-04	mg/kg-day	2.8E-01
				Selenium	1.2E+00	mg/kg	1.4E-05	mg/kg-day	NA		NA	1.7E-04	mg/kg-day	5.0E-03	mg/kg-day	3.4E-02
				Benzo(a)anthracene (12-16)*,+	7.7E-03	mg/kg	6.2E-08	mg/kg-day	2.2E+00	1/(mg/kg-day)	1.4E-07	1.1E-06	mg/kg-day	NA		NA
				Benzo(a)anthracene (16-18)*,+	7.7E-03	mg/kg	3.1E-08	mg/kg-day	7.3E-01	1/(mg/kg-day)	2.3E-08					
				Benzo(a)pyrene (12-16)*,+	1.2E-02	mg/kg	9.5E-08	mg/kg-day	2.2E+01	1/(mg/kg-day)	2.1E-06	1.7E-06	mg/kg-day	NA		NA
				Benzo(a)pyrene (16-18)*,+	1.2E-02	mg/kg	4.7E-08	mg/kg-day	7.3E+00	1/(mg/kg-day)	3.4E-07					
				Benzo(b)fluoranthene (12-16)*,+	6.4E-03	mg/kg	5.1E-08	mg/kg-day	2.2E+00	1/(mg/kg-day)	1.1E-07	9.0E-07	mg/kg-day	NA		NA
				Benzo(b)fluoranthene (16-18)*,+	6.4E-03	mg/kg	2.6E-08	mg/kg-day	7.3E-01	1/(mg/kg-day)	1.9E-08					
				Dibenz(a,h)anthracene (12-16)*,+	3.9E-03	mg/kg	3.2E-08	mg/kg-day	2.2E+01	1/(mg/kg-day)	6.9E-07	5.5E-07	mg/kg-day	NA		NA
				Dibenz(a,h)anthracene (16-18)*,+	3.9E-03	mg/kg	1.6E-08	mg/kg-day	7.3E+00	1/(mg/kg-day)	1.2E-07					
				Indeno(1,2,3-cd)pyrene (12-16)*,+	9.9E-03	mg/kg	7.9E-08	mg/kg-day	2.2E+00	1/(mg/kg-day)	1.7E-07	1.4E-06	mg/kg-day	NA		NA
				Indeno(1,2,3-cd)pyrene (16-18)*,+	9.9E-03	mg/kg	4.0E-08	mg/kg-day	7.3E-01	1/(mg/kg-day)	2.9E-08					
			Exp. Route Total								2.3E-05					3.4E+00
		Exposure Point Total									2.3E-05					3.4E+00
	Exposure Medium Total - Striped Bass in Gowanus Canal										2.3E-05					3.4E+00

REVISED TABLE 7.9.RME

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

REASONABLE MAXIMUM EXPOSURE

Gowanus Canal Remedial Investigation, Brooklyn, New York

Scenario Timeframe: Current/Future
Receptor Population: Angler
Receptor Age: Adolescent

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Surface Water/Sediment	Fish and Crab Tissue	White Perch in Gowanus Canal	Ingestion													
				Dioxin-Like PCB TEQ	5.8E-06	mg/kg	1.3E-11	mg/kg-day	1.6E+05	1/(mg/kg-day)	2.1E-06	1.6E-10	mg/kg-day	NA		NA
				Nondioxin-Like	4.4E-01	mg/kg	1.0E-06	mg/kg-day	2.0E+00	1/(mg/kg-day)	2.0E-06	1.2E-05	mg/kg-day	NA		NA
				Total PCB	4.6E-01	mg/kg	1.1E-06	mg/kg-day	NA		NA	1.2E-05	mg/kg-day	2.0E-05	mg/kg-day	6.2E-01
				Mercury	1.9E-01	mg/kg	4.4E-07	mg/kg-day	NA		NA	5.1E-06	mg/kg-day	1.0E-04	mg/kg-day	5.1E-02
				Selenium	1.4E+00	mg/kg	3.2E-06	mg/kg-day	NA		NA	3.8E-05	mg/kg-day	5.0E-03	mg/kg-day	7.5E-03
				Benzo(a)anthracene (12-16)*,+	7.7E-03	mg/kg	1.2E-08	mg/kg-day	2.2E+00	1/(mg/kg-day)	2.6E-08	2.1E-07	mg/kg-day	NA		NA
				Benzo(a)anthracene (16-18)*,+	7.7E-03	mg/kg	5.9E-09	mg/kg-day	7.3E-01	1/(mg/kg-day)	4.3E-09					
				Benzo(a)pyrene (12-16)*,+	1.2E-02	mg/kg	1.8E-08	mg/kg-day	2.2E+01	1/(mg/kg-day)	4.0E-07	3.2E-07	mg/kg-day	NA		NA
				Benzo(a)pyrene (16-18)*,+	1.2E-02	mg/kg	9.0E-09	mg/kg-day	7.3E+00	1/(mg/kg-day)	6.6E-08					
				Benzo(b)fluoranthene (12-16)*,+	6.4E-03	mg/kg	9.8E-09	mg/kg-day	2.2E+00	1/(mg/kg-day)	2.1E-08	1.7E-07	mg/kg-day	NA		NA
				Benzo(b)fluoranthene (16-18)*,+	6.4E-03	mg/kg	4.9E-09	mg/kg-day	7.3E-01	1/(mg/kg-day)	3.6E-09					
				Dibenz(a,h)anthracene (12-16)*,+	3.9E-03	mg/kg	6.0E-09	mg/kg-day	2.2E+01	1/(mg/kg-day)	1.3E-07	1.1E-07	mg/kg-day	NA		NA
				Dibenz(a,h)anthracene (16-18)*,+	3.9E-03	mg/kg	3.0E-09	mg/kg-day	7.3E+00	1/(mg/kg-day)	2.2E-08					
				Indeno(1,2,3-cd)pyrene (12-16)*,+	9.9E-03	mg/kg	1.5E-08	mg/kg-day	2.2E+00	1/(mg/kg-day)	3.3E-08	2.7E-07	mg/kg-day	NA		NA
				Indeno(1,2,3-cd)pyrene (16-18)*,+	9.9E-03	mg/kg	7.6E-09	mg/kg-day	7.3E-01	1/(mg/kg-day)	5.5E-09					
			Exp. Route Total								4.8E-06					6.8E-01
		Exposure Point Total									4.8E-06					6.8E-01
	Exposure Medium Total - White Perch in Gowanus Canal										4.8E-06					6.8E-01

REVISED TABLE 7.9.RME

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

REASONABLE MAXIMUM EXPOSURE

Gowanus Canal Remedial Investigation, Brooklyn, New York

Scenario Timeframe: Current/Future
Receptor Population: Angler
Receptor Age: Adolescent

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Surface Water/Sediment	Fish and Crab Tissue	Eel in Gowanus Canal	Ingestion													
				alpha-Chlordane	2.2E-02	mg/kg	2.5E-07	mg/kg-day	3.5E-01	1/(mg/kg-day)	8.7E-08	2.9E-06	mg/kg-day	5.0E-04	mg/kg-day	5.8E-03
				Dieldrin	1.7E-02	mg/kg	1.9E-07	mg/kg-day	1.6E+01	1/(mg/kg-day)	3.1E-06	2.2E-06	mg/kg-day	5.0E-05	mg/kg-day	4.5E-02
				gamma-Chlordane	1.3E-02	mg/kg	1.5E-07	mg/kg-day	3.5E-01	1/(mg/kg-day)	5.1E-08	1.7E-06	mg/kg-day	5.0E-04	mg/kg-day	3.4E-03
				p,p'-DDD	3.8E-02	mg/kg	4.3E-07	mg/kg-day	2.4E-01	1/(mg/kg-day)	1.0E-07	5.0E-06	mg/kg-day	NA		NA
				p,p'-DDE	2.5E-02	mg/kg	2.8E-07	mg/kg-day	3.4E-01	1/(mg/kg-day)	9.6E-08	3.3E-06	mg/kg-day	NA		NA
				p,p'-DDT	4.7E-02	mg/kg	5.3E-07	mg/kg-day	3.4E-01	1/(mg/kg-day)	1.8E-07	6.2E-06	mg/kg-day	5.0E-04	mg/kg-day	1.2E-02
				Dioxin-Like PCB TEQ	1.4E-05	mg/kg	1.6E-10	mg/kg-day	1.6E+05	1/(mg/kg-day)	2.5E-05	1.9E-09	mg/kg-day	NA		NA
				Nondioxin-Like	1.2E+00	mg/kg	1.4E-05	mg/kg-day	2.0E+00	1/(mg/kg-day)	2.7E-05	1.6E-04	mg/kg-day	NA		NA
				Total PCB	1.4E+00	mg/kg	1.5E-05	mg/kg-day	NA		NA	1.8E-04	mg/kg-day	2.0E-05	mg/kg-day	8.9E+00
				Arsenic	5.0E-02	mg/kg	5.6E-07	mg/kg-day	1.5E+00	1/(mg/kg-day)	8.4E-07	6.6E-06	mg/kg-day	3.0E-04	mg/kg-day	2.2E-02
				Chromium (12-16)*	6.7E-01	mg/kg	5.0E-06	mg/kg-day	1.5E+00	1/(mg/kg-day)	7.5E-06	8.8E-05	mg/kg-day	3.0E-03	mg/kg-day	2.9E-02
				Chromium (16-18)*	6.7E-01	mg/kg	2.5E-06	mg/kg-day	5.0E-01	1/(mg/kg-day)	1.3E-06					
				Copper	7.4E+00	mg/kg	8.3E-05	mg/kg-day	NA		NA	9.7E-04	mg/kg-day	4.0E-02	mg/kg-day	2.4E-02
				Cyanide, total	3.1E+00	mg/kg	3.5E-05	mg/kg-day	NA		NA	4.1E-04	mg/kg-day	2.0E-02	mg/kg-day	2.0E-02
				Mercury	2.6E-01	mg/kg	2.9E-06	mg/kg-day	NA		NA	3.4E-05	mg/kg-day	1.0E-04	mg/kg-day	3.4E-01
				Selenium	1.4E+00	mg/kg	1.6E-05	mg/kg-day	NA		NA	1.8E-04	mg/kg-day	5.0E-03	mg/kg-day	3.7E-02
				Benzo(a)anthracene (12-16)*,+	7.7E-03	mg/kg	5.8E-08	mg/kg-day	2.2E+00	1/(mg/kg-day)	1.3E-07	1.0E-06	mg/kg-day	NA		NA
				Benzo(a)anthracene (16-18)*,+	7.7E-03	mg/kg	2.9E-08	mg/kg-day	7.3E-01	1/(mg/kg-day)	2.1E-08					
				Benzo(a)pyrene (12-16)*,+	1.2E-02	mg/kg	8.8E-08	mg/kg-day	2.2E+01	1/(mg/kg-day)	1.9E-06	1.5E-06	mg/kg-day	NA		NA
				Benzo(a)pyrene (16-18)*,+	1.2E-02	mg/kg	4.4E-08	mg/kg-day	7.3E+00	1/(mg/kg-day)	3.2E-07					
				Benzo(b)fluoranthene (12-16)*,+	6.4E-03	mg/kg	4.8E-08	mg/kg-day	2.2E+00	1/(mg/kg-day)	1.0E-07	8.4E-07	mg/kg-day	NA		NA
				Benzo(b)fluoranthene (16-18)*,+	6.4E-03	mg/kg	2.4E-08	mg/kg-day	7.3E-01	1/(mg/kg-day)	1.7E-08					
				Dibenz(a,h)anthracene (12-16)*,+	3.9E-03	mg/kg	3.0E-08	mg/kg-day	2.2E+01	1/(mg/kg-day)	6.5E-07	5.2E-07	mg/kg-day	NA		NA
				Dibenz(a,h)anthracene (16-18)*,+	3.9E-03	mg/kg	1.5E-08	mg/kg-day	7.3E+00	1/(mg/kg-day)	1.1E-07					
				Indeno(1,2,3-cd)pyrene (12-16)*,+	9.9E-03	mg/kg	7.4E-08	mg/kg-day	2.2E+00	1/(mg/kg-day)	1.6E-07	1.3E-06	mg/kg-day	NA		NA
				Indeno(1,2,3-cd)pyrene (16-18)*,+	9.9E-03	mg/kg	3.7E-08	mg/kg-day	7.3E-01	1/(mg/kg-day)	2.7E-08					
			Exp. Route Total								6.9E-05					9.4E+00
		Exposure Point Total									6.9E-05					9.4E+00
	Exposure Medium Total - Eel in Gowanus Canal										6.9E-05					9.4E+00

REVISED TABLE 7.9.RME

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

REASONABLE MAXIMUM EXPOSURE

Gowanus Canal Remedial Investigation, Brooklyn, New York

Scenario Timeframe: Current/Future
Receptor Population: Angler
Receptor Age: Adolescent

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Surface Water/Sediment	Fish and Crab Tissue	Blue Crab in Gowanus Canal	Ingestion													
				Benzo(a)anthracene (12-16)*	7.7E-03	mg/kg	1.2E-07	mg/kg-day	2.2E+00	1/(mg/kg-day)	2.5E-07	2.0E-06	mg/kg-day	NA		NA
				Benzo(a)anthracene (16-18)*	7.7E-03	mg/kg	5.8E-08	mg/kg-day	7.3E-01	1/(mg/kg-day)	4.2E-08					
				Benzo(a)pyrene (12-16)*	1.2E-02	mg/kg	1.8E-07	mg/kg-day	2.2E+01	1/(mg/kg-day)	3.9E-06	3.1E-06	mg/kg-day	NA		NA
				Benzo(a)pyrene (16-18)*	1.2E-02	mg/kg	8.9E-08	mg/kg-day	7.3E+00	1/(mg/kg-day)	6.5E-07					
				Benzo(b)fluoranthene (12-16)*	6.4E-03	mg/kg	9.6E-08	mg/kg-day	2.2E+00	1/(mg/kg-day)	2.1E-07	1.7E-06	mg/kg-day	NA		NA
				Benzo(b)fluoranthene (16-18)*	6.4E-03	mg/kg	4.8E-08	mg/kg-day	7.3E-01	1/(mg/kg-day)	3.5E-08					
				Dibenz(a,h)anthracene (12-16)*	3.9E-03	mg/kg	5.9E-08	mg/kg-day	2.2E+01	1/(mg/kg-day)	1.3E-06	1.0E-06	mg/kg-day	NA		NA
				Dibenz(a,h)anthracene (16-18)*	3.9E-03	mg/kg	3.0E-08	mg/kg-day	7.3E+00	1/(mg/kg-day)	2.2E-07					
				Indeno(1,2,3-cd)pyrene (12-16)*	9.9E-03	mg/kg	1.5E-07	mg/kg-day	2.2E+00	1/(mg/kg-day)	3.3E-07	2.6E-06	mg/kg-day	NA		NA
				Indeno(1,2,3-cd)pyrene (16-18)*	9.9E-03	mg/kg	7.5E-08	mg/kg-day	7.3E-01	1/(mg/kg-day)	5.4E-08					
				Dioxin-Like PCB TEQ	5.0E-06	mg/kg	1.1E-10	mg/kg-day	1.6E+05	1/(mg/kg-day)	1.8E-05	1.3E-09	mg/kg-day	NA		NA
				Nondioxin-Like	1.4E-01	mg/kg	3.2E-06	mg/kg-day	2.0E+00	1/(mg/kg-day)	6.5E-06	3.8E-05	mg/kg-day	NA		NA
				Total PCB	1.7E-01	mg/kg	3.7E-06	mg/kg-day	NA		NA	4.4E-05	mg/kg-day	2.0E-05	mg/kg-day	2.2E+00
				Arsenic	1.3E-01	mg/kg	3.0E-06	mg/kg-day	1.5E+00	1/(mg/kg-day)	4.4E-06	3.4E-05	mg/kg-day	3.0E-04	mg/kg-day	1.1E-01
				Copper	1.0E+01	mg/kg	2.3E-04	mg/kg-day	NA		NA	2.7E-03	mg/kg-day	4.0E-02	mg/kg-day	6.7E-02
				Mercury	1.2E-01	mg/kg	2.8E-06	mg/kg-day	NA		NA	3.3E-05	mg/kg-day	1.0E-04	mg/kg-day	3.3E-01
			Exp. Route Total								3.6E-05					2.7E+00
		Exposure Point Total									3.6E-05					2.7E+00
	Exposure Medium Total - Crab in Gowanus Canal										3.6E-05					2.7E+00
Total Fish										Total of Receptor Risks - Fish	9.7E-05				Total of Receptor Hazards - Fish	1.3E+01
Total Blue Crab										Total of Receptor Risks - Blue Crab	3.6E-05				Total of Receptor Hazards - Blue Crab	2.7E+00

Notes-

* Constituent acts via a mutagenic mode of action (MMOA). ADAF of 3 used to adjust CSF for 12-16 year old for exposure duration of 4 years, ADAF of 1 used to adjust CSF for 16-18 year old for exposure duration of 2 years.
Non-cancer calculations shown under 12-16 year old only, as non-cancer calculations are not adjusted for MMOA.

[+] PAH data included for fish is based on mearsued concentrations of PAHs in crab, not on actual fish tissue data

NA = Not available / Not applicable.

REVISED TABLE 7.10.RME

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

REASONABLE MAXIMUM EXPOSURE

Gowanus Canal Remedial Investigation, Brooklyn, New York

Scenario Timeframe: Current/Future
Receptor Population: Angler
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Surface Water/Sediment	Fish and Crab Tissue	Striped Bass in Gowanus Canal	Ingestion													
				p,p'-DDE	1.2E-02	mg/kg	2.9E-07	mg/kg-day	3.4E-01	1/(mg/kg-day)	9.9E-08	3.4E-06	mg/kg-day	NA		NA
				p,p'-DDT	9.6E-03	mg/kg	2.3E-07	mg/kg-day	3.4E-01	1/(mg/kg-day)	7.9E-08	2.7E-06	mg/kg-day	5.0E-04	mg/kg-day	5.4E-03
				Dioxin-Like PCB TEQ	4.3E-06	mg/kg	1.0E-10	mg/kg-day	1.6E+05	1/(mg/kg-day)	1.6E-05	1.2E-09	mg/kg-day	NA		NA
				Nondioxin-Like	4.1E-01	mg/kg	9.9E-06	mg/kg-day	2.0E+00	1/(mg/kg-day)	2.0E-05	1.2E-04	mg/kg-day	NA		NA
				Total PCB	4.4E-01	mg/kg	1.1E-05	mg/kg-day	NA		NA	1.2E-04	mg/kg-day	2.0E-05	mg/kg-day	6.1E+00
				Arsenic	6.8E-02	mg/kg	1.6E-06	mg/kg-day	1.5E+00	1/(mg/kg-day)	2.5E-06	1.9E-05	mg/kg-day	3.0E-04	mg/kg-day	6.4E-02
				Mercury	2.0E-01	mg/kg	4.8E-06	mg/kg-day	NA	1/(mg/kg-day)	NA	5.6E-05	mg/kg-day	1.0E-04	mg/kg-day	5.6E-01
				Selenium	1.2E+00	mg/kg	2.9E-05	mg/kg-day	NA		NA	3.4E-04	mg/kg-day	5.0E-03	mg/kg-day	6.8E-02
				Benzo(a)anthracene (0-2)*,+	7.7E-03	mg/kg	6.2E-08	mg/kg-day	7.3E+00	1/(mg/kg-day)	4.5E-07	2.2E-06	mg/kg-day	NA		NA
				Benzo(a)anthracene (2-6)*,+	7.7E-03	mg/kg	1.2E-07	mg/kg-day	2.2E+00	1/(mg/kg-day)	2.7E-07					
				Benzo(a)pyrene (0-2)*,+	1.2E-02	mg/kg	9.5E-08	mg/kg-day	7.3E+01	1/(mg/kg-day)	6.9E-06	3.3E-06	mg/kg-day	NA		NA
				Benzo(a)pyrene (2-6)*,+	1.2E-02	mg/kg	1.9E-07	mg/kg-day	2.2E+01	1/(mg/kg-day)	4.2E-06					
				Benzo(b)fluoranthene (0-2)*,+	6.4E-03	mg/kg	5.1E-08	mg/kg-day	7.3E+00	1/(mg/kg-day)	3.8E-07	1.8E-06	mg/kg-day	NA		NA
				Benzo(b)fluoranthene (2-6)*,+	6.4E-03	mg/kg	1.0E-07	mg/kg-day	2.2E+00	1/(mg/kg-day)	2.3E-07					
				Dibenz(a,h)anthracene (0-2)*,+	3.9E-03	mg/kg	3.2E-08	mg/kg-day	7.3E+01	1/(mg/kg-day)	2.3E-06	1.1E-06	mg/kg-day	NA		NA
				Dibenz(a,h)anthracene (2-6)*,+	3.9E-03	mg/kg	6.3E-08	mg/kg-day	2.2E+01	1/(mg/kg-day)	1.4E-06					
				Indeno(1,2,3-cd)pyrene (0-2)*,+	9.9E-03	mg/kg	8.0E-08	mg/kg-day	7.3E+00	1/(mg/kg-day)	5.8E-07	2.8E-06	mg/kg-day	NA		NA
				Indeno(1,2,3-cd)pyrene (2-6)*,+	9.9E-03	mg/kg	1.6E-07	mg/kg-day	2.2E+00	1/(mg/kg-day)	3.5E-07					
			Exp. Route Total								5.6E-05					6.8E+00
		Exposure Point Total									5.6E-05					6.8E+00
	Exposure Medium Total - Striped Bass in Gowanus Canal										5.6E-05					6.8E+00

REVISED TABLE 7.10.RME

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

REASONABLE MAXIMUM EXPOSURE

Gowanus Canal Remedial Investigation, Brooklyn, New York

Scenario Timeframe: Current/Future
Receptor Population: Angler
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Surface Water/Sediment	Fish and Crab Tissue	White Perch in Gowanus Canal	Ingestion													
				Dioxin-Like PCB TEQ	5.8E-06	mg/kg	2.7E-11	mg/kg-day	1.6E+05	1/(mg/kg-day)	4.2E-06	3.1E-10	mg/kg-day	NA		NA
				Nondioxin-Like	4.4E-01	mg/kg	2.0E-06	mg/kg-day	2.0E+00	1/(mg/kg-day)	4.0E-06	2.4E-05	mg/kg-day	NA		NA
				Total PCB	4.6E-01	mg/kg	2.1E-06	mg/kg-day	NA		NA	2.5E-05	mg/kg-day	2.0E-05	mg/kg-day	1.2E+00
				Mercury	1.9E-01	mg/kg	8.8E-07	mg/kg-day	NA		NA	1.0E-05	mg/kg-day	1.0E-04	mg/kg-day	1.0E-01
				Selenium	1.4E+00	mg/kg	6.5E-06	mg/kg-day	NA		NA	7.6E-05	mg/kg-day	5.0E-03	mg/kg-day	1.5E-02
				Benzo(a)anthracene (0-2)*,+	7.7E-03	mg/kg	1.2E-08	mg/kg-day	7.3E+00	1/(mg/kg-day)	8.7E-08	4.2E-07	mg/kg-day	NA		NA
				Benzo(a)anthracene (2-6)*,+	7.7E-03	mg/kg	2.4E-08	mg/kg-day	2.2E+00	1/(mg/kg-day)	5.2E-08					
				Benzo(a)pyrene (0-2)*,+	1.2E-02	mg/kg	1.8E-08	mg/kg-day	7.3E+01	1/(mg/kg-day)	1.3E-06	6.4E-07	mg/kg-day	NA		NA
				Benzo(a)pyrene (2-6)*,+	1.2E-02	mg/kg	3.6E-08	mg/kg-day	2.2E+01	1/(mg/kg-day)	8.0E-07					
				Benzo(b)fluoranthene (0-2)*,+	6.4E-03	mg/kg	9.9E-09	mg/kg-day	7.3E+00	1/(mg/kg-day)	7.2E-08	3.5E-07	mg/kg-day	NA		NA
				Benzo(b)fluoranthene (2-6)*,+	6.4E-03	mg/kg	2.0E-08	mg/kg-day	2.2E+00	1/(mg/kg-day)	4.3E-08					
				Dibenz(a,h)anthracene (0-2)*,+	3.9E-03	mg/kg	6.1E-09	mg/kg-day	7.3E+01	1/(mg/kg-day)	4.4E-07	2.1E-07	mg/kg-day	NA		NA
				Dibenz(a,h)anthracene (2-6)*,+	3.9E-03	mg/kg	1.2E-08	mg/kg-day	2.2E+01	1/(mg/kg-day)	2.7E-07					
				Indeno(1,2,3-cd)pyrene (0-2)*,+	9.9E-03	mg/kg	1.5E-08	mg/kg-day	7.3E+00	1/(mg/kg-day)	1.1E-07	5.4E-07	mg/kg-day	NA		NA
				Indeno(1,2,3-cd)pyrene (2-6)*,+	9.9E-03	mg/kg	3.1E-08	mg/kg-day	2.2E+00	1/(mg/kg-day)	6.7E-08					
			Exp. Route Total								1.2E-05					1.4E+00
		Exposure Point Total									1.2E-05					1.4E+00
	Exposure Medium Total - White Perch in Gowanus Canal										1.2E-05					1.4E+00

REVISED TABLE 7.10.RME

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

REASONABLE MAXIMUM EXPOSURE

Gowanus Canal Remedial Investigation, Brooklyn, New York

Scenario Timeframe: Current/Future
Receptor Population: Angler
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Surface Water/Sediment	Fish and Crab Tissue	Eel in Gowanus Canal	Ingestion													
				alpha-Chlordane	2.2E-02	mg/kg	5.0E-07	mg/kg-day	3.5E-01	1/(mg/kg-day)	1.7E-07	5.8E-06	mg/kg-day	5.0E-04	mg/kg-day	1.2E-02
				Dieldrin	1.7E-02	mg/kg	3.8E-07	mg/kg-day	1.6E+01	1/(mg/kg-day)	6.2E-06	4.5E-06	mg/kg-day	5.0E-05	mg/kg-day	9.0E-02
				gamma-Chlordane	1.3E-02	mg/kg	2.9E-07	mg/kg-day	3.5E-01	1/(mg/kg-day)	1.0E-07	3.4E-06	mg/kg-day	5.0E-04	mg/kg-day	6.9E-03
				p,p'-DDD	3.8E-02	mg/kg	8.6E-07	mg/kg-day	2.4E-01	1/(mg/kg-day)	2.1E-07	1.0E-05	mg/kg-day	NA		NA
				p,p'-DDE	2.5E-02	mg/kg	5.7E-07	mg/kg-day	3.4E-01	1/(mg/kg-day)	1.9E-07	6.6E-06	mg/kg-day	NA		NA
				p,p'-DDT	4.7E-02	mg/kg	1.1E-06	mg/kg-day	3.4E-01	1/(mg/kg-day)	3.6E-07	1.2E-05	mg/kg-day	5.0E-04	mg/kg-day	2.5E-02
				Dioxin-Like PCB TEQ	1.4E-05	mg/kg	3.2E-10	mg/kg-day	1.6E+05	1/(mg/kg-day)	5.0E-05	3.7E-09	mg/kg-day	NA		NA
				Nondioxin-Like	1.2E+00	mg/kg	2.8E-05	mg/kg-day	2.0E+00	1/(mg/kg-day)	5.5E-05	3.2E-04	mg/kg-day	NA		NA
				Total PCB	1.4E+00	mg/kg	3.1E-05	mg/kg-day	NA		NA	3.6E-04	mg/kg-day	2.0E-05	mg/kg-day	1.8E+01
				Arsenic	5.0E-02	mg/kg	1.1E-06	mg/kg-day	1.5E+00	1/(mg/kg-day)	1.7E-06	1.3E-05	mg/kg-day	3.0E-04	mg/kg-day	4.4E-02
				Chromium (0-2)*	6.7E-01	mg/kg	5.1E-06	mg/kg-day	5.0E+00	1/(mg/kg-day)	2.5E-05	1.8E-04	mg/kg-day	3.0E-03	mg/kg-day	5.9E-02
				Chromium (2-6)*	6.7E-01	mg/kg	1.0E-05	mg/kg-day	1.5E+00	1/(mg/kg-day)	1.5E-05					
				Copper	7.4E+00	mg/kg	1.7E-04	mg/kg-day	NA		NA	2.0E-03	mg/kg-day	4.0E-02	mg/kg-day	4.9E-02
				Cyanide, total	3.1E+00	mg/kg	7.0E-05	mg/kg-day	NA		NA	8.2E-04	mg/kg-day	2.0E-02	mg/kg-day	4.1E-02
				Mercury	2.6E-01	mg/kg	5.9E-06	mg/kg-day	NA		NA	6.9E-05	mg/kg-day	1.0E-04	mg/kg-day	6.9E-01
				Selenium	1.4E+00	mg/kg	3.2E-05	mg/kg-day	NA		NA	3.7E-04	mg/kg-day	5.0E-03	mg/kg-day	7.4E-02
				Benzo(a)anthracene (0-2)*,+	7.7E-03	mg/kg	5.8E-08	mg/kg-day	7.3E+00	1/(mg/kg-day)	4.2E-07	2.0E-06	mg/kg-day	NA		NA
				Benzo(a)anthracene (2-6)*,+	7.7E-03	mg/kg	1.2E-07	mg/kg-day	2.2E+00	1/(mg/kg-day)	2.5E-07					
				Benzo(a)pyrene (0-2)*,+	1.2E-02	mg/kg	8.9E-08	mg/kg-day	7.3E+01	1/(mg/kg-day)	6.5E-06	3.1E-06	mg/kg-day	NA		NA
				Benzo(a)pyrene (2-6)*,+	1.2E-02	mg/kg	1.8E-07	mg/kg-day	2.2E+01	1/(mg/kg-day)	3.9E-06					
				Benzo(b)fluoranthene (0-2)*,+	6.4E-03	mg/kg	4.8E-08	mg/kg-day	7.3E+00	1/(mg/kg-day)	3.5E-07	1.7E-06	mg/kg-day	NA		NA
				Benzo(b)fluoranthene (2-6)*,+	6.4E-03	mg/kg	9.6E-08	mg/kg-day	2.2E+00	1/(mg/kg-day)	2.1E-07					
				Dibenz(a,h)anthracene (0-2)*,+	3.9E-03	mg/kg	3.0E-08	mg/kg-day	7.3E+01	1/(mg/kg-day)	2.2E-06	1.0E-06	mg/kg-day	NA		NA
				Dibenz(a,h)anthracene (2-6)*,+	3.9E-03	mg/kg	5.9E-08	mg/kg-day	2.2E+01	1/(mg/kg-day)	1.3E-06					
				Indeno(1,2,3-cd)pyrene (0-2)*,+	9.9E-03	mg/kg	7.5E-08	mg/kg-day	7.3E+00	1/(mg/kg-day)	5.5E-07	2.6E-06	mg/kg-day	NA		NA
				Indeno(1,2,3-cd)pyrene (2-6)*,+	9.9E-03	mg/kg	1.5E-07	mg/kg-day	2.2E+00	1/(mg/kg-day)	3.3E-07					
			Exp. Route Total								1.7E-04					1.9E+01
		Exposure Point Total									1.7E-04					1.9E+01
	Exposure Medium Total - Eel in Gowanus Canal										1.7E-04					1.9E+01

REVISED TABLE 7.10.RME

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

REASONABLE MAXIMUM EXPOSURE

Gowanus Canal Remedial Investigation, Brooklyn, New York

Scenario Timeframe: Current/Future
Receptor Population: Angler
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
	Fish and Crab Tissue	Blue Crab in Gowanus Canal	Ingestion													
				Benzo(a)anthracene (0-2)*	7.7E-03	mg/kg	1.2E-07	mg/kg-day	7.3E+00	1/(mg/kg-day)	8.6E-07	4.1E-06	mg/kg-day	NA		NA
				Benzo(a)anthracene (2-6)*	7.7E-03	mg/kg	2.3E-07	mg/kg-day	2.2E+00	1/(mg/kg-day)	5.1E-07					
				Benzo(a)pyrene (0-2)*	1.2E-02	mg/kg	1.8E-07	mg/kg-day	7.3E+01	1/(mg/kg-day)	1.3E-05	6.3E-06	mg/kg-day	NA		NA
				Benzo(a)pyrene (2-6)*	1.2E-02	mg/kg	3.6E-07	mg/kg-day	2.2E+01	1/(mg/kg-day)	7.9E-06					
				Benzo(b)fluoranthene (0-2)*	6.4E-03	mg/kg	9.7E-08	mg/kg-day	7.3E+00	1/(mg/kg-day)	7.1E-07	3.4E-06	mg/kg-day	NA		NA
				Benzo(b)fluoranthene (2-6)*	6.4E-03	mg/kg	1.9E-07	mg/kg-day	2.2E+00	1/(mg/kg-day)	4.3E-07					
				Dibenz(a,h)anthracene (0-2)*	3.9E-03	mg/kg	6.0E-08	mg/kg-day	7.3E+01	1/(mg/kg-day)	4.4E-06	2.1E-06	mg/kg-day	NA		NA
				Dibenz(a,h)anthracene (2-6)*	3.9E-03	mg/kg	1.2E-07	mg/kg-day	2.2E+01	1/(mg/kg-day)	2.6E-06					
				Indeno(1,2,3-cd)pyrene (0-2)*	9.9E-03	mg/kg	1.5E-07	mg/kg-day	7.3E+00	1/(mg/kg-day)	1.1E-06	5.3E-06	mg/kg-day	NA		NA
				Indeno(1,2,3-cd)pyrene (2-6)*	9.9E-03	mg/kg	3.0E-07	mg/kg-day	2.2E+00	1/(mg/kg-day)	6.6E-07					
				Dioxin-Like PCB TEQ	5.0E-06	mg/kg	2.3E-10	mg/kg-day	1.6E+05	1/(mg/kg-day)	3.6E-05	2.7E-09	mg/kg-day	NA		NA
				Nondioxin-Like	1.4E-01	mg/kg	6.5E-06	mg/kg-day	2.0E+00	1/(mg/kg-day)	1.3E-05	7.6E-05	mg/kg-day	NA		NA
				Total PCB	1.7E-01	mg/kg	7.6E-06	mg/kg-day	NA		NA	8.9E-05	mg/kg-day	2.0E-05	mg/kg-day	4.4E+00
				Arsenic	1.3E-01	mg/kg	6.0E-06	mg/kg-day	1.5E+00	1/(mg/kg-day)	9.0E-06	7.0E-05	mg/kg-day	3.0E-04	mg/kg-day	2.3E-01
				Copper	1.0E+01	mg/kg	4.7E-04	mg/kg-day	NA		NA	5.4E-03	mg/kg-day	4.0E-02	mg/kg-day	1.4E-01
				Mercury	1.2E-01	mg/kg	5.7E-06	mg/kg-day	NA		NA	6.6E-05	mg/kg-day	1.0E-04	mg/kg-day	6.6E-01
			Exp. Route Total								9.0E-05					5.5E+00
		Exposure Point Total									9.0E-05					5.5E+00
	Exposure Medium Total - Crab in Gowanus Canal										9.0E-05					5.5E+00
Total Fish										Total of Receptor Risks - Fish	2.4E-04				Total of Receptor Hazards - Fish	2.7E+01
Total Blue Crab										Total of Receptor Risks - Blue Crab	9.0E-05				Total of Receptor Hazards - Blue Crab	5.5E+00

Notes-

NA = Not available / Not applicable.

* Constituent acts via a mutagenic mode of action (MMOA). ADAF of 10 used to adjust CSF for 0-2 year old for exposure duration of 2 years, ADAF of 3 used to adjust CSF for 2-6 year old for exposure duration of 4 years.

+ PAH data included for fish is based on mearsued concentrations of PAHs in crab, not on actual fish tissue data

Non-cancer calculations shown under 0-2 year old only, as non-cancer calculations are not adjusted for MMOA.

REVISED TABLE 7-4

Summary of Total RME Cancer Risks for Angler

Gowanus Canal Remedial Investigation, Brooklyn, New York

Media	Exposure Pathway	Receptor			
		Angler adult Cancer Risk	Angler Adolescent Cancer Risk	Angler Child Cancer Risk	Total Angler Cancer Risk
Striped Bass in Gowanus Canal (top-level predator fish)	Ingestion	1E-04	2E-05	6E-05	2E-04
	Total	1E-04	2E-05	6E-05	2E-04
White Perch in Gowanus Canal (middle-level predator fish)	Ingestion	2E-05	5E-06	1E-05	4E-05
	Total	2E-05	5E-06	1E-05	4E-05
Eel in Gowanus Canal (bottom feeder fish)	Ingestion	3E-04	7E-05	2E-04	5E-04
	Total	3E-04	7E-05	2E-04	5E-04
Blue Crab in Gowanus Canal	Ingestion	2E-04	4E-05	9E-05	3E-04
	Total	2E-04	4E-05	9E-05	3E-04
Fish Total Risk		4E-04	1E-04	2E-04	8E-04
Crab Total Risk		2E-04	4E-05	9E-05	3E-04

Risk associated with fish also includes PAH concentrations from crab data

REVISED TABLE 7.7.CTE

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

CENTRAL TENDENCY EXPOSURE

Gowanus Canal Remedial Investigation, Brooklyn, New York

Scenario Timeframe: Current/Future
Receptor Population: Angler
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
							Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
					Value	Units	Value	Units	Value	Units		Value	Units	Value	Units	
Surface Water/Sediment	Fish and Crab Tissue	Striped Bass in Gowanus Canal	Ingestion													
				p,p'-DDE	1.2E-02	mg/kg	1.8E-08	mg/kg-day	3.4E-01	1/(mg/kg-day)	6.1E-09	4.2E-07	mg/kg-day	NA		NA
				p,p'-DDT	9.6E-03	mg/kg	1.5E-08	mg/kg-day	3.4E-01	1/(mg/kg-day)	5.3E-09	3.6E-07	mg/kg-day	5.0E-04	mg/kg-day	7.2E-04
				Dioxin-Like PCB TEQ	4.3E-06	mg/kg	7.9E-12	mg/kg-day	1.6E+05	1/(mg/kg-day)	1.2E-06	1.8E-10	mg/kg-day	NA		NA
				Nondioxin-Like	4.1E-01	mg/kg	7.5E-07	mg/kg-day	1.0E+00	1/(mg/kg-day)	7.5E-07	1.8E-05	mg/kg-day	NA		NA
				Total PCB	4.4E-01	mg/kg	8.0E-07	mg/kg-day	NA		NA	1.9E-05	mg/kg-day	2.0E-05	mg/kg-day	9.3E-01
				Arsenic	6.8E-02	mg/kg	1.6E-07	mg/kg-day	1.5E+00	1/(mg/kg-day)	2.3E-07	3.7E-06	mg/kg-day	3.0E-04	mg/kg-day	1.2E-02
				Mercury	2.0E-01	mg/kg	4.6E-07	mg/kg-day	NA		NA	1.1E-05	mg/kg-day	1.0E-04	mg/kg-day	1.1E-01
				Selenium	1.2E+00	mg/kg	2.8E-06	mg/kg-day	NA		NA	6.4E-05	mg/kg-day	5.0E-03	mg/kg-day	1.3E-02
				Benzo(a)anthracene*	7.7E-03	mg/kg	1.8E-08	mg/kg-day	7.3E-01	1/(mg/kg-day)	1.3E-08	4.1E-07	mg/kg-day	NA		NA
				Benzo(a)pyrene*	1.2E-02	mg/kg	2.7E-08	mg/kg-day	7.3E+00	1/(mg/kg-day)	2.0E-07	6.3E-07	mg/kg-day	NA		NA
				Benzo(b)fluoranthene*	6.4E-03	mg/kg	1.5E-08	mg/kg-day	7.3E-01	1/(mg/kg-day)	1.1E-08	3.4E-07	mg/kg-day	NA		NA
				Dibenz(a,h)anthracene*	3.9E-03	mg/kg	9.1E-09	mg/kg-day	7.3E+00	1/(mg/kg-day)	6.6E-08	2.1E-07	mg/kg-day	NA		NA
				Indeno(1,2,3-cd)pyrene*	9.9E-03	mg/kg	2.3E-08	mg/kg-day	7.3E-01	1/(mg/kg-day)	1.7E-08	5.3E-07	mg/kg-day	NA		NA
			Exp. Route Total								2.5E-06					1.1E+00
		Exposure Point Total									2.5E-06					1.1E+00
	Exposure Medium Total - Striped Bass in Gowanus Canal										2.5E-06					1.1E+00
	Fish and Crab Tissue	White Perch in Gowanus Canal	Ingestion													
				Dioxin-Like PCB TEQ	5.8E-06	mg/kg	2.0E-12	mg/kg-day	1.6E+05	1/(mg/kg-day)	3.2E-07	4.8E-11	mg/kg-day	NA		NA
				Nondioxin-Like	4.4E-01	mg/kg	1.5E-07	mg/kg-day	1.0E+00	1/(mg/kg-day)	1.5E-07	3.6E-06	mg/kg-day	NA		NA
				Total PCB	4.6E-01	mg/kg	1.6E-07	mg/kg-day	NA		NA	3.8E-06	mg/kg-day	2.0E-05	mg/kg-day	1.9E-01
				Mercury	1.9E-01	mg/kg	8.4E-08	mg/kg-day	NA		NA	2.0E-06	mg/kg-day	1.0E-04	mg/kg-day	2.0E-02
				Selenium	1.4E+00	mg/kg	6.2E-07	mg/kg-day	NA		NA	1.4E-05	mg/kg-day	5.0E-03	mg/kg-day	2.9E-03
				Benzo(a)anthracene*	7.7E-03	mg/kg	3.4E-09	mg/kg-day	7.3E-01	1/(mg/kg-day)	2.5E-09	7.9E-08	mg/kg-day	NA		NA
				Benzo(a)pyrene*	1.2E-02	mg/kg	5.2E-09	mg/kg-day	7.3E+00	1/(mg/kg-day)	3.8E-08	1.2E-07	mg/kg-day	NA		NA
				Benzo(b)fluoranthene*	6.4E-03	mg/kg	2.8E-09	mg/kg-day	7.3E-01	1/(mg/kg-day)	2.1E-09	6.6E-08	mg/kg-day	NA		NA
				Dibenz(a,h)anthracene*	3.9E-03	mg/kg	1.7E-09	mg/kg-day	7.3E+00	1/(mg/kg-day)	1.3E-08	4.1E-08	mg/kg-day	NA		NA
				Indeno(1,2,3-cd)pyrene*	9.9E-03	mg/kg	4.4E-09	mg/kg-day	7.3E-01	1/(mg/kg-day)	3.2E-09	1.0E-07	mg/kg-day	NA		NA
			Exp. Route Total								5.3E-07					2.1E-01
		Exposure Point Total									5.3E-07					2.1E-01
	Exposure Medium Total - White Perch in Gowanus Canal										5.3E-07					2.1E-01

REVISED TABLE 7.7.CTE

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

CENTRAL TENDENCY EXPOSURE

Gowanus Canal Remedial Investigation, Brooklyn, New York

Scenario Timeframe: Current/Future
Receptor Population: Angler
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Surface Water/Sediment	Fish and Crab Tissue	Eel in Gowanus Canal	Ingestion													
				alpha-Chlordane	2.2E-02	mg/kg	3.2E-08	mg/kg-day	3.5E-01	1/(mg/kg-day)	1.1E-08	7.4E-07	mg/kg-day	5.0E-04	mg/kg-day	1.5E-03
				Dieldrin	1.7E-02	mg/kg	2.6E-08	mg/kg-day	1.6E+01	1/(mg/kg-day)	4.1E-07	6.0E-07	mg/kg-day	5.0E-05	mg/kg-day	1.2E-02
				gamma-Chlordane	1.3E-02	mg/kg	1.9E-08	mg/kg-day	3.5E-01	1/(mg/kg-day)	6.6E-09	4.4E-07	mg/kg-day	5.0E-04	mg/kg-day	8.8E-04
				p,p'-DDD	3.8E-02	mg/kg	5.7E-08	mg/kg-day	2.4E-01	1/(mg/kg-day)	1.4E-08	1.3E-06	mg/kg-day	NA		NA
				p,p'-DDE	2.5E-02	mg/kg	3.5E-08	mg/kg-day	3.4E-01	1/(mg/kg-day)	1.2E-08	8.2E-07	mg/kg-day	NA		NA
				p,p'-DDT	4.7E-02	mg/kg	7.1E-08	mg/kg-day	3.4E-01	1/(mg/kg-day)	2.4E-08	1.7E-06	mg/kg-day	5.0E-04	mg/kg-day	3.3E-03
				Dioxin-Like PCB TEQ	1.4E-05	mg/kg	2.4E-11	mg/kg-day	1.6E+05	1/(mg/kg-day)	3.8E-06	5.7E-10	mg/kg-day	NA		NA
				Nondioxin-Like	1.2E+00	mg/kg	2.1E-06	mg/kg-day	1.0E+00	1/(mg/kg-day)	2.1E-06	4.9E-05	mg/kg-day	NA		NA
				Total PCB	1.4E+00	mg/kg	2.3E-06	mg/kg-day	NA		NA	5.4E-05	mg/kg-day	2.0E-05	mg/kg-day	2.7E+00
				Arsenic	5.0E-02	mg/kg	1.1E-07	mg/kg-day	1.5E+00	1/(mg/kg-day)	1.6E-07	2.5E-06	mg/kg-day	3.0E-04	mg/kg-day	8.4E-03
				Chromium	6.7E-01	mg/kg	1.4E-06	mg/kg-day	5.0E-01	1/(mg/kg-day)	7.2E-07	3.4E-05	mg/kg-day	3.0E-03	mg/kg-day	1.1E-02
				Copper	7.4E+00	mg/kg	1.6E-05	mg/kg-day	NA		NA	3.7E-04	mg/kg-day	4.0E-02	mg/kg-day	9.3E-03
				Cyanide, total	3.1E+00	mg/kg	6.7E-06	mg/kg-day	NA		NA	1.6E-04	mg/kg-day	2.0E-02		7.8E-03
				Mercury	2.6E-01	mg/kg	5.6E-07	mg/kg-day	NA		NA	1.3E-05	mg/kg-day	1.0E-04		1.3E-01
				Selenium	1.4E+00	mg/kg	3.0E-06	mg/kg-day	NA		NA	7.0E-05	mg/kg-day	5.0E-03	mg/kg-day	1.4E-02
				Benzo(a)anthracene*	7.7E-03	mg/kg	1.7E-08	mg/kg-day	7.3E-01	1/(mg/kg-day)	1.2E-08	3.9E-07	mg/kg-day	NA		NA
				Benzo(a)pyrene*	1.2E-02	mg/kg	2.5E-08	mg/kg-day	7.3E+00	1/(mg/kg-day)	1.9E-07	5.9E-07	mg/kg-day	NA		NA
				Benzo(b)fluoranthene*	6.4E-03	mg/kg	1.4E-08	mg/kg-day	7.3E-01	1/(mg/kg-day)	1.0E-08	3.2E-07	mg/kg-day	NA		NA
				Dibenz(a,h)anthracene*	3.9E-03	mg/kg	8.5E-09	mg/kg-day	7.3E+00	1/(mg/kg-day)	6.2E-08	2.0E-07	mg/kg-day	NA		NA
				Indeno(1,2,3-cd)pyrene*	9.9E-03	mg/kg	2.1E-08	mg/kg-day	7.3E-01	1/(mg/kg-day)	1.6E-08	5.0E-07	mg/kg-day	NA		NA
			Exp. Route Total								7.5E-06					2.9E+00
		Exposure Point Total									7.5E-06					2.9E+00
	Exposure Medium Total - Eel in Gowanus Canal										7.5E-06					2.9E+00

REVISED TABLE 7.7.CTE

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

CENTRAL TENDENCY EXPOSURE

Gowanus Canal Remedial Investigation, Brooklyn, New York

Scenario Timeframe: Current/Future
Receptor Population: Angler
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Surface Water/Sediment	Fish and Crab Tissue	Blue Crab in Gowanus Canal	Ingestion	Benzo(a)anthracene	7.7E-03	mg/kg	7.5E-08	mg/kg-day	7.3E-01	1/(mg/kg-day)	5.5E-08	1.8E-06	mg/kg-day	NA		NA
				Benzo(a)pyrene	1.2E-02	mg/kg	1.2E-07	mg/kg-day	7.3E+00	1/(mg/kg-day)	8.4E-07	2.7E-06	mg/kg-day	NA		NA
				Benzo(b)fluoranthene	6.4E-03	mg/kg	6.3E-08	mg/kg-day	7.3E-01	1/(mg/kg-day)	4.6E-08	1.5E-06	mg/kg-day	NA		NA
				Dibenz(a,h)anthracene	3.9E-03	mg/kg	3.9E-08	mg/kg-day	7.3E+00	1/(mg/kg-day)	2.8E-07	9.0E-07	mg/kg-day	NA		NA
				Indeno(1,2,3-cd)pyrene	9.9E-03	mg/kg	9.7E-08	mg/kg-day	7.3E-01	1/(mg/kg-day)	7.1E-08	2.3E-06	mg/kg-day	NA		NA
				Dioxin-Like PCB TEQ	5.0E-06	mg/kg	4.9E-11	mg/kg-day	1.6E+05	1/(mg/kg-day)	7.7E-06	1.2E-09	mg/kg-day	NA		NA
				Nondioxin-Like	1.4E-01	mg/kg	1.4E-06	mg/kg-day	1.0E+00	1/(mg/kg-day)	1.4E-06	3.3E-05	mg/kg-day	NA		NA
				Total PCB	1.7E-01	mg/kg	1.6E-06	mg/kg-day	NA		NA	3.8E-05	mg/kg-day	2.0E-05	mg/kg-day	1.9E+00
				Arsenic	1.3E-01	mg/kg	1.3E-06	mg/kg-day	1.5E+00	1/(mg/kg-day)	1.9E-06	3.0E-05	mg/kg-day	3.0E-04	mg/kg-day	1.0E-01
				Copper	1.0E+01	mg/kg	1.0E-04	mg/kg-day	NA		NA	2.3E-03	mg/kg-day	4.0E-02	mg/kg-day	5.8E-02
				Mercury	1.2E-01	mg/kg	1.2E-06	mg/kg-day	NA		NA	2.8E-05	mg/kg-day	1.0E-04	mg/kg-day	2.8E-01
			Exp. Route Total								1.2E-05					2.3E+00
		Exposure Point Total									1.2E-05					2.3E+00
	Exposure Medium Total - Crab in Gowanus Canal										1.2E-05					2.3E+00
Total Fish									Total of Receptor Risks - Fish		1.1E-05			Total of Receptor Hazards - Fish		4.2E+00
Total Blue Crab									Total of Receptor Risks - Blue Crab		1.2E-05			Total of Receptor Hazards - Blue Crab		2.3E+00

Notes-

NA = Not available / Not applicable.

* PAH data included for fish is based on mearsued concentrations of PAHs in crab, not on actual fish tissue data

REVISED TABLE 7.8.CTE

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

CENTRAL TENDENCY EXPOSURE

Gowanus Canal Remedial Investigation, Brooklyn, New York

Scenario Timeframe: Current/Future
Receptor Population: Angler
Receptor Age: Adolescent

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Surface Water/Sediment	Fish and Crab Tissue	Striped Bass in Gowanus Canal	Ingestion	p,p'-DDE	1.2E-02	mg/kg	1.5E-08	mg/kg-day	3.4E-01	1/(mg/kg-day)	5.0E-09	3.4E-07	mg/kg-day	NA		NA
				p,p'-DDT	9.6E-03	mg/kg	1.3E-08	mg/kg-day	3.4E-01	1/(mg/kg-day)	4.3E-09	2.9E-07	mg/kg-day	5.0E-04	mg/kg-day	5.9E-04
				Dioxin-Like PCB TEQ	4.3E-06	mg/kg	6.4E-12	mg/kg-day	1.6E+05	1/(mg/kg-day)	1.0E-06	1.5E-10	mg/kg-day	NA		NA
				Nondioxin-Like	4.1E-01	mg/kg	6.1E-07	mg/kg-day	1.0E+00	1/(mg/kg-day)	6.1E-07	1.4E-05	mg/kg-day	NA		NA
				Total PCB	4.4E-01	mg/kg	6.5E-07	mg/kg-day	NA		NA	1.5E-05	mg/kg-day	2.0E-05	mg/kg-day	7.6E-01
				Arsenic	6.8E-02	mg/kg	1.3E-07	mg/kg-day	1.5E+00	1/(mg/kg-day)	1.9E-07	3.0E-06	mg/kg-day	3.0E-04	mg/kg-day	9.9E-03
				Mercury	2.0E-01	mg/kg	3.7E-07	mg/kg-day	NA		NA	8.7E-06	mg/kg-day	1.0E-04	mg/kg-day	8.7E-02
				Selenium	1.2E+00	mg/kg	2.2E-06	mg/kg-day	NA		NA	5.2E-05	mg/kg-day	5.0E-03	mg/kg-day	1.0E-02
				Benzo(a)anthracene (12-15)*,+	7.7E-03	mg/kg	1.4E-08	mg/kg-day	2.2E+00	1/(mg/kg-day)	3.2E-08	3.4E-07	mg/kg-day	NA		NA
				Benzo(a)pyrene (12-15)*,+	1.2E-02	mg/kg	2.2E-08	mg/kg-day	2.2E+01	1/(mg/kg-day)	4.8E-07	5.2E-07	mg/kg-day	NA		NA
				Benzo(b)fluoranthene (12-15)*,+	6.4E-03	mg/kg	1.2E-08	mg/kg-day	2.2E+00	1/(mg/kg-day)	2.6E-08	2.8E-07	mg/kg-day	NA		NA
				Dibenz(a,h)anthracene (12-15)*,+	3.9E-03	mg/kg	7.4E-09	mg/kg-day	2.2E+01	1/(mg/kg-day)	1.6E-07	1.7E-07	mg/kg-day	NA		NA
				Indeno(1,2,3-cd)pyrene (12-15)*,+	9.9E-03	mg/kg	1.9E-08	mg/kg-day	2.2E+00	1/(mg/kg-day)	4.1E-08	4.3E-07	mg/kg-day	NA		NA
			Exp. Route Total								2.6E-06					8.7E-01
		Exposure Point Total									2.6E-06					8.7E-01
	Exposure Medium Total - Striped Bass in Gowanus Canal										2.6E-06					8.7E-01
	Fish and Crab Tissue	White Perch in Gowanus Canal	Ingestion	Dioxin-Like PCB TEQ	5.8E-06	mg/kg	1.7E-12	mg/kg-day	1.6E+05	1/(mg/kg-day)	2.6E-07	3.9E-11	mg/kg-day	NA		NA
				Nondioxin-Like	4.4E-01	mg/kg	1.3E-07	mg/kg-day	1.0E+00	1/(mg/kg-day)	1.3E-07	2.9E-06	mg/kg-day	NA		NA
				Total PCB	4.6E-01	mg/kg	1.3E-07	mg/kg-day	NA		NA	3.1E-06	mg/kg-day	2.0E-05	mg/kg-day	1.5E-01
				Mercury	1.9E-01	mg/kg	6.8E-08	mg/kg-day	NA		NA	1.6E-06	mg/kg-day	1.0E-04	mg/kg-day	1.6E-02
				Selenium	1.4E+00	mg/kg	5.0E-07	mg/kg-day	NA		NA	1.2E-05	mg/kg-day	5.0E-03	mg/kg-day	2.3E-03
				Benzo(a)anthracene (12-15)*,+	7.7E-03	mg/kg	2.8E-09	mg/kg-day	2.2E+00	1/(mg/kg-day)	6.0E-09	6.4E-08	mg/kg-day	NA		NA
				Benzo(a)pyrene (12-15)*,+	1.2E-02	mg/kg	4.2E-09	mg/kg-day	2.2E+01	1/(mg/kg-day)	9.3E-08	9.9E-08	mg/kg-day	NA		NA
				Benzo(b)fluoranthene (12-15)*,+	6.4E-03	mg/kg	2.3E-09	mg/kg-day	2.2E+00	1/(mg/kg-day)	5.0E-09	5.3E-08	mg/kg-day	NA		NA
				Dibenz(a,h)anthracene (12-15)*,+	3.9E-03	mg/kg	1.4E-09	mg/kg-day	2.2E+01	1/(mg/kg-day)	3.1E-08	3.3E-08	mg/kg-day	NA		NA
				Indeno(1,2,3-cd)pyrene (12-15)*,+	9.9E-03	mg/kg	3.6E-09	mg/kg-day	2.2E+00	1/(mg/kg-day)	7.8E-09	8.3E-08	mg/kg-day	NA		NA
			Exp. Route Total								5.3E-07					1.7E-01
		Exposure Point Total									5.3E-07					1.7E-01
	Exposure Medium Total - White Perch in Gowanus Canal										5.3E-07					1.7E-01

REVISED TABLE 7.8.CTE

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

CENTRAL TENDENCY EXPOSURE

Gowanus Canal Remedial Investigation, Brooklyn, New York

Scenario Timeframe: Current/Future
Receptor Population: Angler
Receptor Age: Adolescent

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Surface Water/Sediment	Fish and Crab Tissue	Eel in Gowanus Canal	Ingestion													
				alpha-Chlordane	2.2E-02	mg/kg	2.6E-08	mg/kg-day	3.5E-01	1/(mg/kg-day)	9.0E-09	6.0E-07	mg/kg-day	5.0E-04	mg/kg-day	1.2E-03
				Dieldrin	1.7E-02	mg/kg	2.1E-08	mg/kg-day	1.6E+01	1/(mg/kg-day)	3.3E-07	4.9E-07	mg/kg-day	5.0E-05	mg/kg-day	9.7E-03
				gamma-Chlordane	1.3E-02	mg/kg	1.5E-08	mg/kg-day	3.5E-01	1/(mg/kg-day)	5.3E-09	3.6E-07	mg/kg-day	5.0E-04	mg/kg-day	7.1E-04
				p,p'-DDD	3.8E-02	mg/kg	4.7E-08	mg/kg-day	2.4E-01	1/(mg/kg-day)	1.1E-08	1.1E-06	mg/kg-day	NA		NA
				p,p'-DDE	2.5E-02	mg/kg	2.8E-08	mg/kg-day	3.4E-01	1/(mg/kg-day)	9.7E-09	6.6E-07	mg/kg-day	NA		NA
				p,p'-DDT	4.7E-02	mg/kg	5.8E-08	mg/kg-day	3.4E-01	1/(mg/kg-day)	2.0E-08	1.3E-06	mg/kg-day	5.0E-04	mg/kg-day	2.7E-03
				Dioxin-Like PCB TEQ	1.4E-05	mg/kg	2.0E-11	mg/kg-day	1.6E+05	1/(mg/kg-day)	3.1E-06	4.6E-10	mg/kg-day	NA		NA
				Nondioxin-Like	1.2E+00	mg/kg	1.7E-06	mg/kg-day	1.0E+00	1/(mg/kg-day)	1.7E-06	4.0E-05	mg/kg-day	NA		NA
				Total PCB	1.4E+00	mg/kg	1.9E-06	mg/kg-day	NA		NA	4.4E-05	mg/kg-day	2.0E-05	mg/kg-day	2.2E+00
				Arsenic	5.0E-02	mg/kg	8.8E-08	mg/kg-day	1.5E+00	1/(mg/kg-day)	1.3E-07	2.0E-06	mg/kg-day	3.0E-04	mg/kg-day	6.8E-03
				Chromium (12-15)*	6.7E-01	mg/kg	1.2E-06	mg/kg-day	1.5E+00	1/(mg/kg-day)	1.8E-06	2.7E-05	mg/kg-day	3.0E-03	mg/kg-day	9.1E-03
				Copper	7.4E+00	mg/kg	1.3E-05	mg/kg-day	NA		NA	3.0E-04	mg/kg-day	4.0E-02	mg/kg-day	7.6E-03
				Cyanide, total	3.1E+00	mg/kg	5.4E-06	mg/kg-day	NA		NA	1.3E-04	mg/kg-day	2.0E-02	mg/kg-day	6.3E-03
				Mercury	2.6E-01	mg/kg	4.6E-07	mg/kg-day	NA		NA	1.1E-05	mg/kg-day	1.0E-04	mg/kg-day	1.1E-01
				Selenium	1.4E+00	mg/kg	2.5E-06	mg/kg-day	NA		NA	5.7E-05	mg/kg-day	5.0E-03	mg/kg-day	1.1E-02
				Benzo(a)anthracene (12-15)*,+	7.7E-03	mg/kg	1.4E-08	mg/kg-day	2.2E+00	1/(mg/kg-day)	3.0E-08	3.2E-07	mg/kg-day	NA		NA
				Benzo(a)pyrene (12-15)*,+	1.2E-02	mg/kg	2.1E-08	mg/kg-day	2.2E+01	1/(mg/kg-day)	4.5E-07	4.8E-07	mg/kg-day	NA		NA
				Benzo(b)fluoranthene (12-15)*,+	6.4E-03	mg/kg	1.1E-08	mg/kg-day	2.2E+00	1/(mg/kg-day)	2.5E-08	2.6E-07	mg/kg-day	NA		NA
				Dibenz(a,h)anthracene (12-15)*,+	3.9E-03	mg/kg	6.9E-09	mg/kg-day	2.2E+01	1/(mg/kg-day)	1.5E-07	1.6E-07	mg/kg-day	NA		NA
				Indeno(1,2,3-cd)pyrene (12-15)*,+	9.9E-03	mg/kg	1.7E-08	mg/kg-day	2.2E+00	1/(mg/kg-day)	3.8E-08	4.1E-07	mg/kg-day	NA		NA
			Exp. Route Total								7.8E-06					2.4E+00
		Exposure Point Total									7.8E-06					2.4E+00
	Exposure Medium Total - Eel in Gowanus Canal										7.8E-06					2.4E+00

REVISED TABLE 7.8.CTE

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

CENTRAL TENDENCY EXPOSURE

Gowanus Canal Remedial Investigation, Brooklyn, New York

Scenario Timeframe: Current/Future
Receptor Population: Angler
Receptor Age: Adolescent

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC Value	EPC Units	Cancer Risk Calculations: Intake/Exposure Concentration Value	Intake/Exposure Concentration Units	CSF/Unit Risk Value	CSF/Unit Risk Units	Cancer Risk	Non-Cancer Hazard Calculations: Intake/Exposure Concentration Value	Intake/Exposure Concentration Units	RfD/RfC Value	RfD/RfC Units	Hazard Quotient
Surface Water/Sediment	Fish and Crab Tissue	Blue Crab in Gowanus Canal	Ingestion													
				Benzo(a)anthracene (12-15)*	7.7E-03	mg/kg	6.2E-08	mg/kg-day	2.2E+00	1/(mg/kg-day)	1.4E-07	1.4E-06	mg/kg-day	NA		NA
				Benzo(a)pyrene (12-15)*	1.2E-02	mg/kg	9.5E-08	mg/kg-day	2.2E+01	1/(mg/kg-day)	2.1E-06	2.2E-06	mg/kg-day	NA		NA
				Benzo(b)fluoranthene (12-15)*	6.4E-03	mg/kg	5.1E-08	mg/kg-day	2.2E+00	1/(mg/kg-day)	1.1E-07	1.2E-06	mg/kg-day	NA		NA
				Dibenz(a,h)anthracene (12-15)*	3.9E-03	mg/kg	3.2E-08	mg/kg-day	2.2E+01	1/(mg/kg-day)	6.9E-07	7.4E-07	mg/kg-day	NA		NA
				Indeno(1,2,3-cd)pyrene (12-15)*	9.9E-03	mg/kg	8.0E-08	mg/kg-day	2.2E+00	1/(mg/kg-day)	1.7E-07	1.9E-06	mg/kg-day	NA		NA
				Dioxin-Like PCB TEQ	5.0E-06	mg/kg	4.1E-11	mg/kg-day	1.6E+05	1/(mg/kg-day)	6.3E-06	9.5E-10	mg/kg-day	NA		NA
				Nondioxin-Like	1.4E-01	mg/kg	1.2E-06	mg/kg-day	1.0E+00	1/(mg/kg-day)	1.2E-06	2.7E-05	mg/kg-day	NA		NA
				Total PCB	1.7E-01	mg/kg	1.3E-06	mg/kg-day	NA		NA	3.1E-05	mg/kg-day	2.0E-05	mg/kg-day	1.6E+00
				Arsenic	1.3E-01	mg/kg	1.1E-06	mg/kg-day	1.5E+00	1/(mg/kg-day)	1.6E-06	2.5E-05	mg/kg-day	3.0E-04	mg/kg-day	8.2E-02
				Copper	1.0E+01	mg/kg	8.2E-05	mg/kg-day	NA		NA	1.9E-03	mg/kg-day	4.0E-02	mg/kg-day	4.8E-02
				Mercury	1.2E-01	mg/kg	1.0E-06	mg/kg-day	NA		NA	2.3E-05	mg/kg-day	1.0E-04	mg/kg-day	2.3E-01
			Exp. Route Total								1.2E-05					1.9E+00
		Exposure Point Total									1.2E-05					1.9E+00
	Exposure Medium Total - Crab in Gowanus Canal										1.2E-05					1.9E+00
Total Fish										Total of Receptor Risks - Fish	1.1E-05				Total of Receptor Hazards - Fish	3.4E+00
Total Blue Crab										Total of Receptor Risks - Blue Crab	1.2E-05				Total of Receptor Hazards - Blue Crab	1.9E+00

Notes-

NA = Not available / Not applicable.

* Constituent acts via a mutagenic mode of action (MMOA). ADAF of 3 used to adjust CSF for 12-15 year old for exposure duration of 3 years, the CTE exposure duration for an adolescent.

+ PAH data included for fish is based on mearsued concentrations of PAHs in crab, not on actual fish tissue data

REVISED TABLE 7.9.CTE

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

CENTRAL TENDENCY EXPOSURE

Gowanus Canal Remedial Investigation, Brooklyn, New York

Scenario Timeframe: Current/Future
Receptor Population: Angler
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Surface Water/Sediment	Fish and Crab Tissue	Striped Bass in Gowanus Canal	Ingestion													
				p,p'-DDE	1.2E-02	mg/kg	2.8E-08	mg/kg-day	3.4E-01	1/(mg/kg-day)	9.6E-09	6.6E-07	mg/kg-day	NA		NA
				p,p'-DDT	9.6E-03	mg/kg	2.4E-08	mg/kg-day	3.4E-01	1/(mg/kg-day)	8.3E-09	5.7E-07	mg/kg-day	5.0E-04	mg/kg-day	1.1E-03
				Dioxin-Like PCB TEQ	4.3E-06	mg/kg	1.2E-11	mg/kg-day	1.6E+05	1/(mg/kg-day)	1.9E-06	2.9E-10	mg/kg-day	NA		NA
				Nondioxin-Like	4.1E-01	mg/kg	1.2E-06	mg/kg-day	1.0E+00	1/(mg/kg-day)	1.2E-06	2.8E-05	mg/kg-day	NA		NA
				Total PCB	4.4E-01	mg/kg	1.3E-06	mg/kg-day	NA		NA	2.9E-05	mg/kg-day	2.0E-05	mg/kg-day	1.5E+00
				Arsenic	6.8E-02	mg/kg	2.5E-07	mg/kg-day	1.5E+00	1/(mg/kg-day)	3.7E-07	5.8E-06	mg/kg-day	3.0E-04	mg/kg-day	1.9E-02
				Mercury	2.0E-01	mg/kg	7.3E-07	mg/kg-day	NA	1/(mg/kg-day)	NA	1.7E-05	mg/kg-day	1.0E-04	mg/kg-day	1.7E-01
				Selenium	1.2E+00	mg/kg	4.4E-06	mg/kg-day	NA		NA	1.0E-04	mg/kg-day	5.0E-03	mg/kg-day	2.0E-02
				Benzo(a)anthracene (0-2)*,+	7.7E-03	mg/kg	1.9E-08	mg/kg-day	7.3E+00	1/(mg/kg-day)	1.4E-07	6.5E-07	mg/kg-day	NA		NA
				Benzo(a)anthracene (2-3)*,+	7.7E-03	mg/kg	9.3E-09	mg/kg-day	2.2E+00	1/(mg/kg-day)	2.0E-08					
				Benzo(a)pyrene (0-2)*,+	1.2E-02	mg/kg	2.9E-08	mg/kg-day	7.3E+01	1/(mg/kg-day)	2.1E-06	1.0E-06	mg/kg-day	NA		NA
				Benzo(a)pyrene (2-3)*,+	1.2E-02	mg/kg	1.4E-08	mg/kg-day	2.2E+01	1/(mg/kg-day)	3.1E-07					
				Benzo(b)fluoranthene (0-2)*,+	6.4E-03	mg/kg	1.5E-08	mg/kg-day	7.3E+00	1/(mg/kg-day)	1.1E-07	5.4E-07	mg/kg-day	NA		NA
				Benzo(b)fluoranthene (2-3)*,+	6.4E-03	mg/kg	7.7E-09	mg/kg-day	2.2E+00	1/(mg/kg-day)	1.7E-08					
				Dibenz(a,h)anthracene (0-2)*,+	3.9E-03	mg/kg	9.5E-09	mg/kg-day	7.3E+01	1/(mg/kg-day)	7.0E-07	3.3E-07	mg/kg-day	NA		NA
				Dibenz(a,h)anthracene (2-3)*,+	3.9E-03	mg/kg	4.8E-09	mg/kg-day	2.2E+01	1/(mg/kg-day)	1.0E-07					
				Indeno(1,2,3-cd)pyrene (0-2)*,+	9.9E-03	mg/kg	2.4E-08	mg/kg-day	7.3E+00	1/(mg/kg-day)	1.7E-07	8.4E-07	mg/kg-day	NA		NA
				Indeno(1,2,3-cd)pyrene (2-3)*,+	9.9E-03	mg/kg	1.2E-08	mg/kg-day	2.2E+00	1/(mg/kg-day)	2.6E-08					
			Exp. Route Total								7.2E-06					1.7E+00
		Exposure Point Total									7.2E-06					1.7E+00
	Exposure Medium Total - Striped Bass in Gowanus Canal										7.2E-06					1.7E+00

REVISED TABLE 7.9.CTE

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

CENTRAL TENDENCY EXPOSURE

Gowanus Canal Remedial Investigation, Brooklyn, New York

Scenario Timeframe: Current/Future
Receptor Population: Angler
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Surface Water/Sediment	Fish and Crab Tissue	White Perch in Gowanus Canal	Ingestion													
				Dioxin-Like PCB TEQ	5.8E-06	mg/kg	3.2E-12	mg/kg-day	1.6E+05	1/(mg/kg-day)	5.0E-07	7.5E-11	mg/kg-day	NA		NA
				Nondioxin-Like	4.4E-01	mg/kg	2.4E-07	mg/kg-day	1.0E+00	1/(mg/kg-day)	2.4E-07	5.7E-06	mg/kg-day	NA		NA
				Total PCB	4.6E-01	mg/kg	2.6E-07	mg/kg-day	NA		NA	6.0E-06	mg/kg-day	2.0E-05	mg/kg-day	3.0E-01
				Mercury	1.9E-01	mg/kg	1.3E-07	mg/kg-day	NA		NA	3.1E-06	mg/kg-day	1.0E-04	mg/kg-day	3.1E-02
				Selenium	1.4E+00	mg/kg	9.7E-07	mg/kg-day	NA		NA	2.3E-05	mg/kg-day	5.0E-03	mg/kg-day	4.5E-03
				Benzo(a)anthracene (0-2)*,+	7.7E-03	mg/kg	3.6E-09	mg/kg-day	7.3E+00	1/(mg/kg-day)	2.6E-08	6.5E-07	mg/kg-day	NA		NA
				Benzo(a)anthracene (2-3)*,+	7.7E-03	mg/kg	1.8E-09	mg/kg-day	2.2E+00	1/(mg/kg-day)	3.9E-09					
				Benzo(a)pyrene (0-2)*,+	1.2E-02	mg/kg	5.5E-09	mg/kg-day	7.3E+01	1/(mg/kg-day)	4.0E-07	1.0E-06	mg/kg-day	NA		NA
				Benzo(a)pyrene (2-3)*,+	1.2E-02	mg/kg	2.7E-09	mg/kg-day	2.2E+01	1/(mg/kg-day)	6.0E-08					
				Benzo(b)fluoranthene (0-2)*,+	6.4E-03	mg/kg	3.0E-09	mg/kg-day	7.3E+00	1/(mg/kg-day)	2.2E-08	5.4E-07	mg/kg-day	NA		NA
				Benzo(b)fluoranthene (2-3)*,+	6.4E-03	mg/kg	1.5E-09	mg/kg-day	2.2E+00	1/(mg/kg-day)	3.2E-09					
				Dibenz(a,h)anthracene (0-2)*,+	3.9E-03	mg/kg	1.8E-09	mg/kg-day	7.3E+01	1/(mg/kg-day)	1.3E-07	3.3E-07	mg/kg-day	NA		NA
				Dibenz(a,h)anthracene (2-3)*,+	3.9E-03	mg/kg	9.1E-10	mg/kg-day	2.2E+01	1/(mg/kg-day)	2.0E-08					
				Indeno(1,2,3-cd)pyrene (0-2)*,+	9.9E-03	mg/kg	4.6E-09	mg/kg-day	7.3E+00	1/(mg/kg-day)	3.3E-08	8.4E-07	mg/kg-day	NA		NA
				Indeno(1,2,3-cd)pyrene (2-3)*,+	9.9E-03	mg/kg	2.3E-09	mg/kg-day	2.2E+00	1/(mg/kg-day)	5.0E-09					
			Exp. Route Total								1.5E-06					3.3E-01
		Exposure Point Total									1.5E-06					3.3E-01
	Exposure Medium Total - White Perch in Gowanus Canal										1.5E-06					3.3E-01

REVISED TABLE 7.9.CTE

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

CENTRAL TENDENCY EXPOSURE

Gowanus Canal Remedial Investigation, Brooklyn, New York

Scenario Timeframe: Current/Future
Receptor Population: Angler
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Surface Water/Sediment	Fish and Crab Tissue	Eel in Gowanus Canal	Ingestion													
				alpha-Chlordane	2.2E-02	mg/kg	5.0E-08	mg/kg-day	3.5E-01	1/(mg/kg-day)	1.8E-08	1.2E-06	mg/kg-day	5.0E-04	mg/kg-day	2.3E-03
				Dieldrin	1.7E-02	mg/kg	4.0E-08	mg/kg-day	1.6E+01	1/(mg/kg-day)	6.5E-07	9.4E-07	mg/kg-day	5.0E-05	mg/kg-day	1.9E-02
				gamma-Chlordane	1.3E-02	mg/kg	3.0E-08	mg/kg-day	3.5E-01	1/(mg/kg-day)	1.0E-08	6.9E-07	mg/kg-day	5.0E-04	mg/kg-day	1.4E-03
				p,p'-DDD	3.8E-02	mg/kg	9.0E-08	mg/kg-day	2.4E-01	1/(mg/kg-day)	2.2E-08	2.1E-06	mg/kg-day	NA		NA
				p,p'-DDE	2.5E-02	mg/kg	5.5E-08	mg/kg-day	3.4E-01	1/(mg/kg-day)	1.9E-08	1.3E-06	mg/kg-day	NA		NA
				p,p'-DDT	4.7E-02	mg/kg	1.1E-07	mg/kg-day	3.4E-01	1/(mg/kg-day)	3.8E-08	2.6E-06	mg/kg-day	5.0E-04	mg/kg-day	5.2E-03
				Dioxin-Like PCB TEQ	1.4E-05	mg/kg	3.8E-11	mg/kg-day	1.6E+05	1/(mg/kg-day)	6.0E-06	8.9E-10	mg/kg-day	NA		NA
				Nondioxin-Like	1.2E+00	mg/kg	3.3E-06	mg/kg-day	1.0E+00	1/(mg/kg-day)	3.3E-06	7.7E-05	mg/kg-day	NA		NA
				Total PCB	1.4E+00	mg/kg	3.7E-06	mg/kg-day	NA		NA	8.6E-05	mg/kg-day	2.0E-05	mg/kg-day	4.3E+00
				Arsenic	5.0E-02	mg/kg	1.7E-07	mg/kg-day	1.5E+00	1/(mg/kg-day)	2.5E-07	4.0E-06	mg/kg-day	3.0E-04	mg/kg-day	1.3E-02
				Chromium (0-2)*	6.7E-01	mg/kg	1.5E-06	mg/kg-day	5.0E+00	1/(mg/kg-day)	7.6E-06	5.3E-05	mg/kg-day	3.0E-03	mg/kg-day	1.8E-02
				Chromium (2-3)*	6.7E-01	mg/kg	7.6E-07	mg/kg-day	1.5E+00	1/(mg/kg-day)	1.1E-06					
				Copper	7.4E+00	mg/kg	2.5E-05	mg/kg-day	NA		NA	5.9E-04	mg/kg-day	4.0E-02	mg/kg-day	1.5E-02
				Cyanide, total	3.1E+00	mg/kg	1.1E-05	mg/kg-day	NA		NA	2.5E-04	mg/kg-day	2.0E-02	mg/kg-day	1.2E-02
				Mercury	2.6E-01	mg/kg	8.8E-07	mg/kg-day	NA		NA	2.1E-05	mg/kg-day	1.0E-04	mg/kg-day	2.1E-01
				Selenium	1.4E+00	mg/kg	4.8E-06	mg/kg-day	NA		NA	1.1E-04	mg/kg-day	5.0E-03	mg/kg-day	2.2E-02
				Benzo(a)anthracene (0-2)*,+	7.7E-03	mg/kg	1.7E-08	mg/kg-day	7.3E+00	1/(mg/kg-day)	1.3E-07	6.1E-07	mg/kg-day	NA		NA
				Benzo(a)anthracene (2-3)*,+	7.7E-03	mg/kg	8.7E-09	mg/kg-day	2.2E+00	1/(mg/kg-day)	1.9E-08					
				Benzo(a)pyrene (0-2)*,+	1.2E-02	mg/kg	2.7E-08	mg/kg-day	7.3E+01	1/(mg/kg-day)	1.9E-06	9.3E-07	mg/kg-day	NA		NA
				Benzo(a)pyrene (2-3)*,+	1.2E-02	mg/kg	1.3E-08	mg/kg-day	2.2E+01	1/(mg/kg-day)	2.9E-07					
				Benzo(b)fluoranthene (0-2)*,+	6.4E-03	mg/kg	1.4E-08	mg/kg-day	7.3E+00	1/(mg/kg-day)	1.1E-07	5.1E-07	mg/kg-day	NA		NA
				Benzo(b)fluoranthene (2-3)*,+	6.4E-03	mg/kg	7.2E-09	mg/kg-day	2.2E+00	1/(mg/kg-day)	1.6E-08					
				Dibenz(a,h)anthracene (0-2)*,+	3.9E-03	mg/kg	8.9E-09	mg/kg-day	7.3E+01	1/(mg/kg-day)	6.5E-07	3.1E-07	mg/kg-day	NA		NA
				Dibenz(a,h)anthracene (2-3)*,+	3.9E-03	mg/kg	4.5E-09	mg/kg-day	2.2E+01	1/(mg/kg-day)	9.8E-08					
				Indeno(1,2,3-cd)pyrene (0-2)*,+	9.9E-03	mg/kg	2.2E-08	mg/kg-day	7.3E+00	1/(mg/kg-day)	1.6E-07	7.8E-07	mg/kg-day	NA		NA
				Indeno(1,2,3-cd)pyrene (2-3)*,+	9.9E-03	mg/kg	1.1E-08	mg/kg-day	2.2E+00	1/(mg/kg-day)	2.5E-08					
			Exp. Route Total								2.2E-05					4.6E+00
		Exposure Point Total									2.2E-05					4.6E+00
	Exposure Medium Total - Eel in Gowanus Canal										2.2E-05					4.6E+00

REVISED TABLE 7.9.CTE

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

CENTRAL TENDENCY EXPOSURE

Gowanus Canal Remedial Investigation, Brooklyn, New York

Scenario Timeframe: Current/Future
Receptor Population: Angler
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
	Fish and Crab Tissue	Blue Crab in Gowanus Canal	Ingestion													
				Benzo(a)anthracene (0-2)*	7.7E-03	mg/kg	7.8E-08	mg/kg-day	7.3E+00	1/(mg/kg-day)	5.7E-07	2.7E-06	mg/kg-day	NA		NA
				Benzo(a)anthracene (2-3)*	7.7E-03	mg/kg	3.9E-08	mg/kg-day	2.2E+00	1/(mg/kg-day)	8.5E-08					
				Benzo(a)pyrene (0-2)*	1.2E-02	mg/kg	1.2E-07	mg/kg-day	7.3E+01	1/(mg/kg-day)	8.7E-06	4.2E-06	mg/kg-day	NA		NA
				Benzo(a)pyrene (2-3)*	1.2E-02	mg/kg	6.0E-08	mg/kg-day	2.2E+01	1/(mg/kg-day)	1.3E-06					
				Benzo(b)fluoranthene (0-2)*	6.4E-03	mg/kg	6.5E-08	mg/kg-day	7.3E+00	1/(mg/kg-day)	4.7E-07	2.3E-06	mg/kg-day	NA		NA
				Benzo(b)fluoranthene (2-3)*	6.4E-03	mg/kg	3.2E-08	mg/kg-day	2.2E+00	1/(mg/kg-day)	7.1E-08					
				Dibenz(a,h)anthracene (0-2)*	3.9E-03	mg/kg	4.0E-08	mg/kg-day	7.3E+01	1/(mg/kg-day)	2.9E-06	1.4E-06	mg/kg-day	NA		NA
				Dibenz(a,h)anthracene (2-3)*	3.9E-03	mg/kg	2.0E-08	mg/kg-day	2.2E+01	1/(mg/kg-day)	4.4E-07					
				Indeno(1,2,3-cd)pyrene (0-2)*	9.9E-03	mg/kg	1.0E-07	mg/kg-day	7.3E+00	1/(mg/kg-day)	7.3E-07	3.5E-06	mg/kg-day	NA		NA
				Indeno(1,2,3-cd)pyrene (2-3)*	9.9E-03	mg/kg	5.0E-08	mg/kg-day	2.2E+00	1/(mg/kg-day)	1.1E-07					
				Dioxin-Like PCB TEQ	5.0E-06	mg/kg	7.6E-11	mg/kg-day	1.6E+05	1/(mg/kg-day)	1.2E-05	1.8E-09	mg/kg-day	NA		NA
				Nondioxin-Like	1.4E-01	mg/kg	2.2E-06	mg/kg-day	1.0E+00	1/(mg/kg-day)	2.2E-06	5.1E-05	mg/kg-day	NA		NA
				Total PCB	1.7E-01	mg/kg	2.5E-06	mg/kg-day	NA		NA	5.9E-05	mg/kg-day	2.0E-05	mg/kg-day	2.9E+00
				Arsenic	1.3E-01	mg/kg	2.0E-06	mg/kg-day	1.5E+00	1/(mg/kg-day)	3.0E-06	4.6E-05	mg/kg-day	3.0E-04	mg/kg-day	1.5E-01
				Copper	1.0E+01	mg/kg	1.5E-04	mg/kg-day	NA		NA	3.6E-03	mg/kg-day	4.0E-02	mg/kg-day	9.0E-02
				Mercury	1.2E-01	mg/kg	1.9E-06	mg/kg-day	NA		NA	4.4E-05	mg/kg-day	1.0E-04	mg/kg-day	4.4E-01
			Exp. Route Total								3.2E-05					3.6E+00
		Exposure Point Total									3.2E-05					3.6E+00
	Exposure Medium Total - Crab in Gowanus Canal										3.2E-05					3.6E+00
Total Fish										Total of Receptor Risks - Fish	3.1E-05				Total of Receptor Hazards - Fish	6.6E+00
Total Blue Crab										Total of Receptor Risks - Blue Crab	3.2E-05				Total of Receptor Hazards - Blue Crab	3.6E+00

Notes-

* Constituent acts via a mutagenic mode of action (MMOA). ADAF of 10 used to adjust CSF for 0-2 year old for exposure duration of 2 years, ADAF of 3 used to adjust CSF for 2-3 year old for exposure duration of 1 year, for a total CTE exposure duration of 3 years.
Non-cancer calculations shown under 0-2 year old only, as non-cancer calculations are not adjusted for MMOA.

NA = Not available / Not applicable.

[+] PAH data included for fish is based on mearsued concentrations of PAHs in crab, not on actual fish tissue data

REVISED TABLE 7-5

Summary of Total CTE Cancer Risks for Angler

Gowanus Canal Remedial Investigation, Brooklyn, New York

Media	Exposure Pathway	Receptor			
		Angler adult Cancer Risk	Angler Adolescent Cancer Risk	Angler Child Cancer Risk	Total Angler Cancer Risk
Striped Bass in Gowanus Canal (top-level predator fish)	Ingestion	3E-06	3E-06	7E-06	1E-05
	Total	3E-06	3E-06	7E-06	1E-05
White Perch in Gowanus Canal (middle-level predator fish)	Ingestion	5E-07	5E-07	1E-06	3E-06
	Total	5E-07	5E-07	1E-06	3E-06
Eel in Gowanus Canal (bottom feeder fish)	Ingestion	8E-06	8E-06	2E-05	4E-05
	Total	8E-06	8E-06	2E-05	4E-05
Blue Crab in Gowanus Canal	Ingestion	1E-05	1E-05	3E-05	6E-05
	Total	1E-05	1E-05	3E-05	6E-05
Fish Total Risk		1E-05	1E-05	3E-05	5E-05
Crab Total Risk		1E-05	1E-05	3E-05	6E-05

Risk associated with fish also includes PAH concentrations from crab data

Attachment 2

Table 4.7.RME
VALUES USED FOR DAILY INTAKE CALCULATIONS
REASONABLE MAXIMUM EXPOSURE
Gowanus Canal Remedial Investigation, Brooklyn, New York

Scenario Timeframe: Current/Future
Medium: Surface Water / Sediment
Exposure Medium: Fish and Crab Tissue

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Subsistence Fisherman	Adult	Striped Bass White Perch Eel	CFish	Chemical Concentration in Fish	Tables 3.8.RME, 3.9.RME, and 3.10.RME	mg/kg	Tables 3.8.RME, 3.9.RME, and 3.10.RME	Chronic Daily Intake (CDI) (mg/kg-day) = CFish x IR-Fish x FI x EF x ED x CF3 x 1/BW x 1/AT
				IR-Fish	Ingestion of Fish	65	g/day	Going Costal, 2010 (1)	
				FI	Fraction Ingested -	fish specific	unitless	EPA, 2000	
					Striped Bass	0.47	unitless	Connelly, 1992, (4)	
					White Perch	0.09	unitless	Connelly, 1992, (4)	
					Eel	0.44	unitless	Connelly, 1992, (4)	
				EF	Exposure Frequency	365	days/year	EPA, 1997	
				ED	Exposure Duration	24	years	EPA, 1991	
				CF3	Conversion Factor 3	0.001	kg/g	- -	
				BW	Body Weight	70	kg	EPA, 1991	
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	8,760	days	EPA, 1989	
		Adolescent (12-18 years)	Striped Bass White Perch Eel	CFish	Chemical Concentration in Fish	Tables 3.8.RME, 3.9.RME, and 3.10.RME	mg/kg	Tables 3.8.RME, 3.9.RME, and 3.10.RME	Chronic Daily Intake (CDI) (mg/kg-day) = CFish x IR-Fish x FI x EF x ED x CF3 x 1/BW x 1/AT
				IR-Fish	Ingestion of Fish	43	g/day	(2)	
				FI	Fraction Ingested -	fish specific	unitless	EPA, 2000	
					Striped Bass	0.47	unitless	Connelly, 1992, (4)	
					White Perch	0.09	unitless	Connelly, 1992, (4)	
					Eel	0.44	unitless	Connelly, 1992, (4)	
				EF	Exposure Frequency	365	days/year	EPA, 1997	
				ED	Exposure Duration	6	years	EPA, 1991	
				CF	Conversion Factor	0.001	kg/g	- -	
				BW	Body Weight	57	kg	EPA, 1991	
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	2,190	days	EPA, 1989	
		Child	Striped Bass White Perch Eel	CFish	Chemical Concentration in Fish	Tables 3.8.RME, 3.9.RME, and 3.10.RME	mg/kg	Tables 3.8.RME, 3.9.RME, and 3.10.RME	Chronic Daily Intake (CDI) (mg/kg-day) = CFish x IR-Fish x FI x EF x ED x CF3 x 1/BW x 1/AT
				IR-Fish	Ingestion of Fish	21	g/day	(3)	
				FI	Fraction Ingested -	fish specific	unitless	EPA, 2000	
					Striped Bass	0.47	unitless	Connelly, 1992, (4)	
					White Perch	0.09	unitless	Connelly, 1992, (4)	
					Eel	0.44	unitless	Connelly, 1992, (4)	
				EF	Exposure Frequency	365	days/year	EPA, 1997	
				ED	Exposure Duration	6	years	EPA, 1991	
				CF	Conversion Factor	0.001	kg/g	- -	
				BW	Body Weight	15	kg	EPA, 1991	
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	2,190	days	EPA, 1989	

Table 4.7.RME

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE

Gowanus Canal Remedial Investigation, Brooklyn, New York

Scenario Timeframe: Current/Future
Medium: Surface Water / Sediment
Exposure Medium: Fish and Crab Tissue

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Angler	Adult	Blue Crab	CFish	Chemical Concentration in Crab	Table 3.11.RME	mg/kg	Table 3.11.RME	Chronic Daily Intake (CDI) (mg/kg-day) =
				IR-Fish	Ingestion of Crab	65	g/day	(5)	CFish x IR-Sed x EF x ED x CF3 x 1/BW x 1/AT
				EF	Exposure Frequency	365	days/year	EPA, 1997	
				ED	Exposure Duration	24	years	EPA, 1991	
				CF3	Conversion Factor 3	0.001	kg/g	- -	
				BW	Body Weight	70	kg	EPA, 1991	
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	8,760	days	EPA, 1989	
		Adolescent (12-18 years)	Blue Crab	CFish	Chemical Concentration in Crab	Table 3.11.RME	mg/kg	Table 3.11.RME	Chronic Daily Intake (CDI) (mg/kg-day) =
				IR-Fish	Ingestion of Crab	43	g/day	(5)	CFish x IR-Fish x EF x ED x CF3 x 1/BW x 1/AT
				EF	Exposure Frequency	365	days/year	EPA, 1997	
				ED	Exposure Duration	6	years	EPA, 1991	
				CF3	Conversion Factor 3	0.001	kg/g	- -	
				BW	Body Weight	57	kg	EPA, 1991	
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	2,190	days	EPA, 1989	
		Child	Blue Crab	CFish	Chemical Concentration in Crab	Table 3.11.RME	mg/kg	Table 3.11.RME	Chronic Daily Intake (CDI) (mg/kg-day) =
				IR-Fish	Ingestion of Crab	21	g/day	(5)	CFish x IR-Fish x EF x ED x CF3 x 1/BW x 1/AT
				EF	Exposure Frequency	365	days/year	EPA, 1997	
				ED	Exposure Duration	6	years	EPA, 1991	
				CF	Conversion Factor	0.001	kg/g	- -	
				BW	Body Weight	15	kg	EPA, 1991	
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	2,190	days	EPA, 1989	

Notes:

(1) Based on average number of fish consumed per month (i.e., eight 8-oz. fish meals) by fisherman whose children less than 15 yrs of age also consumed fish.

(2) Ingestion rate assumed to be 2/3 the adult ingestion rate.

(3) Ingestion rate assumed to be 1/3 the adult ingestion rate.

(4) Bottom feeders percent consumption (44%) used to for eel, intermediate level percent consumption (47%) used for striped bass, and remaining percent (4%) used for white perch.

(5) Subsitence ingestion rate assumed the same for crab as it is for fish.

Sources:

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REVISED TABLE 7.11.RME

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

REASONABLE MAXIMUM EXPOSURE

Gowanus Canal Remedial Investigation, Brooklyn, New York

Scenario Timeframe: Current/Future
Receptor Population: Subsistence Fisherman
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Surface Water/Sediment	Fish and Crab Tissue	Striped Bass in Gowanus Canal	Ingestion													
				p,p'-DDE	1.2E-02	mg/kg	1.8E-06	mg/kg-day	3.4E-01	1/(mg/kg-day)	6.1E-07	5.2E-06	mg/kg-day	NA		NA
				p,p'-DDT	9.6E-03	mg/kg	1.4E-06	mg/kg-day	3.4E-01	1/(mg/kg-day)	4.9E-07	4.2E-06	mg/kg-day	5.0E-04	mg/kg-day	8.4E-03
				Dioxin-Like PCB TEQ	4.3E-06	mg/kg	6.4E-10	mg/kg-day	1.6E+05	1/(mg/kg-day)	1.0E-04	1.9E-09	mg/kg-day	NA		NA
				Nondioxin-Like	4.1E-01	mg/kg	6.1E-05	mg/kg-day	2.0E+00	1/(mg/kg-day)	1.2E-04	1.8E-04	mg/kg-day	NA		NA
				Total PCB	4.4E-01	mg/kg	6.5E-05	mg/kg-day	NA		NA	1.9E-04	mg/kg-day	2.0E-05	mg/kg-day	9.5E+00
				Arsenic	6.8E-02	mg/kg	1.0E-05	mg/kg-day	1.5E+00	1/(mg/kg-day)	1.5E-05	3.0E-05	mg/kg-day	3.0E-04	mg/kg-day	9.9E-02
				Mercury	2.0E-01	mg/kg	3.0E-05	mg/kg-day	NA		NA	8.7E-05	mg/kg-day	1.0E-04	mg/kg-day	8.7E-01
				Selenium	1.2E+00	mg/kg	1.8E-04	mg/kg-day	NA		NA	5.2E-04	mg/kg-day	5.0E-03	mg/kg-day	1.0E-01
				Benzo(a)anthracene*	7.7E-03	mg/kg	1.2E-06	mg/kg-day	7.3E-01	1/(mg/kg-day)	8.4E-07	3.4E-06	mg/kg-day	NA		NA
				Benzo(a)pyrene*	1.2E-02	mg/kg	1.8E-06	mg/kg-day	7.3E+00	1/(mg/kg-day)	1.3E-05	5.1E-06	mg/kg-day	NA		NA
				Benzo(b)fluoranthene*	6.4E-03	mg/kg	9.6E-07	mg/kg-day	7.3E-01	1/(mg/kg-day)	7.0E-07	2.8E-06	mg/kg-day	NA		NA
				Dibenz(a,h)anthracene*	3.9E-03	mg/kg	5.9E-07	mg/kg-day	7.3E+00	1/(mg/kg-day)	4.3E-06	1.7E-06	mg/kg-day	NA		NA
				Indeno(1,2,3-cd)pyrene*	9.9E-03	mg/kg	1.5E-06	mg/kg-day	7.3E-01	1/(mg/kg-day)	1.1E-06	4.3E-06	mg/kg-day	NA		NA
			Exp. Route Total								2.6E-04					1.1E+01
		Exposure Point Total									2.6E-04					1.1E+01
	Exposure Medium Total - Striped Bass in Gowanus Canal										2.6E-04					1.1E+01
	Fish and Crab Tissue	White Perch in Gowanus Canal	Ingestion													
				Dioxin-Like PCB TEQ	5.8E-06	mg/kg	1.7E-10	mg/kg-day	1.6E+05	1/(mg/kg-day)	2.6E-05	4.8E-10	mg/kg-day	NA		NA
				Nondioxin-Like	4.4E-01	mg/kg	1.3E-05	mg/kg-day	2.0E+00	1/(mg/kg-day)	2.5E-05	3.7E-05	mg/kg-day	NA		NA
				Total PCB	4.6E-01	mg/kg	1.3E-05	mg/kg-day	NA		NA	3.9E-05	mg/kg-day	2.0E-05	mg/kg-day	1.9E+00
				Mercury	1.9E-01	mg/kg	5.4E-06	mg/kg-day	NA		NA	1.6E-05	mg/kg-day	1.0E-04	mg/kg-day	1.6E-01
				Selenium	1.4E+00	mg/kg	4.0E-05	mg/kg-day	NA		NA	1.2E-04	mg/kg-day	5.0E-03	mg/kg-day	2.3E-02
				Benzo(a)anthracene*	7.7E-03	mg/kg	2.2E-07	mg/kg-day	7.3E-01	1/(mg/kg-day)	1.6E-07	6.4E-07	mg/kg-day	NA		NA
				Benzo(a)pyrene*	1.2E-02	mg/kg	3.4E-07	mg/kg-day	7.3E+00	1/(mg/kg-day)	2.5E-06	9.9E-07	mg/kg-day	NA		NA
				Benzo(b)fluoranthene*	6.4E-03	mg/kg	1.8E-07	mg/kg-day	7.3E-01	1/(mg/kg-day)	1.3E-07	5.3E-07	mg/kg-day	NA		NA
				Dibenz(a,h)anthracene*	3.9E-03	mg/kg	1.1E-07	mg/kg-day	7.3E+00	1/(mg/kg-day)	8.2E-07	3.3E-07	mg/kg-day	NA		NA
				Indeno(1,2,3-cd)pyrene*	9.9E-03	mg/kg	2.8E-07	mg/kg-day	7.3E-01	1/(mg/kg-day)	2.1E-07	8.3E-07	mg/kg-day	NA		NA
			Exp. Route Total								5.5E-05					2.1E+00
		Exposure Point Total									5.5E-05					2.1E+00
	Exposure Medium Total - White Perch in Gowanus Canal										5.5E-05					2.1E+00

REVISED TABLE 7.11.RME

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

REASONABLE MAXIMUM EXPOSURE

Gowanus Canal Remedial Investigation, Brooklyn, New York

Scenario Timeframe: Current/Future
Receptor Population: Subsistence Fisherman
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Surface Water/Sediment	Fish and Crab Tissue	Eel in Gowanus Canal	Ingestion													
				alpha-Chlordane	2.2E-02	mg/kg	3.1E-06	mg/kg-day	3.5E-01	1/(mg/kg-day)	1.1E-06	9.0E-06	mg/kg-day	5.0E-04	mg/kg-day	1.8E-02
				Dieldrin	1.7E-02	mg/kg	2.4E-06	mg/kg-day	1.6E+01	1/(mg/kg-day)	3.8E-05	6.9E-06	mg/kg-day	5.0E-05	mg/kg-day	1.4E-01
				gamma-Chlordane	1.3E-02	mg/kg	1.8E-06	mg/kg-day	3.5E-01	1/(mg/kg-day)	6.4E-07	5.3E-06	mg/kg-day	5.0E-04	mg/kg-day	1.1E-02
				p,p'-DDD	3.8E-02	mg/kg	5.3E-06	mg/kg-day	2.4E-01	1/(mg/kg-day)	1.3E-06	1.6E-05	mg/kg-day	NA		NA
				p,p'-DDE	2.5E-02	mg/kg	3.5E-06	mg/kg-day	3.4E-01	1/(mg/kg-day)	1.2E-06	1.0E-05	mg/kg-day	NA		NA
				p,p'-DDT	4.7E-02	mg/kg	6.6E-06	mg/kg-day	3.4E-01	1/(mg/kg-day)	2.2E-06	1.9E-05	mg/kg-day	5.0E-04	mg/kg-day	3.8E-02
				Dioxin-Like PCB TEQ	1.4E-05	mg/kg	2.0E-09	mg/kg-day	1.6E+05	1/(mg/kg-day)	3.1E-04	5.8E-09	mg/kg-day	NA		NA
				Nondioxin-Like	1.2E+00	mg/kg	1.7E-04	mg/kg-day	2.0E+00	1/(mg/kg-day)	3.4E-04	5.0E-04	mg/kg-day	NA		NA
				Total PCB	1.4E+00	mg/kg	1.9E-04	mg/kg-day	NA		NA	5.5E-04	mg/kg-day	2.0E-05	mg/kg-day	2.8E+01
				Arsenic	5.0E-02	mg/kg	7.0E-06	mg/kg-day	1.5E+00	1/(mg/kg-day)	1.1E-05	2.0E-05	mg/kg-day	3.0E-04	mg/kg-day	6.8E-02
				Chromium	6.7E-01	mg/kg	9.4E-05	mg/kg-day	5.0E-01	1/(mg/kg-day)	4.7E-05	2.7E-04	mg/kg-day	3.0E-03	mg/kg-day	9.1E-02
				Copper	7.4E+00	mg/kg	1.0E-03	mg/kg-day	NA		NA	3.0E-03	mg/kg-day	4.0E-02	mg/kg-day	7.6E-02
				Cyanide, total	3.1E+00	mg/kg	4.3E-04	mg/kg-day	NA		NA	1.3E-03	mg/kg-day	2.0E-02		6.3E-02
				Mercury	2.6E-01	mg/kg	3.6E-05	mg/kg-day	NA		NA	1.1E-04	mg/kg-day	1.0E-04		1.1E+00
				Selenium	1.4E+00	mg/kg	2.0E-04	mg/kg-day	NA		NA	5.7E-04	mg/kg-day	5.0E-03	mg/kg-day	1.1E-01
				Benzo(a)anthracene*	7.7E-03	mg/kg	1.1E-06	mg/kg-day	7.3E-01	1/(mg/kg-day)	7.9E-07	3.1E-06	mg/kg-day	NA		NA
				Benzo(a)pyrene*	1.2E-02	mg/kg	1.7E-06	mg/kg-day	7.3E+00	1/(mg/kg-day)	1.2E-05	4.8E-06	mg/kg-day	NA		NA
				Benzo(b)fluoranthene*	6.4E-03	mg/kg	9.0E-07	mg/kg-day	7.3E-01	1/(mg/kg-day)	6.5E-07	2.6E-06	mg/kg-day	NA		NA
				Dibenz(a,h)anthracene*	3.9E-03	mg/kg	5.5E-07	mg/kg-day	7.3E+00	1/(mg/kg-day)	4.0E-06	1.6E-06	mg/kg-day	NA		NA
				Indeno(1,2,3-cd)pyrene*	9.9E-03	mg/kg	1.4E-06	mg/kg-day	7.3E-01	1/(mg/kg-day)	1.0E-06	4.0E-06	mg/kg-day	NA		NA
			Exp. Route Total								7.7E-04					2.9E+01
		Exposure Point Total									7.7E-04					2.9E+01
	Exposure Medium Total - Eel in Gowanus Canal										7.7E-04					2.9E+01

REVISED TABLE 7.11.RME

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

REASONABLE MAXIMUM EXPOSURE

Gowanus Canal Remedial Investigation, Brooklyn, New York

Scenario Timeframe: Current/Future
Receptor Population: Subsistence Fisherman
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Surface Water/Sediment	Fish and Crab Tissue	Blue Crab in Gowanus Canal	Ingestion													
				Benzo(a)anthracene	7.7E-03	mg/kg	2.5E-06	mg/kg-day	7.3E-01	1/(mg/kg-day)	1.8E-06	7.2E-06	mg/kg-day	NA		NA
				Benzo(a)pyrene	1.2E-02	mg/kg	3.8E-06	mg/kg-day	7.3E+00	1/(mg/kg-day)	2.7E-05	1.1E-05	mg/kg-day	NA		NA
				Benzo(b)fluoranthene	6.4E-03	mg/kg	2.0E-06	mg/kg-day	7.3E-01	1/(mg/kg-day)	1.5E-06	5.9E-06	mg/kg-day	NA		NA
				Dibenz(a,h)anthracene	3.9E-03	mg/kg	1.3E-06	mg/kg-day	7.3E+00	1/(mg/kg-day)	9.2E-06	3.7E-06	mg/kg-day	NA		NA
				Indeno(1,2,3-cd)pyrene	9.9E-03	mg/kg	3.2E-06	mg/kg-day	7.3E-01	1/(mg/kg-day)	2.3E-06	9.2E-06	mg/kg-day	NA		NA
				Dioxin-Like PCB TEQ	5.0E-06	mg/kg	1.6E-09	mg/kg-day	1.6E+05	1/(mg/kg-day)	2.5E-04	4.7E-09	mg/kg-day	NA		NA
				Nondioxin-Like	1.4E-01	mg/kg	4.6E-05	mg/kg-day	2.0E+00	1/(mg/kg-day)	9.1E-05	1.3E-04	mg/kg-day	NA		NA
				Total PCB	1.7E-01	mg/kg	5.3E-05	mg/kg-day	NA		NA	1.5E-04	mg/kg-day	2.0E-05	mg/kg-day	7.7E+00
				Arsenic	1.3E-01	mg/kg	4.2E-05	mg/kg-day	1.5E+00	1/(mg/kg-day)	6.3E-05	1.2E-04	mg/kg-day	3.0E-04	mg/kg-day	4.1E-01
				Copper	1.0E+01	mg/kg	3.2E-03	mg/kg-day	NA		NA	9.5E-03	mg/kg-day	4.0E-02	mg/kg-day	2.4E-01
				Mercury	1.2E-01	mg/kg	3.9E-05	mg/kg-day	NA		NA	1.2E-04	mg/kg-day	1.0E-04	mg/kg-day	1.2E+00
			Exp. Route Total								4.5E-04					9.5E+00
		Exposure Point Total									4.5E-04					9.5E+00
	Exposure Medium Total - Crab in Gowanus Canal										4.5E-04					9.5E+00
Total Fish									Total of Receptor Risks - Fish		1.1E-03			Total of Receptor Hazards - Fish		4.2E+01
Total Blue Crab									Total of Receptor Risks - Blue Crab		4.5E-04			Total of Receptor Hazards - Blue Crab		9.5E+00

Notes-

NA = Not available / Not applicable.

* PAH data included for fish is based on mearsued concentrations of PAHs in crab, not on actual fish tissue data

TABLE 7.12.RME

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

REASONABLE MAXIMUM EXPOSURE

Gowanus Canal Remedial Investigation, Brooklyn, New York

Scenario Timeframe: Current/Future
Receptor Population: Subsistence Fisherman
Receptor Age: Adolescent

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Surface Water/Sediment	Fish and Crab Tissue	Striped Bass in Gowanus Canal	Ingestion													
				p,p'-DDE	1.2E-02	mg/kg	3.6E-07	mg/kg-day	3.4E-01	1/(mg/kg-day)	1.2E-07	4.3E-06	mg/kg-day	NA		NA
				p,p'-DDT	9.6E-03	mg/kg	2.9E-07	mg/kg-day	3.4E-01	1/(mg/kg-day)	9.9E-08	3.4E-06	mg/kg-day	5.0E-04	mg/kg-day	6.8E-03
				Dioxin-Like PCB TEQ	4.3E-06	mg/kg	1.3E-10	mg/kg-day	1.6E+05	1/(mg/kg-day)	2.0E-05	1.5E-09	mg/kg-day	NA		NA
				Nondioxin-Like	4.1E-01	mg/kg	1.2E-05	mg/kg-day	2.0E+00	1/(mg/kg-day)	2.5E-05	1.5E-04	mg/kg-day	NA		NA
				Total PCB	4.4E-01	mg/kg	1.3E-05	mg/kg-day	NA		NA	1.5E-04	mg/kg-day	2.0E-05	mg/kg-day	7.7E+00
				Arsenic	6.8E-02	mg/kg	2.1E-06	mg/kg-day	1.5E+00	1/(mg/kg-day)	3.1E-06	2.4E-05	mg/kg-day	3.0E-04	mg/kg-day	8.0E-02
				Mercury	2.0E-01	mg/kg	6.1E-06	mg/kg-day	NA		NA	7.1E-05	mg/kg-day	1.0E-04	mg/kg-day	7.1E-01
				Selenium	1.2E+00	mg/kg	3.6E-05	mg/kg-day	NA		NA	4.3E-04	mg/kg-day	5.0E-03	mg/kg-day	8.5E-02
				Benzo(a)anthracene (12-16)*,+	7.7E-03	mg/kg	1.6E-07	mg/kg-day	2.2E+00	1/(mg/kg-day)	3.4E-07	2.7E-06	mg/kg-day	NA		NA
				Benzo(a)anthracene (16-18)*,+	7.7E-03	mg/kg	7.8E-08	mg/kg-day	7.3E-01	1/(mg/kg-day)	5.7E-08					
				Benzo(a)pyrene (12-16)*,+	1.2E-02	mg/kg	2.4E-07	mg/kg-day	2.2E+01	1/(mg/kg-day)	5.2E-06	4.2E-06	mg/kg-day	NA		NA
				Benzo(a)pyrene (16-18)*,+	1.2E-02	mg/kg	1.2E-07	mg/kg-day	7.3E+00	1/(mg/kg-day)	8.7E-07					
				Benzo(b)fluoranthene (12-16)*,+	6.4E-03	mg/kg	1.3E-07	mg/kg-day	2.2E+00	1/(mg/kg-day)	2.8E-07	2.3E-06	mg/kg-day	NA		NA
				Benzo(b)fluoranthene (16-18)*,+	6.4E-03	mg/kg	6.5E-08	mg/kg-day	7.3E-01	1/(mg/kg-day)	4.7E-08					
				Dibenz(a,h)anthracene (12-16)*,+	3.9E-03	mg/kg	8.0E-08	mg/kg-day	2.2E+01	1/(mg/kg-day)	1.7E-06	1.4E-06	mg/kg-day	NA		NA
				Dibenz(a,h)anthracene (16-18)*,+	3.9E-03	mg/kg	4.0E-08	mg/kg-day	7.3E+00	1/(mg/kg-day)	2.9E-07					
				Indeno(1,2,3-cd)pyrene (12-16)*,+	9.9E-03	mg/kg	2.0E-07	mg/kg-day	2.2E+00	1/(mg/kg-day)	4.4E-07	3.5E-06	mg/kg-day	NA		NA
				Indeno(1,2,3-cd)pyrene (16-18)*,+	9.9E-03	mg/kg	1.0E-07	mg/kg-day	7.3E-01	1/(mg/kg-day)	7.3E-08					
			Exp. Route Total								5.8E-05					8.6E+00
		Exposure Point Total									5.8E-05					8.6E+00
	Exposure Medium Total - Striped Bass in Gowanus Canal										5.8E-05					8.6E+00

TABLE 7.12.RME

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

REASONABLE MAXIMUM EXPOSURE

Gowanus Canal Remedial Investigation, Brooklyn, New York

Scenario Timeframe: Current/Future
Receptor Population: Subsistence Fisherman
Receptor Age: Adolescent

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Surface Water/Sediment	Fish and Crab Tissue	White Perch in Gowanus Canal	Ingestion													
				Dioxin-Like PCB TEQ	5.8E-06	mg/kg	3.4E-11	mg/kg-day	1.6E+05	1/(mg/kg-day)	5.3E-06	3.9E-10	mg/kg-day	NA		NA
				Nondioxin-Like	4.4E-01	mg/kg	2.5E-06	mg/kg-day	2.0E+00	1/(mg/kg-day)	5.1E-06	3.0E-05	mg/kg-day	NA		NA
				Total PCB	4.6E-01	mg/kg	2.7E-06	mg/kg-day	NA		NA	3.1E-05	mg/kg-day	2.0E-05	mg/kg-day	1.6E+00
				Mercury	1.9E-01	mg/kg	1.1E-06	mg/kg-day	NA		NA	1.3E-05	mg/kg-day	1.0E-04	mg/kg-day	1.3E-01
				Selenium	1.4E+00	mg/kg	8.1E-06	mg/kg-day	NA		NA	9.5E-05	mg/kg-day	5.0E-03	mg/kg-day	1.9E-02
				Benzo(a)anthracene (12-16)*,+	7.7E-03	mg/kg	3.0E-08	mg/kg-day	2.2E+00	1/(mg/kg-day)	6.5E-08	5.2E-07	mg/kg-day	NA		NA
				Benzo(a)anthracene (16-18)*,+	7.7E-03	mg/kg	1.5E-08	mg/kg-day	7.3E-01	1/(mg/kg-day)	1.1E-08					
				Benzo(a)pyrene (12-16)*,+	1.2E-02	mg/kg	4.6E-08	mg/kg-day	2.2E+01	1/(mg/kg-day)	1.0E-06	8.0E-07	mg/kg-day	NA		NA
				Benzo(a)pyrene (16-18)*,+	1.2E-02	mg/kg	2.3E-08	mg/kg-day	7.3E+00	1/(mg/kg-day)	1.7E-07					
				Benzo(b)fluoranthene (12-16)*,+	6.4E-03	mg/kg	2.5E-08	mg/kg-day	2.2E+00	1/(mg/kg-day)	5.4E-08	4.3E-07	mg/kg-day	NA		NA
				Benzo(b)fluoranthene (16-18)*,+	6.4E-03	mg/kg	1.2E-08	mg/kg-day	7.3E-01	1/(mg/kg-day)	9.0E-09					
				Dibenz(a,h)anthracene (12-16)*,+	3.9E-03	mg/kg	1.5E-08	mg/kg-day	2.2E+01	1/(mg/kg-day)	3.3E-07	2.7E-07	mg/kg-day	NA		NA
				Dibenz(a,h)anthracene (16-18)*,+	3.9E-03	mg/kg	7.6E-09	mg/kg-day	7.3E+00	1/(mg/kg-day)	5.6E-08					
				Indeno(1,2,3-cd)pyrene (12-16)*,+	9.9E-03	mg/kg	3.8E-08	mg/kg-day	2.2E+00	1/(mg/kg-day)	8.4E-08	6.7E-07	mg/kg-day	NA		NA
				Indeno(1,2,3-cd)pyrene (16-18)*,+	9.9E-03	mg/kg	1.9E-08	mg/kg-day	7.3E-01	1/(mg/kg-day)	1.4E-08					
			Exp. Route Total								1.2E-05					1.7E+00
		Exposure Point Total									1.2E-05					1.7E+00
	Exposure Medium Total - White Perch in Gowanus Canal										1.2E-05					1.7E+00

TABLE 7.12.RME

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

REASONABLE MAXIMUM EXPOSURE

Gowanus Canal Remedial Investigation, Brooklyn, New York

Scenario Timeframe: Current/Future
Receptor Population: Subsistence Fisherman
Receptor Age: Adolescent

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Surface Water/Sediment	Fish and Crab Tissue	Eel in Gowanus Canal	Ingestion													
				alpha-Chlordane	2.2E-02	mg/kg	6.3E-07	mg/kg-day	3.5E-01	1/(mg/kg-day)	2.2E-07	7.3E-06	mg/kg-day	5.0E-04	mg/kg-day	1.5E-02
				Dieldrin	1.7E-02	mg/kg	4.8E-07	mg/kg-day	1.6E+01	1/(mg/kg-day)	7.7E-06	5.6E-06	mg/kg-day	5.0E-05	mg/kg-day	1.1E-01
				gamma-Chlordane	1.3E-02	mg/kg	3.7E-07	mg/kg-day	3.5E-01	1/(mg/kg-day)	1.3E-07	4.3E-06	mg/kg-day	5.0E-04	mg/kg-day	8.6E-03
				p,p'-DDD	3.8E-02	mg/kg	1.1E-06	mg/kg-day	2.4E-01	1/(mg/kg-day)	2.6E-07	1.3E-05	mg/kg-day	NA		NA
				p,p'-DDE	2.5E-02	mg/kg	7.1E-07	mg/kg-day	3.4E-01	1/(mg/kg-day)	2.4E-07	8.3E-06	mg/kg-day	NA		NA
				p,p'-DDT	4.7E-02	mg/kg	1.3E-06	mg/kg-day	3.4E-01	1/(mg/kg-day)	4.5E-07	1.6E-05	mg/kg-day	5.0E-04	mg/kg-day	3.1E-02
				Dioxin-Like PCB TEQ	1.4E-05	mg/kg	4.0E-10	mg/kg-day	1.6E+05	1/(mg/kg-day)	6.3E-05	4.7E-09	mg/kg-day	NA		NA
				Nondioxin-Like	1.2E+00	mg/kg	3.5E-05	mg/kg-day	2.0E+00	1/(mg/kg-day)	6.9E-05	4.0E-04	mg/kg-day	NA		NA
				Total PCB	1.4E+00	mg/kg	3.8E-05	mg/kg-day	NA		NA	4.5E-04	mg/kg-day	2.0E-05	mg/kg-day	2.2E+01
				Arsenic	5.0E-02	mg/kg	1.4E-06	mg/kg-day	1.5E+00	1/(mg/kg-day)	2.1E-06	1.7E-05	mg/kg-day	3.0E-04	mg/kg-day	5.5E-02
				Chromium (12-16)*	6.7E-01	mg/kg	1.3E-05	mg/kg-day	1.5E+00	1/(mg/kg-day)	1.9E-05	2.2E-04	mg/kg-day	3.0E-03	mg/kg-day	7.4E-02
				Chromium (16-18)*	6.7E-01	mg/kg	6.4E-06	mg/kg-day	5.0E-01	1/(mg/kg-day)	3.2E-06					
				Copper	7.4E+00	mg/kg	2.1E-04	mg/kg-day	NA		NA	2.5E-03	mg/kg-day	4.0E-02	mg/kg-day	6.1E-02
				Cyanide, total	3.1E+00	mg/kg	8.8E-05	mg/kg-day	NA		NA	1.0E-03	mg/kg-day	2.0E-02	mg/kg-day	5.1E-02
				Mercury	2.6E-01	mg/kg	7.4E-06	mg/kg-day	NA		NA	8.6E-05	mg/kg-day	1.0E-04	mg/kg-day	8.6E-01
				Selenium	1.4E+00	mg/kg	4.0E-05	mg/kg-day	NA		NA	4.6E-04	mg/kg-day	5.0E-03	mg/kg-day	9.3E-02
				Benzo(a)anthracene (12-16)*,+	7.7E-03	mg/kg	1.5E-07	mg/kg-day	2.2E+00	1/(mg/kg-day)	3.2E-07	2.6E-06	mg/kg-day	NA		NA
				Benzo(a)anthracene (16-18)*,+	7.7E-03	mg/kg	7.3E-08	mg/kg-day	7.3E-01	1/(mg/kg-day)	5.3E-08					
				Benzo(a)pyrene (12-16)*,+	1.2E-02	mg/kg	2.2E-07	mg/kg-day	2.2E+01	1/(mg/kg-day)	4.9E-06	3.9E-06	mg/kg-day	NA		NA
				Benzo(a)pyrene (16-18)*,+	1.2E-02	mg/kg	1.1E-07	mg/kg-day	7.3E+00	1/(mg/kg-day)	8.2E-07					
				Benzo(b)fluoranthene (12-16)*,+	6.4E-03	mg/kg	1.2E-07	mg/kg-day	2.2E+00	1/(mg/kg-day)	2.7E-07	2.1E-06	mg/kg-day	NA		NA
				Benzo(b)fluoranthene (16-18)*,+	6.4E-03	mg/kg	6.1E-08	mg/kg-day	7.3E-01	1/(mg/kg-day)	4.4E-08					
				Dibenz(a,h)anthracene (12-16)*,+	3.9E-03	mg/kg	7.5E-08	mg/kg-day	2.2E+01	1/(mg/kg-day)	1.6E-06	1.3E-06	mg/kg-day	NA		NA
				Dibenz(a,h)anthracene (16-18)*,+	3.9E-03	mg/kg	3.7E-08	mg/kg-day	7.3E+00	1/(mg/kg-day)	2.7E-07					
				Indeno(1,2,3-cd)pyrene (12-16)*,+	9.9E-03	mg/kg	1.9E-07	mg/kg-day	2.2E+00	1/(mg/kg-day)	4.1E-07	3.3E-06	mg/kg-day	NA		NA
				Indeno(1,2,3-cd)pyrene (16-18)*,+	9.9E-03	mg/kg	9.4E-08	mg/kg-day	7.3E-01	1/(mg/kg-day)	6.9E-08					
			Exp. Route Total								1.7E-04					2.4E+01
		Exposure Point Total									1.7E-04					2.4E+01
	Exposure Medium Total - Eel in Gowanus Canal										1.7E-04					2.4E+01

TABLE 7.12.RME

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

REASONABLE MAXIMUM EXPOSURE

Gowanus Canal Remedial Investigation, Brooklyn, New York

Scenario Timeframe: Current/Future
Receptor Population: Subsistence Fisherman
Receptor Age: Adolescent

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Surface Water/Sediment	Fish and Crab Tissue	Blue Crab in Gowanus Canal	Ingestion													
				Benzo(a)anthracene (12-16)*	7.7E-03	mg/kg	3.3E-07	mg/kg-day	2.2E+00	1/(mg/kg-day)	7.3E-07	5.8E-06	mg/kg-day	NA		NA
				Benzo(a)anthracene (16-18)*	7.7E-03	mg/kg	1.7E-07	mg/kg-day	7.3E-01	1/(mg/kg-day)	1.2E-07					
				Benzo(a)pyrene (12-16)*	1.2E-02	mg/kg	5.1E-07	mg/kg-day	2.2E+01	1/(mg/kg-day)	1.1E-05	8.9E-06	mg/kg-day	NA		NA
				Benzo(a)pyrene (16-18)*	1.2E-02	mg/kg	2.5E-07	mg/kg-day	7.3E+00	1/(mg/kg-day)	1.9E-06					
				Benzo(b)fluoranthene (12-16)*	6.4E-03	mg/kg	2.8E-07	mg/kg-day	2.2E+00	1/(mg/kg-day)	6.0E-07	4.8E-06	mg/kg-day	NA		NA
				Benzo(b)fluoranthene (16-18)*	6.4E-03	mg/kg	1.4E-07	mg/kg-day	7.3E-01	1/(mg/kg-day)	1.0E-07					
				Dibenz(a,h)anthracene (12-16)*	3.9E-03	mg/kg	1.7E-07	mg/kg-day	2.2E+01	1/(mg/kg-day)	3.7E-06	3.0E-06	mg/kg-day	NA		NA
				Dibenz(a,h)anthracene (16-18)*	3.9E-03	mg/kg	8.5E-08	mg/kg-day	7.3E+00	1/(mg/kg-day)	6.2E-07					
				Indeno(1,2,3-cd)pyrene (12-16)*	9.9E-03	mg/kg	4.3E-07	mg/kg-day	2.2E+00	1/(mg/kg-day)	9.4E-07	7.5E-06	mg/kg-day	NA		NA
				Indeno(1,2,3-cd)pyrene (16-18)*	9.9E-03	mg/kg	2.1E-07	mg/kg-day	7.3E-01	1/(mg/kg-day)	1.6E-07					
				Dioxin-Like PCB TEQ	5.0E-06	mg/kg	3.3E-10	mg/kg-day	1.6E+05	1/(mg/kg-day)	5.1E-05	3.8E-09	mg/kg-day	NA		NA
				Nondioxin-Like	1.4E-01	mg/kg	9.2E-06	mg/kg-day	2.0E+00	1/(mg/kg-day)	1.8E-05	1.1E-04	mg/kg-day	NA		NA
				Total PCB	1.7E-01	mg/kg	1.1E-05	mg/kg-day	NA		NA	1.3E-04	mg/kg-day	2.0E-05	mg/kg-day	6.3E+00
				Arsenic	1.3E-01	mg/kg	8.5E-06	mg/kg-day	1.5E+00	1/(mg/kg-day)	1.3E-05	9.9E-05	mg/kg-day	3.0E-04	mg/kg-day	3.3E-01
				Copper	1.0E+01	mg/kg	6.6E-04	mg/kg-day	NA		NA	7.7E-03	mg/kg-day	4.0E-02	mg/kg-day	1.9E-01
				Mercury	1.2E-01	mg/kg	8.0E-06	mg/kg-day	NA		NA	9.4E-05	mg/kg-day	1.0E-04	mg/kg-day	9.4E-01
			Exp. Route Total								1.0E-04					7.7E+00
		Exposure Point Total									1.0E-04					7.7E+00
	Exposure Medium Total - Crab in Gowanus Canal										1.0E-04					7.7E+00
Total Fish									Total of Receptor Risks - Fish		2.4E-04		Total of Receptor Hazards - Fish			3.4E+01
Total Blue Crab									Total of Receptor Risks - Blue Crab		1.0E-04		Total of Receptor Hazards - Blue Crab			7.7E+00

Notes-

* Constituent acts via a mutagenic mode of action (MMOA). ADAF of 3 used to adjust CSF for 12-16 year old for exposure duration of 4 years, ADAF of 1 used to adjust CSF for 16-18 year old for exposure duration of 2 years.
Non-cancer calculations shown under 12-16 year old only, as non-cancer calculations are not adjusted for MMOA.

+ PAH data included for fish is based on mearsued concentrations of PAHs in crab, not on actual fish tissue data

NA = Not available / Not applicable.

TABLE 7.13.RME

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

REASONABLE MAXIMUM EXPOSURE

Gowanus Canal Remedial Investigation, Brooklyn, New York

Scenario Timeframe: Current/Future
Receptor Population: Subsistence Fisherman
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Surface Water/Sediment	Fish and Crab Tissue	Striped Bass in Gowanus Canal	Ingestion													
				p,p'-DDE	1.2E-02	mg/kg	6.8E-07	mg/kg-day	3.4E-01	1/(mg/kg-day)	2.3E-07	7.9E-06	mg/kg-day	NA		NA
				p,p'-DDT	9.6E-03	mg/kg	5.4E-07	mg/kg-day	3.4E-01	1/(mg/kg-day)	1.8E-07	6.3E-06	mg/kg-day	5.0E-04	mg/kg-day	1.3E-02
				Dioxin-Like PCB TEQ	4.3E-06	mg/kg	2.4E-10	mg/kg-day	1.6E+05	1/(mg/kg-day)	3.8E-05	2.8E-09	mg/kg-day	NA		NA
				Nondioxin-Like	4.1E-01	mg/kg	2.3E-05	mg/kg-day	2.0E+00	1/(mg/kg-day)	4.6E-05	2.7E-04	mg/kg-day	NA		NA
				Total PCB	4.4E-01	mg/kg	2.5E-05	mg/kg-day	NA		NA	2.9E-04	mg/kg-day	2.0E-05	mg/kg-day	1.4E+01
				Arsenic	6.8E-02	mg/kg	3.8E-06	mg/kg-day	1.5E+00	1/(mg/kg-day)	5.8E-06	4.5E-05	mg/kg-day	3.0E-04	mg/kg-day	1.5E-01
				Mercury	2.0E-01	mg/kg	1.1E-05	mg/kg-day	NA	1/(mg/kg-day)	NA	1.3E-04	mg/kg-day	1.0E-04	mg/kg-day	1.3E+00
				Selenium	1.2E+00	mg/kg	6.8E-05	mg/kg-day	NA		NA	7.9E-04	mg/kg-day	5.0E-03	mg/kg-day	1.6E-01
				Benzo(a)anthracene (0-2)*,[+]	7.7E-03	mg/kg	1.4E-07	mg/kg-day	7.3E+00	1/(mg/kg-day)	1.1E-06	5.1E-06	mg/kg-day	NA		NA
				Benzo(a)anthracene (2-6)*,[+]	7.7E-03	mg/kg	2.9E-07	mg/kg-day	2.2E+00	1/(mg/kg-day)	6.3E-07					
				Benzo(a)pyrene (0-2)*,[+]	1.2E-02	mg/kg	2.2E-07	mg/kg-day	7.3E+01	1/(mg/kg-day)	1.6E-05	7.8E-06	mg/kg-day	NA		NA
				Benzo(a)pyrene (2-6)*,[+]	1.2E-02	mg/kg	4.4E-07	mg/kg-day	2.2E+01	1/(mg/kg-day)	9.7E-06					
				Benzo(b)fluoranthene (0-2)*,[+]	6.4E-03	mg/kg	1.2E-07	mg/kg-day	7.3E+00	1/(mg/kg-day)	8.8E-07	4.2E-06	mg/kg-day	NA		NA
				Benzo(b)fluoranthene (2-6)*,[+]	6.4E-03	mg/kg	2.4E-07	mg/kg-day	2.2E+00	1/(mg/kg-day)	5.3E-07					
				Dibenz(a,h)anthracene (0-2)*,[+]	3.9E-03	mg/kg	7.4E-08	mg/kg-day	7.3E+01	1/(mg/kg-day)	5.4E-06	2.6E-06	mg/kg-day	NA		NA
				Dibenz(a,h)anthracene (2-6)*,[+]	3.9E-03	mg/kg	1.5E-07	mg/kg-day	2.2E+01	1/(mg/kg-day)	3.2E-06					
				Indeno(1,2,3-cd)pyrene (0-2)*,[+]	9.9E-03	mg/kg	1.9E-07	mg/kg-day	7.3E+00	1/(mg/kg-day)	1.4E-06	6.5E-06	mg/kg-day	NA		NA
				Indeno(1,2,3-cd)pyrene (2-6)*,[+]	9.9E-03	mg/kg	3.7E-07	mg/kg-day	2.2E+00	1/(mg/kg-day)	8.2E-07					
			Exp. Route Total								1.3E-04					1.6E+01
		Exposure Point Total									1.3E-04					1.6E+01
	Exposure Medium Total - Striped Bass in Gowanus Canal										1.3E-04					1.6E+01

TABLE 7.13.RME

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

REASONABLE MAXIMUM EXPOSURE

Gowanus Canal Remedial Investigation, Brooklyn, New York

Scenario Timeframe: Current/Future
Receptor Population: Subsistence Fisherman
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Surface Water/Sediment	Fish and Crab Tissue	White Perch in Gowanus Canal	Ingestion													
				Dioxin-Like PCB TEQ	5.8E-06	mg/kg	6.3E-11	mg/kg-day	1.6E+05	1/(mg/kg-day)	9.8E-06	7.3E-10	mg/kg-day	NA		NA
				Nondioxin-Like	4.4E-01	mg/kg	4.7E-06	mg/kg-day	2.0E+00	1/(mg/kg-day)	9.4E-06	5.5E-05	mg/kg-day	NA		NA
				Total PCB	4.6E-01	mg/kg	5.0E-06	mg/kg-day	NA		NA	5.8E-05	mg/kg-day	2.0E-05	mg/kg-day	2.9E+00
				Mercury	1.9E-01	mg/kg	2.1E-06	mg/kg-day	NA		NA	2.4E-05	mg/kg-day	1.0E-04	mg/kg-day	2.4E-01
				Selenium	1.4E+00	mg/kg	1.5E-05	mg/kg-day	NA		NA	1.8E-04	mg/kg-day	5.0E-03	mg/kg-day	3.5E-02
				Benzo(a)anthracene (0-2)*,+	7.7E-03	mg/kg	2.8E-08	mg/kg-day	7.3E+00	1/(mg/kg-day)	2.0E-07	9.7E-07	mg/kg-day	NA		NA
				Benzo(a)anthracene (2-6)*,+	7.7E-03	mg/kg	5.5E-08	mg/kg-day	2.2E+00	1/(mg/kg-day)	1.2E-07					
				Benzo(a)pyrene (0-2)*,+	1.2E-02	mg/kg	4.2E-08	mg/kg-day	7.3E+01	1/(mg/kg-day)	3.1E-06	1.5E-06	mg/kg-day	NA		NA
				Benzo(a)pyrene (2-6)*,+	1.2E-02	mg/kg	8.5E-08	mg/kg-day	2.2E+01	1/(mg/kg-day)	1.9E-06					
				Benzo(b)fluoranthene (0-2)*,+	6.4E-03	mg/kg	2.3E-08	mg/kg-day	7.3E+00	1/(mg/kg-day)	1.7E-07	8.1E-07	mg/kg-day	NA		NA
				Benzo(b)fluoranthene (2-6)*,+	6.4E-03	mg/kg	4.6E-08	mg/kg-day	2.2E+00	1/(mg/kg-day)	1.0E-07					
				Dibenz(a,h)anthracene (0-2)*,+	3.9E-03	mg/kg	1.4E-08	mg/kg-day	7.3E+01	1/(mg/kg-day)	1.0E-06	5.0E-07	mg/kg-day	NA		NA
				Dibenz(a,h)anthracene (2-6)*,+	3.9E-03	mg/kg	2.8E-08	mg/kg-day	2.2E+01	1/(mg/kg-day)	6.2E-07					
				Indeno(1,2,3-cd)pyrene (0-2)*,+	9.9E-03	mg/kg	3.6E-08	mg/kg-day	7.3E+00	1/(mg/kg-day)	2.6E-07	1.2E-06	mg/kg-day	NA		NA
				Indeno(1,2,3-cd)pyrene (2-6)*,+	9.9E-03	mg/kg	7.1E-08	mg/kg-day	2.2E+00	1/(mg/kg-day)	1.6E-07					
			Exp. Route Total								2.7E-05					3.2E+00
		Exposure Point Total									2.7E-05					3.2E+00
	Exposure Medium Total - White Perch in Gowanus Canal										2.7E-05					3.2E+00

TABLE 7.13.RME

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

REASONABLE MAXIMUM EXPOSURE

Gowanus Canal Remedial Investigation, Brooklyn, New York

Scenario Timeframe: Current/Future
Receptor Population: Subsistence Fisherman
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Surface Water/Sediment	Fish and Crab Tissue	Eel in Gowanus Canal	Ingestion													
				alpha-Chlordane	2.2E-02	mg/kg	1.2E-06	mg/kg-day	3.5E-01	1/(mg/kg-day)	4.1E-07	1.4E-05	mg/kg-day	5.0E-04	mg/kg-day	2.7E-02
				Dieldrin	1.7E-02	mg/kg	9.0E-07	mg/kg-day	1.6E+01	1/(mg/kg-day)	1.4E-05	1.0E-05	mg/kg-day	5.0E-05	mg/kg-day	2.1E-01
				gamma-Chlordane	1.3E-02	mg/kg	6.9E-07	mg/kg-day	3.5E-01	1/(mg/kg-day)	2.4E-07	8.0E-06	mg/kg-day	5.0E-04	mg/kg-day	1.6E-02
				p,p'-DDD	3.8E-02	mg/kg	2.0E-06	mg/kg-day	2.4E-01	1/(mg/kg-day)	4.8E-07	2.3E-05	mg/kg-day	NA		NA
				p,p'-DDE	2.5E-02	mg/kg	1.3E-06	mg/kg-day	3.4E-01	1/(mg/kg-day)	4.5E-07	1.5E-05	mg/kg-day	NA		NA
				p,p'-DDT	4.7E-02	mg/kg	2.5E-06	mg/kg-day	3.4E-01	1/(mg/kg-day)	8.4E-07	2.9E-05	mg/kg-day	5.0E-04	mg/kg-day	5.8E-02
				Dioxin-Like PCB TEQ	1.4E-05	mg/kg	7.4E-10	mg/kg-day	1.6E+05	1/(mg/kg-day)	1.2E-04	8.7E-09	mg/kg-day	NA		NA
				Nondioxin-Like	1.2E+00	mg/kg	6.4E-05	mg/kg-day	2.0E+00	1/(mg/kg-day)	1.3E-04	7.5E-04	mg/kg-day	NA		NA
				Total PCB	1.4E+00	mg/kg	7.1E-05	mg/kg-day	NA		NA	8.3E-04	mg/kg-day	2.0E-05	mg/kg-day	4.2E+01
				Arsenic	5.0E-02	mg/kg	2.6E-06	mg/kg-day	1.5E+00	1/(mg/kg-day)	4.0E-06	3.1E-05	mg/kg-day	3.0E-04	mg/kg-day	1.0E-01
				Chromium (0-2)*	6.7E-01	mg/kg	1.2E-05	mg/kg-day	5.0E+00	1/(mg/kg-day)	5.9E-05	4.1E-04	mg/kg-day	3.0E-03	mg/kg-day	1.4E-01
				Chromium (2-6)*	6.7E-01	mg/kg	2.4E-05	mg/kg-day	1.5E+00	1/(mg/kg-day)	3.5E-05					
				Copper	7.4E+00	mg/kg	3.9E-04	mg/kg-day	NA		NA	4.6E-03	mg/kg-day	4.0E-02	mg/kg-day	1.1E-01
				Cyanide, total	3.1E+00	mg/kg	1.6E-04	mg/kg-day	NA		NA	1.9E-03	mg/kg-day	2.0E-02	mg/kg-day	9.5E-02
				Mercury	2.6E-01	mg/kg	1.4E-05	mg/kg-day	NA		NA	1.6E-04	mg/kg-day	1.0E-04	mg/kg-day	1.6E+00
				Selenium	1.4E+00	mg/kg	7.4E-05	mg/kg-day	NA		NA	8.6E-04	mg/kg-day	5.0E-03	mg/kg-day	1.7E-01
				Benzo(a)anthracene (0-2)*,+	7.7E-03	mg/kg	1.4E-07	mg/kg-day	7.3E+00	1/(mg/kg-day)	9.9E-07	4.7E-06	mg/kg-day	NA		NA
				Benzo(a)anthracene (2-6)*,+	7.7E-03	mg/kg	2.7E-07	mg/kg-day	2.2E+00	1/(mg/kg-day)	5.9E-07					
				Benzo(a)pyrene (0-2)*,+	1.2E-02	mg/kg	2.1E-07	mg/kg-day	7.3E+01	1/(mg/kg-day)	1.5E-05	7.3E-06	mg/kg-day	NA		NA
				Benzo(a)pyrene (2-6)*,+	1.2E-02	mg/kg	4.2E-07	mg/kg-day	2.2E+01	1/(mg/kg-day)	9.1E-06					
				Benzo(b)fluoranthene (0-2)*,+	6.4E-03	mg/kg	1.1E-07	mg/kg-day	7.3E+00	1/(mg/kg-day)	8.2E-07	3.9E-06	mg/kg-day	NA		NA
				Benzo(b)fluoranthene (2-6)*,+	6.4E-03	mg/kg	2.2E-07	mg/kg-day	2.2E+00	1/(mg/kg-day)	4.9E-07					
				Dibenz(a,h)anthracene (0-2)*,+	3.9E-03	mg/kg	6.9E-08	mg/kg-day	7.3E+01	1/(mg/kg-day)	5.1E-06	2.4E-06	mg/kg-day	NA		NA
				Dibenz(a,h)anthracene (2-6)*,+	3.9E-03	mg/kg	1.4E-07	mg/kg-day	2.2E+01	1/(mg/kg-day)	3.0E-06					
				Indeno(1,2,3-cd)pyrene (0-2)*,+	9.9E-03	mg/kg	1.7E-07	mg/kg-day	7.3E+00	1/(mg/kg-day)	1.3E-06	6.1E-06	mg/kg-day	NA		NA
				Indeno(1,2,3-cd)pyrene (2-6)*,+	9.9E-03	mg/kg	3.5E-07	mg/kg-day	2.2E+00	1/(mg/kg-day)	7.6E-07					
			Exp. Route Total								4.0E-04					4.4E+01
		Exposure Point Total									4.0E-04					4.4E+01
	Exposure Medium Total - Eel in Gowanus Canal										4.0E-04					4.4E+01

TABLE 7.13.RME

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

REASONABLE MAXIMUM EXPOSURE

Gowanus Canal Remedial Investigation, Brooklyn, New York

Scenario Timeframe: Current/Future
Receptor Population: Subsistence Fisherman
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
	Fish and Crab Tissue	Blue Crab in Gowanus Canal	Ingestion													
				Benzo(a)anthracene (0-2)*	7.7E-03	mg/kg	3.1E-07	mg/kg-day	7.3E+00	1/(mg/kg-day)	2.2E-06	1.1E-05	mg/kg-day	NA		NA
				Benzo(a)anthracene (2-6)*	7.7E-03	mg/kg	6.2E-07	mg/kg-day	2.2E+00	1/(mg/kg-day)	1.3E-06					
				Benzo(a)pyrene (0-2)*	1.2E-02	mg/kg	4.7E-07	mg/kg-day	7.3E+01	1/(mg/kg-day)	3.4E-05	1.7E-05	mg/kg-day	NA		NA
				Benzo(a)pyrene (2-6)*	1.2E-02	mg/kg	9.4E-07	mg/kg-day	2.2E+01	1/(mg/kg-day)	2.1E-05					
				Benzo(b)fluoranthene (0-2)*	6.4E-03	mg/kg	2.6E-07	mg/kg-day	7.3E+00	1/(mg/kg-day)	1.9E-06	8.9E-06	mg/kg-day	NA		NA
				Benzo(b)fluoranthene (2-6)*	6.4E-03	mg/kg	5.1E-07	mg/kg-day	2.2E+00	1/(mg/kg-day)	1.1E-06					
				Dibenz(a,h)anthracene (0-2)*	3.9E-03	mg/kg	1.6E-07	mg/kg-day	7.3E+01	1/(mg/kg-day)	1.2E-05	5.5E-06	mg/kg-day	NA		NA
				Dibenz(a,h)anthracene (2-6)*	3.9E-03	mg/kg	3.2E-07	mg/kg-day	2.2E+01	1/(mg/kg-day)	6.9E-06					
				Indeno(1,2,3-cd)pyrene (0-2)*	9.9E-03	mg/kg	4.0E-07	mg/kg-day	7.3E+00	1/(mg/kg-day)	2.9E-06	1.4E-05	mg/kg-day	NA		NA
				Indeno(1,2,3-cd)pyrene (2-6)*	9.9E-03	mg/kg	7.9E-07	mg/kg-day	2.2E+00	1/(mg/kg-day)	1.7E-06					
				Dioxin-Like PCB TEQ	5.0E-06	mg/kg	6.0E-10	mg/kg-day	1.6E+05	1/(mg/kg-day)	9.4E-05	7.1E-09	mg/kg-day	NA		NA
				Nondioxin-Like	1.4E-01	mg/kg	1.7E-05	mg/kg-day	2.0E+00	1/(mg/kg-day)	3.4E-05	2.0E-04	mg/kg-day	NA		NA
				Total PCB	1.7E-01	mg/kg	2.0E-05	mg/kg-day	NA		NA	2.3E-04	mg/kg-day	2.0E-05	mg/kg-day	1.2E+01
				Arsenic	1.3E-01	mg/kg	1.6E-05	mg/kg-day	1.5E+00	1/(mg/kg-day)	2.4E-05	1.8E-04	mg/kg-day	3.0E-04	mg/kg-day	6.1E-01
				Copper	1.0E+01	mg/kg	1.2E-03	mg/kg-day	NA		NA	1.4E-02	mg/kg-day	4.0E-02	mg/kg-day	3.6E-01
				Mercury	1.2E-01	mg/kg	1.5E-05	mg/kg-day	NA		NA	1.7E-04	mg/kg-day	1.0E-04	mg/kg-day	1.7E+00
			Exp. Route Total								2.4E-04					1.4E+01
		Exposure Point Total									2.4E-04					1.4E+01
	Exposure Medium Total - Crab in Gowanus Canal										2.4E-04					1.4E+01
Total Fish									Total of Receptor Risks - Fish		5.5E-04		Total of Receptor Hazards - Fish			6.3E+01
Total Blue Crab									Total of Receptor Risks - Blue Crab		2.4E-04		Total of Receptor Hazards - Blue Crab			1.4E+01

Notes-

NA = Not available / Not applicable.

* Constituent acts via a mutagenic mode of action (MMOA). ADAF of 10 used to adjust CSF for 0-2 year old for exposure duration of 2 years, ADAF of 3 used to adjust CSF for 2-6 year old for exposure duration of 4 years.

[+] PAH data included for fish is based on mearsued concentrations of PAHs in crab, not on actual fish tissue data

Non-cancer calculations shown under 0-2 year old only, as non-cancer calculations are not adjusted for MMOA.

Attachment 3

TABLE 12.1.RME

CALCULATION OF SAFE TISSUE LEVELS FOR THE ANGLER SCENARIO

REASONABLE MAXIMUM EXPOSURE

Gowanus Canal Remedial Investigation, Brooklyn, New York

Target Risk	1.00E-06
Target HQ	1

Units are in mg (chem)/kg (biota tissue)

Biota	COPCs	Carcinogenic Risk Based								Non-carcinogenic Risk Based			
		ELCR=10-6				ELCR=10-4				HQ=1			
		Adult	Adolescent	Child	**Lowest**	Adult	Adolescent	Child	**Lowest**	Adult	Adolescent	Child	**Lowest**
Striped Bass	Dioxin-Like PCB TEQ	1.1E-07	5.3E-07	2.7E-07	1.1E-07	1.1E-05	5.3E-05	2.7E-05	1.1E-05	NA	NA	NA	NA
Striped Bass	Nondioxin-Like	8.4E-03	4.2E-02	2.1E-02	8.4E-03	8.4E-01	4.2E+00	2.1E+00	8.4E-01	NA	NA	NA	NA
Striped Bass	Total PCB	NA	NA	NA	NA	NA	NA	NA	NA	1.1E-01	1.4E-01	7.1E-02	7.1E-02
Striped Bass	Arsenic	1.1E-02	5.5E-02	2.8E-02	1.1E-02	1.1E+00	5.5E+00	2.8E+00	1.1E+00	1.7E+00	2.1E+00	1.1E+00	1.1E+00
Striped Bass	Mercury	NA	NA	NA	NA	NA	NA	NA	NA	5.7E-01	7.1E-01	3.5E-01	3.5E-01
Striped Bass	Benzo(a)pyrene*	2.3E-03	4.9E-03	1.1E-03	1.1E-03	2.3E-01	4.9E-01	1.1E-01	1.1E-01	NA	NA	NA	NA
Striped Bass	Dibenz(a,h)anthracene*	2.3E-03	4.9E-03	1.1E-03	1.1E-03	2.3E-01	4.9E-01	1.1E-01	1.1E-01	NA	NA	NA	NA

Biota	COPCs	Carcinogenic Risk Based								Non-carcinogenic Risk Based			
		ELCR=10-6				ELCR=10-4				HQ=1			
		Adult	Adolescent	Child	**Lowest**	Adult	Adolescent	Child	**Lowest**	Adult	Adolescent	Child	**Lowest**
White Perch	Dioxin-Like PCB TEQ	5.6E-07	2.8E-06	1.4E-06	5.6E-07	5.6E-05	2.8E-04	1.4E-04	5.6E-05	NA	NA	NA	NA
White Perch	Nondioxin-Like	4.4E-02	2.2E-01	1.1E-01	4.4E-02	4.4E+00	2.2E+01	1.1E+01	4.4E+00	NA	NA	NA	NA
White Perch	Total PCB	NA	NA	NA	NA	NA	NA	NA	NA	6.0E-01	7.5E-01	3.7E-01	3.7E-01

Biota	COPCs	Carcinogenic Risk Based								Non-carcinogenic Risk Based			
		ELCR=10-6				ELCR=10-4				HQ=1			
		Adult	Adolescent	Child	**Lowest**	Adult	Adolescent	Child	**Lowest**	Adult	Adolescent	Child	**Lowest**
Eel	Dieldrin	1.1E-03	5.6E-03	2.8E-03	1.1E-03	1.1E-01	5.6E-01	2.8E-01	1.1E-01	3.1E-01	3.8E-01	1.9E-01	1.9E-01
Eel	Dioxin-Like PCB TEQ	1.1E-07	5.7E-07	2.8E-07	1.1E-07	1.1E-05	5.7E-05	2.8E-05	1.1E-05	NA	NA	NA	NA
Eel	Nondioxin-Like	8.9E-03	4.4E-02	2.2E-02	8.9E-03	8.9E-01	4.4E+00	2.2E+00	8.9E-01	NA	NA	NA	NA
Eel	Total PCB	NA	NA	NA	NA	NA	NA	NA	NA	1.2E-01	1.5E-01	7.6E-02	7.6E-02
Eel	Arsenic	1.2E-02	5.9E-02	2.9E-02	1.2E-02	1.2E+00	5.9E+00	2.9E+00	1.2E+00	1.8E+00	2.3E+00	1.1E+00	1.1E+00
Eel	Chromium	3.6E-02	7.6E-02	1.7E-02	1.7E-02	3.6E+00	7.6E+00	1.7E+00	1.7E+00	1.8E+01	2.3E+01	1.1E+01	1.1E+01
Eel	Mercury	NA	NA	NA	NA	NA	NA	NA	NA	6.1E-01	7.6E-01	3.8E-01	3.8E-01
Eel	Benzo(a)pyrene*	2.4E-03	5.2E-03	1.1E-03	1.1E-03	2.4E-01	5.2E-01	1.1E-01	1.1E-01	NA	NA	NA	NA
Eel	Dibenz(a,h)anthracene*	2.4E-03	5.2E-03	1.1E-03	1.1E-03	2.4E-01	5.2E-01	1.1E-01	1.1E-01	NA	NA	NA	NA

Biota	COPCs	Carcinogenic Risk Based								Non-carcinogenic Risk Based			
		ELCR=10-6				ELCR=10-4				HQ=1			
		Adult	Adolescent	Child	**Lowest**	Adult	Adolescent	Child	**Lowest**	Adult	Adolescent	Child	**Lowest**
Blue Crab	Benzo(a)pyrene	1.2E-03	2.6E-03	5.6E-04	5.6E-04	1.2E-01	2.6E-01	5.6E-02	5.6E-02	NA	NA	NA	NA
Blue Crab	Dibenz(a,h)anthracene	1.2E-03	2.6E-03	5.6E-04	5.6E-04	1.2E-01	2.6E-01	5.6E-02	5.6E-02	NA	NA	NA	NA
Blue Crab	Dioxin-Like PCB TEQ	5.7E-08	2.8E-07	1.4E-07	5.7E-08	5.7E-06	2.8E-05	1.4E-05	5.7E-06	NA	NA	NA	NA
Blue Crab	Nondioxin-Like	4.4E-03	2.2E-02	1.1E-02	4.4E-03	4.4E-01	2.2E+00	1.1E+00	4.4E-01	NA	NA	NA	NA
Blue Crab	Total PCB	NA	NA	NA	NA	NA	NA	NA	NA	6.1E-02	7.6E-02	3.8E-02	3.8E-02
Blue Crab	Arsenic	5.9E-03	3.0E-02	1.5E-02	5.9E-03	5.9E-01	3.0E+00	1.5E+00	5.9E-01	9.1E-01	1.1E+00	5.6E-01	5.6E-01
Blue Crab	Mercury	NA	NA	NA	NA	NA	NA	NA	NA	3.0E-01	3.8E-01	1.9E-01	1.9E-01

TABLE 12.2.RME

CALCULATION OF SAFE TISSUE LEVELS FOR THE SUBSISTENCE FISHERMAN SCENARIO

REASONABLE MAXIMUM EXPOSURE

Gowanus Canal Remedial Investigation, Brooklyn, New York

Target Risk	1.00E-06
Target HQ	1

Units are in mg (chem)/kg (biota tissue)

Biota	COPCs	Carcinogenic Risk Based								Non-carcinogenic Risk Based			
		ELCR=10-6				ELCR=10-4				HQ=1			
		Adult	Adolescent	Child	**Lowest**	Adult	Adolescent	Child	**Lowest**	Adult	Adolescent	Child	**Lowest**
Striped Bass	Dioxin-Like PCB TEQ	4.3E-08	2.1E-07	1.1E-07	4.3E-08	4.3E-06	2.1E-05	1.1E-05	4.3E-06	NA	NA	NA	NA
Striped Bass	Nondioxin-Like	3.3E-03	1.6E-02	8.9E-03	3.3E-03	3.3E-01	1.6E+00	8.9E-01	3.3E-01	NA	NA	NA	NA
Striped Bass	Total PCB	NA	NA	NA	NA	NA	NA	NA	NA	4.6E-02	5.6E-02	3.0E-02	3.0E-02
Striped Bass	Arsenic	4.5E-03	2.2E-02	1.2E-02	4.5E-03	4.5E-01	2.2E+00	1.2E+00	4.5E-01	6.9E-01	8.5E-01	4.6E-01	4.6E-01
Striped Bass	Mercury	NA	NA	NA	NA	NA	NA	NA	NA	2.3E-01	2.8E-01	1.5E-01	1.5E-01
Striped Bass	Benzo(a)pyrene*	9.2E-04	1.9E-03	4.6E-04	4.6E-04	9.2E-02	1.9E-01	4.6E-02	4.6E-02	NA	NA	NA	NA
Striped Bass	Dibenz(a,h)anthracene*	9.2E-04	1.9E-03	4.6E-04	4.6E-04	9.2E-02	1.9E-01	4.6E-02	4.6E-02	NA	NA	NA	NA

Biota	COPCs	Carcinogenic Risk Based								Non-carcinogenic Risk Based			
		ELCR=10-6				ELCR=10-4				HQ=1			
		Adult	Adolescent	Child	**Lowest**	Adult	Adolescent	Child	**Lowest**	Adult	Adolescent	Child	**Lowest**
White Perch	Dioxin-Like PCB TEQ	2.2E-07	1.1E-06	5.9E-07	2.2E-07	2.2E-05	1.1E-04	5.9E-05	2.2E-05	NA	NA	NA	NA
White Perch	Nondioxin-Like	1.7E-02	8.6E-02	4.6E-02	1.7E-02	1.7E+00	8.6E+00	4.6E+00	1.7E+00	NA	NA	NA	NA
White Perch	Total PCB	NA	NA	NA	NA	NA	NA	NA	NA	2.4E-01	2.9E-01	1.6E-01	1.6E-01
White Perch	Mercury	NA	NA	NA	NA	NA	NA	NA	NA	1.2E+00	1.5E+00	7.9E-01	7.9E-01
White Perch	Benzo(a)pyrene*	4.8E-03	1.0E-02	2.4E-03	2.4E-03	4.8E-01	1.0E+00	2.4E-01	2.4E-01	NA	NA	NA	NA

Biota	COPCs	Carcinogenic Risk Based								Non-carcinogenic Risk Based			
		ELCR=10-6				ELCR=10-4				HQ=1			
		Adult	Adolescent	Child	**Lowest**	Adult	Adolescent	Child	**Lowest**	Adult	Adolescent	Child	**Lowest**
Eel	Dieldrin	4.5E-04	2.2E-03	1.2E-03	4.5E-04	4.5E-02	2.2E-01	1.2E-01	4.5E-02	1.2E-01	1.5E-01	8.1E-02	8.1E-02
Eel	p,p'-DDT	2.1E-02	1.0E-01	5.6E-02	2.1E-02	2.1E+00	1.0E+01	5.6E+00	2.1E+00	1.2E+00	1.5E+00	8.1E-01	8.1E-01
Eel	Dioxin-Like PCB TEQ	4.6E-08	2.3E-07	1.2E-07	4.6E-08	4.6E-06	2.3E-05	1.2E-05	4.6E-06	NA	NA	NA	NA
Eel	Nondioxin-Like	3.6E-03	1.8E-02	9.5E-03	3.6E-03	3.6E-01	1.8E+00	9.5E-01	3.6E-01	NA	NA	NA	NA
Eel	Total PCB	NA	NA	NA	NA	NA	NA	NA	NA	4.9E-02	6.0E-02	3.2E-02	3.2E-02
Eel	Arsenic	4.8E-03	2.3E-02	1.3E-02	4.8E-03	4.8E-01	2.3E+00	1.3E+00	4.8E-01	7.3E-01	9.0E-01	4.9E-01	4.9E-01
Eel	Chromium	1.4E-02	3.0E-02	7.1E-03	7.1E-03	1.4E+00	3.0E+00	7.1E-01	7.1E-01	7.3E+00	9.0E+00	4.9E+00	4.9E+00
Eel	Mercury	NA	NA	NA	NA	NA	NA	NA	NA	2.4E-01	3.0E-01	1.6E-01	1.6E-01
Eel	Benzo(a)pyrene*	9.8E-04	2.1E-03	4.9E-04	4.9E-04	9.8E-02	2.1E-01	4.9E-02	4.9E-02	NA	NA	NA	NA
Eel	Dibenz(a,h)anthracene*	9.8E-04	2.1E-03	4.9E-04	4.9E-04	9.8E-02	2.1E-01	4.9E-02	4.9E-02	NA	NA	NA	NA

Biota	COPCs	Carcinogenic Risk Based								Non-carcinogenic Risk Based			
		ELCR=10-6				ELCR=10-4				HQ=1			
		Adult	Adolescent	Child	**Lowest**	Adult	Adolescent	Child	**Lowest**	Adult	Adolescent	Child	**Lowest**
Blue Crab	Benzo(a)anthracene	4.3E-03	9.1E-03	2.1E-03	2.1E-03	4.3E-01	9.1E-01	2.1E-01	2.1E-01	NA	NA	NA	NA
Blue Crab	Benzo(a)pyrene	4.3E-04	9.1E-04	2.1E-04	2.1E-04	4.3E-02	9.1E-02	2.1E-02	2.1E-02	NA	NA	NA	NA
Blue Crab	Dibenz(a,h)anthracene	4.3E-04	9.1E-04	2.1E-04	2.1E-04	4.3E-02	9.1E-02	2.1E-02	2.1E-02	NA	NA	NA	NA
Blue Crab	Indeno(1,2,3-cd)pyrene	4.3E-03	9.1E-03	2.1E-03	2.1E-03	4.3E-01	9.1E-01	2.1E-01	2.1E-01	NA	NA	NA	NA
Blue Crab	Dioxin-Like PCB TEQ	2.0E-08	9.9E-08	5.3E-08	2.0E-08	2.0E-06	9.9E-06	5.3E-06	2.0E-06	NA	NA	NA	NA
Blue Crab	Nondioxin-Like	1.6E-03	7.7E-03	4.2E-03	1.6E-03	1.6E-01	7.7E-01	4.2E-01	1.6E-01	NA	NA	NA	NA
Blue Crab	Total PCB	NA	NA	NA	NA	NA	NA	NA	NA	2.2E-02	2.7E-02	1.4E-02	1.4E-02
Blue Crab	Arsenic	2.1E-03	1.0E-02	5.6E-03	2.1E-03	2.1E-01	1.0E+00	5.6E-01	2.1E-01	3.2E-01	4.0E-01	2.1E-01	2.1E-01
Blue Crab	Mercury	NA	NA	NA	NA	NA	NA	NA	NA	1.1E-01	1.3E-01	7.1E-02	7.1E-02

Preliminary Estimate of Solids Reductions Needed to Achieve Remediation Goals
Gowanus Canal
Brooklyn, New York

Prepared for

U.S. Environmental Protection Agency
Region 2

Prepared under contract
AES10 Task Order 072-RI-FS-02ZP
Architect and Engineering Services Contract
Contract No. 68-S7-04-01

Prepared by

CH2MHILL

Preliminary Estimate of Solids Reductions Needed to Achieve Remediation Goals

Contents

1. Introduction

Combined sewer overflow (CSO) and stormwater discharges to the Gowanus Canal adversely affect canal sediment quality and are contributing to unacceptable risks that must be addressed under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) (USEPA, 2012a). The New York City Department of Environmental Protection (NYCDEP) is implementing sewage system and flushing tunnel repairs and upgrades which will reduce CSO discharges in the middle and lower portions of the Canal and improve canal water circulation. This work is being done pursuant to its Gowanus Canal Waterbody/Watershed Facility Plan (Facility Plan) which addresses Clean Water Act requirements. However, additional CSO control measures will be necessary to prevent recontamination of the canal with CERCLA hazardous substances after the canal sediments are remediated. The present technical memorandum estimates levels of CSO solids load reductions necessary to achieve site-specific preliminary remediation goals (PRGs) for surface sediments. The analysis presented herein includes the following elements:

- Summary of the sources of solids to the Gowanus Canal and description of current and expected future conditions after implementation of NYCDEP's Facility Plan
- Summary of site-specific PRGs for surface sediments
- Estimated reductions in CSO solids discharges needed to achieve the PRGs for surface sediments

In addition, uncertainties associated with the analysis are identified.

2. Current and Expected Future Conditions

Sediment accumulates in the Gowanus Canal due to the discharge of solids by CSOs and stormwater, and the settling of water column solids from source waters. Source waters include CSOs, stormwater, the Gowanus Canal flushing tunnel, and tidal exchange with Gowanus Bay (groundwater discharge is another source of water to the canal, but not of solids). The NYCDEP reports that 377 million gallons of combined sewage (sanitary and stormwater) and 75 million gallons of stormwater are discharged to the canal in a typical precipitation year (NYCDEP, 2008). The flushing tunnel most recently pumped approximately 150 million gallons per day (mgd) of Upper New York Bay waters to the canal. The mass of solids delivered to the canal by each source was not quantified in the Gowanus Canal Remedial Investigation/Feasibility Study (RI/FS) (USEPA, 2011a and 2011b); however, multiple lines of evidence indicate that CSOs have a significantly greater influence on surface sediment quality in the upper reach of the canal[1] than solids from Gowanus Bay and Upper New York Bay (USEPA, 2012a).

The NYCDEP's Facility Plan includes a number of actions that will reduce CSO discharges to the Gowanus Canal and increase hydraulic flushing. NYCDEP estimates that reconstructing the Gowanus Pump Station and replacing its force main will reduce the annual volume of CSO

[1] The upper reach is from the head of the canal to just south of the 3rd Street Bridge.

discharges to the canal from outfalls RH-035 and RH-031[2] by 90 percent, and to the canal overall by 34 percent, in a typical precipitation year.

The rehabilitation of the flushing tunnel will increase its average capacity by roughly 40 percent to 215 mgd. Before it was shut down in July 2011, the flushing tunnel dominated the volumetric discharge to the canal on an annual basis (99 percent of the annual source), and it will continue to do so after the Facility Plan is implemented. Although most of the suspended solids in the flushing tunnel discharge remain in suspension while heavier solids discharged by CSOs settle in the canal, some settling of suspended solids from the flushing tunnel and, to a lesser degree, the Gowanus Bay waters would be expected to dilute the CSO solids deposition.

The NYCDEP documented solids sedimentation calculations for a baseline scenario in the modeling report that supports the Facility Plan (NYCDEP, 2007). The baseline scenario does not account for the flushing tunnel and represents conditions from the mid 1960s when the flushing tunnel stopped operating to 1999 when NYCDEP reactivated it. The NYCDEP calculated sedimentation rates as high as 18 mm/year (0.7 inches/year) in the upper reach of the canal down to 7 mm/year (0.28 inches/year) from approximately 1,500 feet to 2,000 from the head of the canal (between Carroll Street and 2nd Street). The NYCDEP calculated sedimentation rates of 7 mm/year (0.28 inches/year) or less throughout the canal for the Facility Plan scenario.

Data are available to assess NYCDEP's calculations by comparing bathymetric differences (changes in the sediment surface elevation) in the upper reach of the canal over time. The New York City Department of Water Resources was reportedly the last entity to dredge the upper reach of the canal in 1975 to a depth of 7 feet from Douglass Street to Sackett Street (Felter, 2012). Sediments in this reach are now exposed at low tide. The filled 7-foot depth difference translates to an average sedimentation rate of 2.4 inches/year from 1975 to 2010 (with the flushing tunnel running from 1999 to 2010). Bathymetry data collected in 2003 and 2010, as reported in the RI (USEPA, 2011a), indicate that over this 7-year period elevation differences were minor upstream of Sackett Street where further sedimentation is limited by the shallow depth (i.e., sediment mound that is exposed at low tide) and presumed equilibrium between deposition and scour by CSOs and possibly flushing tunnel currents. However, the bathymetric differences recorded in USEPA's study between Sackett Street and 3rd Street translate to net sediment accumulation rates of approximately 1.5 to 5 in/year between 2003 and 2010. These observed sedimentation rates are much higher than NYCDEP's calculations with and without the flushing tunnel operating.

Data collected for the Gowanus Canal RI indicate that estimated concentrations of polycyclic aromatic hydrocarbons (PAHs), copper and lead in wet weather CSO solids are similar to concentrations in surface sediments in the upper reach of the canal and exceed the site-specific

[2] Outfall RH-035 is located in the middle reach of the canal at Bond Street, and RH-031 is located in the lower reach of the canal near the Gowanus Expressway.

ecological PRGs, whereas estimated concentrations in suspended solids in the Gowanus Bay and Upper New York Bay waters are similar to concentrations in the reference area surface sediments and are generally below the PRGs (USEPA, 2012a). The highest sediment accumulation rates are observed in the upper reach of the canal downstream of the flushing tunnel discharge, suggesting that settleable CSO solids discharged from RH-034 at the head of the canal are conveyed downstream by CSO and flushing tunnel velocities until settling velocities dominate and the solids settle to the sediment bed.

Polychlorinated biphenyls (PCBs) were detected in one CSO wet weather water sample and two CSO sediment samples collected from the sewer system based on PCB Aroclor analysis (USEPA, 2011a). Total PCB congener concentrations in surface sediments in the upper reach of the canal are slightly higher than the average concentration in the Gowanus Bay and Upper New York Bay reference area sediment.[3]

The NYCDEP's Facility Plan will reduce discharges at CSO outfalls RH-035 and RH-031. These outfalls are located in the middle and lower reaches of the canal. CSOs at RH-034, at the head of the canal, will increase by approximately 5 percent upon implementation of the Facility Plan, and will still contribute 97 percent of the CSO solids load to the upper reach. Similarly, outfall OH-007 will continue to contribute 28 percent of the total CSO loading to the canal. Therefore, the CSO reductions planned under the Facility Plan will not reduce the CSO solids that are primarily responsible for sediment accumulation and chemical contamination in the surface sediment in the upper reach of the canal. Additional reductions in CSO solids loads will be required at the CSO outfalls in the upper reach of the canal in order to reduce chemical contaminant concentrations in upper reach surface sediments to final cleanup levels.

3. Preliminary Remediation Goals

Site-specific, risk-based ecological PRGs for PAHs in sediment were developed for the FS (USEPA, 2011b). After the FS was completed, an alternative PRG for PAHs and PRGs for copper and lead were derived. A human health PRG for total PCBs in sediment was also developed (USEPA, 2012b). These PRGs are as follows:

- Total PAHs - 20 mg/kg at 6 percent TOC
- Copper – 80 mg/kg
- Lead – 94 mg/kg
- Total PCBs – 0.48 mg/kg

4. Estimated Reductions in CSO Solids Discharges

Reductions in CSO solids were calculated for total PAHs, copper, lead and total PCBs so that following remedy implementation, the remedy would be able to achieve and maintain surface sediment concentrations of these contaminants, introduced by CSO discharges, at levels

[3] PCB congener analysis is more sensitive and accurate than PCB Aroclor analysis.

complying with the PRGs for the site. Average chemical concentrations under existing conditions were based on mean concentrations measured in surface sediments in the upper reach of Gowanus Canal in the RI (CH2M HILL, 2011a). The 95 percent confidence interval on the mean concentration was used to estimate the range of possible reductions needed to achieve the PRGs. Table 1 lists the mean surface sediment concentrations in the upper reach of the canal.

CSO solids would be diluted in surface sediments if NYCDEP reduced CSO discharges and all other conditions remained the same. Associated mean contaminant concentrations in surface sediment would therefore also decline. Because NYCDEP plans to increase discharges from CSO RH-034 by approximately 5 percent, the rate of CSO solids dilution may in fact decrease in the upper reach of the canal. As a result, associated mean contaminant concentrations in the surface sediment may increase slightly.

The projected reductions in contaminant concentrations in surface sediments were calculated using a straight linear reduction as a reasonable simplifying assumption. Specifically, it was assumed that reducing the CSO solids load would lead to a linear reduction in the average surface sediment concentrations in the upper reach of the canal. This assumption is supported by previous studies that have shown that metals and PAHs in urban and stormwater runoff are strongly associated with the particulate phase (Grant et al., 2003; Engstrom, 2004; Hwang and Foster, 2005; Brown et al., 2011).

TABLE 1
Chemical Concentrations in Upper Reach Surface Sediments
Gowanus Canal, Brooklyn, NY

	Dry Weight Concentrations			
Mean and 95% Confidence Interval	**Total PAH (mg/kg)**	**Copper* (mg/kg)**	**Lead* (mg/kg)**	**Total PCBs* (mg/kg)**
Number of samples	10	9	9	6
Lower Confidence Limit (LCL)	41	158	226	0.42
Mean	56	171	296	0.54
Upper Confidence Limit (UCL)	70	185	367	0.67

*Excluding the outlier at location 308A.

The figures in the attachment show the estimated CSO solids load reductions that may be required at outfall RH-034 to reduce mean chemical concentrations (total PAHs, copper, lead and total PCBs) in surface sediments (including the 95 percent confidence interval) to the PRGs. The individual reduction graphs for each chemical were calculated independently of each other. From these graphical representations it can be deduced that for meeting the PRG for PAHs following remediation, CSO solids load reductions in the range of 51 to 71 percent would be required. Similarly, consistent with this analysis, the required CSO solid load reduction ranges for meeting the PRGs for copper and lead would be 49 to 57 percent and 58 to 74 percent respectively. The required CSO solid load reduction range for meeting the total PCB PRG would be 0 to 28 percent. Therefore, reductions on the order of 58 to 74 percent would be required to meet the PRGs for all four contaminants.

5. Uncertainties

As documented in the "Impact of Combined Sewer Overflows on Gowanus Canal Sediments" section of USEPA's FS Addendum, multiple lines of evidence demonstrate that CSO solid reductions are necessary to prevent recontamination of the post-remedial clean surface sediments with hazardous substances adhering to those solids. USEPA has calculated PRGs and associated CSO reduction ranges based on the available information and reasonable technical assumptions. The use of CSO reduction ranges is intended to reflect potential engineering uncertainties. Additional studies, including further sampling and modeling, performed during the remedial design phase of the project will be utilized to further reduce uncertainty and to refine the level of solid reductions in the CSO discharges of the upper canal so as to render the remedy effective.

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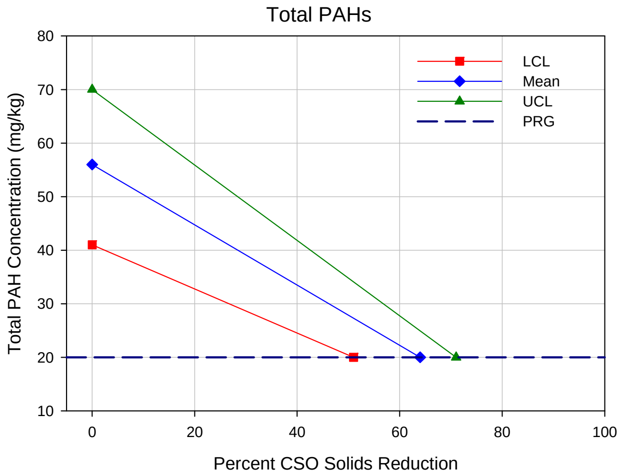
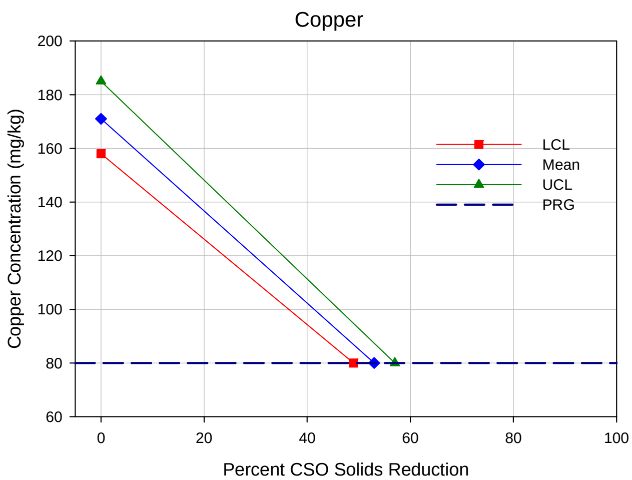
USEPA (U.S. Environmental Protection Agency). 2012b. Technical Memorandum – Supplemental Evaluation of Remediation Goals, Gowanus Canal, Brooklyn, NY. Prepared by CH2M HILL for USEPA Region 2. December.

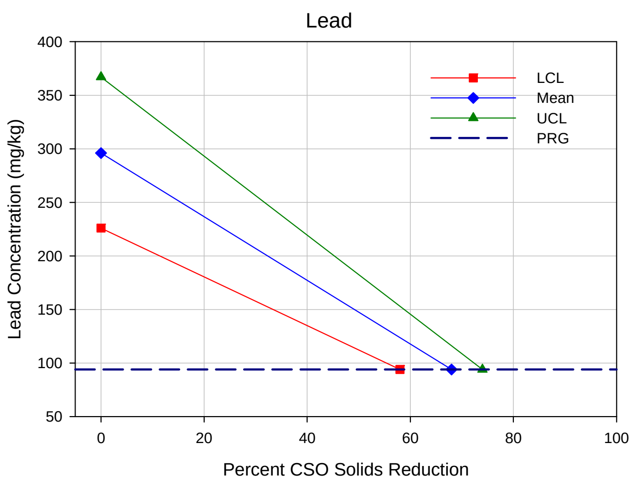
7. ATTACHMENT

Estimated CSO Solids Load Reductions at RH-034 Required to Reduce Chemical Concentrations in Surface Sediments of the Upper Reach

Gowanus Canal, Brooklyn, NY

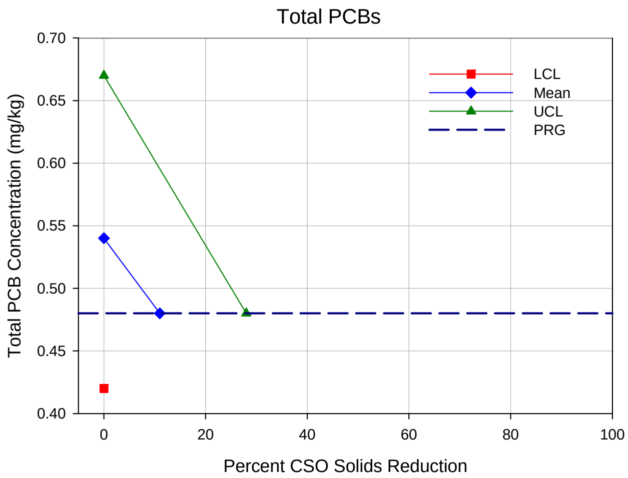






Estimated CSO Solids Load Reductions at RH-034 Required to Reduce Chemical Concentrations in Surface Sediments of the Upper Reach

Gowanus Canal, Brooklyn, NY



Technologies for Combined Sewer Overflows Controls

Screening and Evaluation Using Established Criteria Gowanus Canal, Brooklyn, New York

Prepared for

U.S. Environmental Protection Agency Region 2

Prepared under contract
AES10 Task Order 072-RI-FS-02ZP
Architect and Engineering Services Contract
Contract No. 68-S7-04-01

Prepared by
CH2MHILL

TABLE
Technologies for Combined Sewer Overflow Controls - Screening and Evaluation Using Established Criteria
Gowanus Canal
Brooklyn, New York

General Response Action	Remedial Technology Type	Process Option	Description	Effective-ness	Implemen-tability	Cost	Retained for Further Evaluation (Yes/No)	Screening Comments
No Action	None	Not Applicable	Remedial actions would not be implemented. No action assumes that solids discharges will continue from the combined sewer overflows (CSOs) at the site would be unchanged.	1	4	4	No	Source control actions for upland sources, CSO discharges, and discharges from other open pipes to the canal must be implemented as part of the remedy to ensure its long term effectiveness. Because remedial actions would not be implemented, No Action would not be effective at reducing the discharges of CSO solids to the Gowanus Canal. No Action is retained for further evaluation as a baseline for comparison with other technologies in accordance with the National Contingency Plan (NCP). This action will not facilitate the solids reductions needed to achieve the PRGs.
Source Control	CSO Discharge Control	Optimize Existing CSO OH-007 Trap Chamber	An existing CSO trap chamber is at outfall OH-007. The trap is a concrete chamber on the overflow intended to capture floatables and solids. It requires periodic cleaning. This action is for optimizing the operation of the existing trap chamber by conducting an improved maintenance program and removing accumulated solids.	1	4	4	Yes as auxiliary and /or temporary measure	The City of New York (CITY) has not provided performance data to indicate whether the trap is effective in capturing CSO solids. The CITY reports do not indicate what solids removal efficiencies may be achieved by optimizing the existing trap. The performance of the trap may be improved by making structural and mechanical changes that increases its size and/or depth, adds screens, adds a flushing and pump-back system to automatically remove the solids, etc. This action may reduce solids discharges at OH-007 but not at RH-034 and will not facilitate the solids reductions needed to achieve the PRGs.
Source Control	CSO Discharge Control	CSO Sediment Trap at CSO RH-034	This action would require constructing an interim or permanent trap chamber at outfall RH-034 to capture CSO solids discharged by outfall RH-034.	1	1	1	Yes as auxiliary and /or temporary measure	There is insufficient room to construct a trap chamber upstream of or on the site of the Gowanus Pump Station where the overflow diversion to RH-034 is located. Even if a small trap was constructed at the diversion itself, the discharge flow is too high and turbulent to facilitate solids settlement. A trap could be constructed downstream of the RH-034 outfall but it would have to be in the canal itself, which would require constructing a chamber in a significant portion of the head end of the waterbody in order to construct a trap of sufficient length that facilitates conditions required to trap solids. This could potentially require filling parts of the canal and/or loosing navigational abilities for certain users. The canal also has a historical designation that will preclude any filling or construction in the canal, There are also significant engineering challenges to building in the canal and being able to service the structure during operations. This action may reduce solids discharges at RH-034 but will not facilitate the solids reductions needed to achieve the PRGs.

TABLE
Technologies for Combined Sewer Overflow Controls - Screening and Evaluation Using Established Criteria
Gowanus Canal
Brooklyn, New York

General Response Action	Remedial Technology Type	Process Option	Description	Effective-ness	Implemen-tability	Cost	Retained for Further Evaluation (Yes/No)	Screening Comments
Source Control	CSO Discharge Control	Silt Curtains and/or Netting Facilities	This action would require constructing silt curtains and/or netting facilities at all CSO outfalls discharging to the Gowanus Canal. Silt curtains are made of impervious materials that primarily redirect flow around a dredging area. Silt screens are made from synthetic geotextile fabrics that allow water to flow through, but retain a large fraction of the suspended solids. They can be anchored in a variety of ways such as attaching them to driven piles in the water similar to the existing CSO floatables boom in the canal. Captured solids would have to be dredged or removed on a regular basis. Netting facilities could be constructed at the end of a CSO outfall in the canal or along the outfall pipe itself.	1	1	3	No	The effectiveness of silt curtains and screens constructed in Gowanus Canal will most likely be poor because conditions that may reduce the effectiveness of these barriers include significant currents (should be <1 ft/sec), changing water levels due to tidal fluctuation (>5 feet in the canal), excessive wave height due to ship wakes and drifting ice and debris. They would be unsuitable for installation at all CSO outfalls on the canal due to lack of space, the discharge velocities of the CSOs, flushing tunnel velocities in addition to the tidal velocities on ebbing tides, fluctuating water elevations, vessel traffic, ice and debris in the canal, interference with vessel traffic and recreational uses, etc. Silt curtains or screens would be shredded fairly quickly and would need to be frequently repaired and routinely replaced, possibly after every discharge. The CITY will construct floatables screening at RH-034 but floatables nets will be ineffective at controlling solids discharges. This action will not facilitate the solids reductions needed to achieve the PRGs.

TABLE
Technologies for Combined Sewer Overflow Controls - Screening and Evaluation Using Established Criteria
Gowanus Canal
Brooklyn, New York

General Response Action	Remedial Technology Type	Process Option	Description	Effective-ness	Implemen-tability	Cost	Retained for Further Evaluation (Yes/No)	Screening Comments
Removal	Dredging	Maintenance Dredging	This action is for periodic maintenance dredging of CSO solids settled in the Canal via mechanical and/or hydraulic dredging. Based on bathymetric differencing evaluations performed by USEPA and National Grid, the sedimentation rates in the upper reach of the canal are estimated to be between 0.13 to 0.42 feet per year. Maintenance dredging would likely be performed when approximately 2 feet of sediment have accumulated in the upper canal, or every 5 to 16 years. Mechanical dredging removes sediment using buckets (e.g., clamshell) either suspended by cables from a crane or attached to a backhoe. The dredged sediments are typically placed in a barge for transport. Hydraulic dredging removes sediments with hydraulic suction. The sediments are then pumped through a pipeline to a staging area (e.g., dewatering site). Common hydraulic dredges include cutter head, horizontal augers, plain suction, pneumatic submersible pumps, specialty dredge heads, and diver assisted hand-held hydraulic suctions.	2	2	2	Yes	The armoring layer of the cap would need to be designed to allow dredging without impacting the armoring layer and cap performance. Mechanical dredging may be an effective removal technology. Accessibility in shallow areas of the canal will be limited by tidal conditions. The dredged material could be transported via a barge to a treatment and/or disposal facility. Dewatering would be needed to support the operation. Suspended sediments are expected to be mobilized during the dredging process. Hydraulic dredging may be an effective removal technology if a nearby staging area could be identified to support the process. The volume of the sediment slurry produced by hydraulic dredging would be greater than the volume of sediments generated from mechanical dredging. This slurry would require significantly more dewatering and solidification than sediments produced from mechanical dredging prior to disposal. This action will not facilitate the solids reductions needed to achieve the PRGs but will remove settled solids on a periodic basis. This approach may achieve the PRGs for a percentage of the time between periodic dredging activities while new solids released from the CSOs begin to settle. The estimated costs are for single dredging event covering an area of 214,120 square feet, which at a depth of 2 feet, corresponds to a volume of 15, 900 CY range between $9.34 M to $9.91M. See notes at bottom of table.
Source Control	CSO Discharge Control	Sewer Cleaning	This action is the implementation of additional regular sewer cleaning in the combined sewer drainage area. The purpose of sewer cleaning is to remove accumulated material from the sewer. This increases the capacity of the sewers to store and convey wet weather flow to treatment works and reduces CSO discharges at optimal system performance. This also minimizes the accumulation of solids and debris that could be resuspended during high flow events and discharged to the canal. Sewer cleaning is one of fourteen best management practices (BMPs) that the CITY is required to perform in its State Pollutant Discharge Elimination System (SPDES) permit.	2	4	4	Yes	The CITY is required to clean its sewers in the Maximize Use of Collection System for Storage practice of the 14 BMPs in its SPDES permit. The CITY reports the cleaning of sewers in its CSO BMP annual reports, which lists the sewers in the Gowanus Canal sewer drainage area that have been cleaned. Sewer cleaning reduces the frequency and volume of discharges to the capacity of the system itself, but will not reduce discharges any more than the existing sewers can convey. Although this action will minimize the resuspension of settled solids in the sewers themselves, it will not control the discharge of solids in the CSOs during wet weather. This action will not facilitate the solids reductions needed to achieve the PRGs.

TABLE
Technologies for Combined Sewer Overflow Controls - Screening and Evaluation Using Established Criteria
Gowanus Canal
Brooklyn, New York

General Response Action	Remedial Technology Type	Process Option	Description	Effective-ness	Implemen-tability	Cost	Retained for Further Evaluation (Yes/No)	Screening Comments
Source Control	CSO Discharge Control	CSO Storage	This action is the construction of inline or offline storage tanks and modular systems, and storage conduits within the combined sewer collection system or at CSO outfalls. Starting in the 1970s the City has constructed storage tanks at Spring Creek, Paerdegat Basin and Flushing Creek. Tanks store excess combined sewage to be treated following a wet weather event. Conveyance, pumping facilities, odor control, cleaning processes, and other design features are required. Tanks can be built as flow-through facilities such that excess volumes are still discharged but undergo a certain level of treatment that achieves solids removals.	4	3	1	Yes	Solids discharges are reduced volumetrically by storing combined sewage and conveying the stored volume to the wastewater treatment plant when conveyance capacity is available at the end of the wet weather event. Flow-through tanks that discharge when the tank volume is completely filled will still achieve some level of solids reduction via settling action in the tank. Smaller events may be completely abated while the frequency and volume of discharges during larger events will be reduced and the first flush of solids can be retained. Storage conduits can replace existing sewers in City streets where there is room with existing utilities or relocation is possible. Although there is no space at the RH-034 outfall itself, there are other properties in the immediate vicinity including the Douglass & Degraw Pool/Thomas Green Playground one block away from RH-034. The trap chamber at OH-007 could be replaced with a storage tank using CITY-owned vacant land adjacent to the chamber. This action can be designed to facilitate the solids reductions needed to achieve the PRGs.

Notes:

Technologies are screened to assess their ability to achieve the following remedial action objective (RAO): Provide CSO solids controls to prevent buildup of surface sediment above the preliminary remediation goals (PRGs) in the upper section of the Gowanus Canal.

Shaded rows indicate technology was not retained for further evaluation.
Ranking is on scale of 1 to 4; 1 is poorest and 4 is the best.
The qualitative ranking guidelines for the technology screening scores are described in Table 3-2 of the Draft Feasibility Study report.

Screening Criteria:

1. Technical Effectiveness

   The technical effectiveness of a technology/process option was evaluated based on its ability to meet the RAO under the conditions and limitations present at the site. The technical effectiveness criterion was used to determine which technologies would be effective based on the site characteristics and other engineering considerations. The NCP defines effectiveness as the “degree to which an alternative reduces toxicity, mobility, or volume through treatment, minimizes residual risk, affords long-term protection, complies with applicable or relevant and appropriate requirements (ARARs), minimizes short-term impacts, and how quickly it achieves protection.” Remedial technologies that are not likely to be effective for addressing CSO solids are screened out and not retained for further evaluation.

2. Implementability

   “Implementability” refers to the relative degree of difficulty anticipated in implementing a particular technology/process option under the regulatory and technical constraints posed at the site. Implementability is evaluated in terms of the technical and administrative feasibility of constructing, operating, and maintaining the technology/process option, as well as the availability of services and materials. Technical feasibility refers to the ability to construct, reliably operate, and comply with regulatory requirements during implementation of the technology/process option. Technical feasibility also refers to the future operation, maintenance, and monitoring after the technology/process option has been completed. Administrative feasibility refers to the ability to coordinate with and obtain approvals and permits from regulatory agencies. Availability of services and materials may include the availability and capacity of treatment, storage, and disposal services; the availability of bulk materials; and the requirements for and availability of specialized equipment and technicians. Technologies that cannot be implemented at the site are screened out and not retained for further evaluation.

3. Cost

   The primary purpose of the cost-screening criterion is to allow for a comparison of rough costs associated with the technologies/process options. The cost criterion addresses costs to capital and operation and maintenance costs for the controls. At this stage of the process, the cost criterion is qualitative and used for rough comparative purposes only.

Maintenance dredging of sediment mound near RH-034

Costs are order of magnitude estimates (plus 50 minus 30 percent). Detailed assumptions serving as the basis for the estimates are available and build upon the assumptions in the Draft Feasibility Study, December 2011.
Maintenance dredging estimated to be needed when approximately 2 feet of new sediment accumulate.
Maintenance dredging is estimated to be needed every 8 – 9 years.
The estimated costs are for single dredging event covering an area of 214,120 square feet, which at a depth of 2 feet, corresponds to a volume of 15,900 CY.
Cap repair following dredging event, is assumed for for 5% of the dredged area (consistent with assumption used for the Draft FS).

Dredging - $1,088,628
Cap Repair - $88,311
Disposal options
A - Offsite thermal desorption, beneficial use - $8,252,267
B - Offsite disposal (landfill) - $8,818,455
Total costs – $9.429 M to $9.995M

CSO Storage

These cost estimates are considered Class 5 - Planning Level estimates as defined by the American Association of Cost Engineering (AACE) and as designated in ASTM E 2516-06. They are considered accurate from +75% to -40% based on less than 2% of the complete project definition.
Storage tank cost based on below-ground storage facility. The construction cost accounts for the cost for excavation, sheeting and bracing, backfill, 3-inch-spacing coarse screening, automated flushing, instrumentation, and SCADA. Markups added for odor control, dewatering, and brownfields.
Pumping cost based on submersible pump stations at a 50-foot depth below the ground surface. The construction cost accounts for excavation, structure, piping, valves, pumps, electronics including variable frequency drives, control room, instrumentation and site restoration. Markups added for construction in rock, grinders, one grit pit, dewatering, odor control and brownfields.
Open-cut sewer cost for OH-007 based on 900 linear feet of 36-inch pipe at an average depth of 15 feet with 4 manholes. Open-cut sewer cost of RH-034 based on 500 linear feet of 96-inch pipe at an average depth of 20 feet with 3 manholes. Markups added for construction in rock, dewatering, maintenance of flow, brownfields, traffic maintenance and urban alignment. Street width of 30 feet used for calculations.
Force main cost based on 500 linear feet of pipe with varying diameters at an average depth of 8 feet with 0 manholes and 0 air release valves. Pipe diameters calculated using Manning formula based on the peak flow rate of the storage pump, a pipe length of 500 feet, a roughness coefficient of 0.012, an elevation difference of 20 feet, an inlet pressure of 5 PSI, and an outlet pressure of 0 PSI. Markups added for construction in rock, dewatering, brownfields, and traffic maintenance. Street width of 30 feet used for calculations.
The following are not included in the construction costs: capital cost markups, property costs, demolition, rebuild of site surface, extra costs from unknown soil conditions, extra costs for staging and hauling, and heavy dewatering costs involving ground-freezing.

The following are a range of tank sizes for RH-034 (at CITY's Douglass & Degraw Pool/Thomas Green Playground one block away from RH-034) and OH-007 (on the triangular, CITY-owned vacant lot adjacent to the CSO) and conceptual planning-level construction costs.

CSO	Tank Size (million gallons)	Class 5 Construction Cost Estimate (October 2012)
RH-034	2	$ 24,687,000
RH-034	4	$ 31,933,000
RH-034	6	$ 39,177,000
RH-034	8	$ 46,429,000
RH-034	10	$ 53,676,000
RH-034	12	$ 60,918,000
RH-034	15	$ 71,795,000
RH-034	17	$ 79,037,000
OH-007	2	$ 24,029,000
OH-007	4	$ 31,272,000
OH-007	6	$ 38,514,000
OH-007	8.2	$ 46,481,000

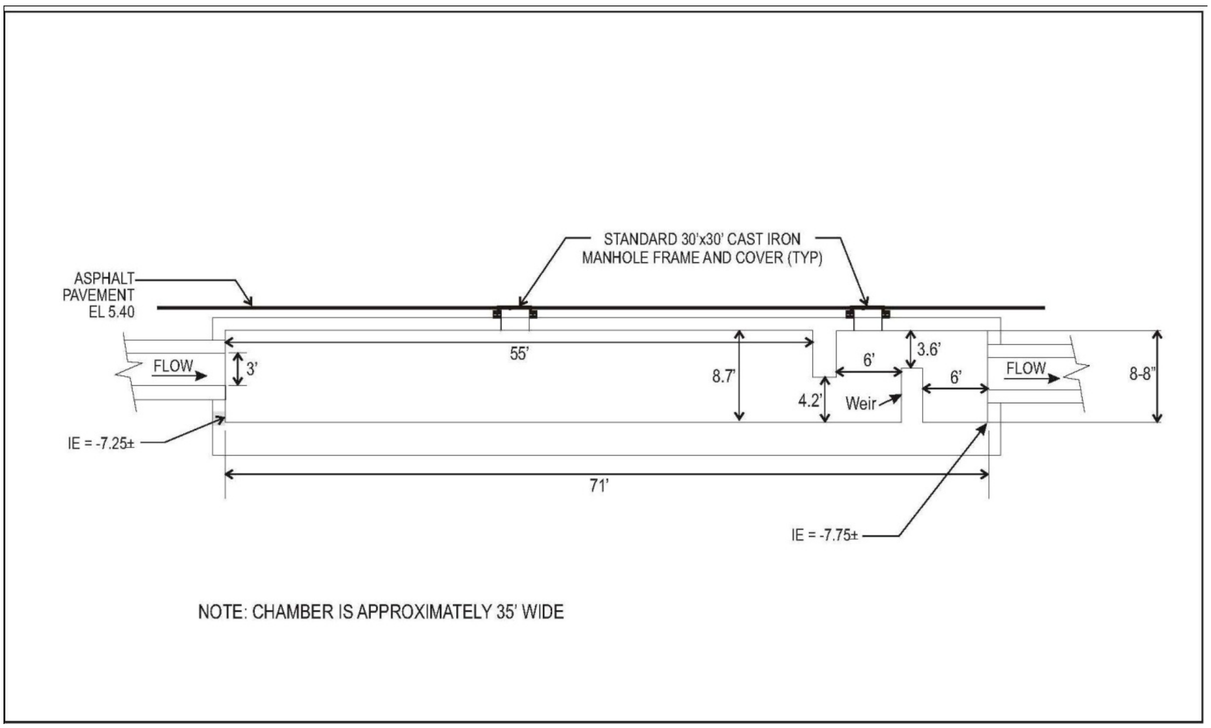
REFERENCES

Description of Outfall OH-007 "Trap Chamber" (NYCDEP, 2009)

Discharges from this outfall originate with flows that exceeds the capacity of the 12-inch inlet to the Second Avenue Pump Station and overtop a one-foot weir in the diversion chamber, then pass through tide gates and into a floatables/settleable solids trap chamber measuring approximately 70 feet long, 35 feet wide, and 8 feet high (Figure 7-9). The dimensions of the chamber allow the flow to slow as it enters the trap, and heavier solids settle to the bottom while floatable items rise to the surface. At its downstream end, the chamber contains a baffle/weir combination that acts to retain the floatables and settled solids within the trap while allowing flow to pass under the baffle and over the weir to the chamber exit.

CSO OH-007 Floatables/Solids Trap Chamber

From Figure 7-9 (NYCDEP, 2009)



Silt Curtains from EPA's 2005 Contaminated Sediment Remediation Guidance for Hazardous Waste Sites

Silt curtains and silt screens are flexible barriers that hang down from the water surface. Both systems use a series of floats on the surface and a ballast chain or anchors along the bottom. Although the terms "silt curtain" and "silt screen" may be frequently used interchangeably, there are fundamental differences. Silt curtains are made of impervious materials, such as coated nylon, and primarily redirect flow around the dredging area. In contrast, silt screens are made from synthetic geotextile fabrics, which allow water to flow through, but retain a large fraction of the suspended solids (Averett et al. 1990). Silt curtains or silt screens may be appropriate when site conditions dictate the need for minimal transport of suspended sediment, for example, when dredging hot spots of high contaminant concentration.

Silt curtains have been used at many locations with varying degrees of success. For example, silt curtains were found to be effective in limiting suspended solids transport during in-water dike construction of the

CDF for the New Bedford Harbor pilot project. However, the same silt curtains were ineffective in limiting contaminant migration during dredging operations at the same site primarily as a result of tidal fluctuation and wind (Averett et al. 1990). Problems were experienced during installation of silt curtains at the General Motors site (Massena, New York) due to high current velocities and back eddies. Dye tests conducted after installation revealed significant leakage, and the silt curtains were removed. Sheet piling was then installed around the area to be dredged with silt curtains used as supplemental containment for hot spot areas. A silt curtain and silt screen containment system were effectively applied during dredging of the Sheboygan River in 1990 and 1991, where water depths were 2 m or less. A silt curtain was found to reduce suspended solids from approximately 400 mg/L (inside) to 5 mg/L (outside) during rock fill and dredging activities in Halifax Harbor, Canada (MacKnight 1992). At some sites, changes in dredging operating procedures may offer more effective control of resuspension than containment barriers.

The effectiveness of silt curtains and screens is primarily determined by the hydrodynamic conditions at the site. Conditions that may reduce the effectiveness of these and other types of barriers include the following:

- *Significant currents;*
- *High winds;*
- *Changing water levels (i.e., tidal fluctuation);*
- *Excessive wave height, including ship wakes; and*
- *Drifting ice and debris.*

Silt curtains and screens are generally most effective in relatively shallow, undisturbed water. As water depth increases and turbulence caused by currents and waves increases, it becomes difficult to isolate the dredging operation effectively from the ambient water. The St. Lawrence Centre (1993) advises against the use of silt curtains in water deeper than 6.5 m or in currents greater than 50 cm/sec.

Installing, operation and maintenance:

(1) *what water conditions such as velocities and depths do they work?* – less than 20' in depth, less than ~1 ft/s velocity, no tidal fluctuations.

(2) *what's needed to install and maintain them* – they can be anchored in a variety of ways. Not that I would recommend them for this application, but the most robust means of anchorage would be to attach them to driven piles in the water. Silt curtains used in Gowanus would be shredded fairly quickly and would need to be replaced routinely.

(3) *service life* – replace after every significant rainfall event.

(4) *Costs* – we have an estimate of $40 per linear foot in our FS cost estimate. I would double that for this single application because of small quantity. We also need to include perhaps $40,000 to mobilize a barge-based crane initially drive the piles to anchor the silt curtain. Once we are replacing the silt curtains on a perhaps monthly basis, you would have a crew of three in a workboat doing the replacement, so the $80 per linear foot could probably work at that point.

CSO Storage Tanks
Draft Cost Estimates
Gowanus Canal,
Brooklyn, New York

Prepared for

U.S. Environmental Protection Agency
Region 2

Prepared under contract
AES10 Task Order 072-RI-FS-02ZP
Architect and Engineering Services Contract
Contract No. 68-S7-04-01

Prepared by
CH2MHILL

Gowanus Canal CSO Storage Tanks Draft Cost Estimates

PREPARED FOR: Christos Tsiamis, USEPA

PREPARED BY: CH2M HILL

DATE: October 25, 2012

Conceptual cost estimates were prepared for estimating the construction costs of offline storage tanks to retain combined sewer overflows (CSOs) at Gowanus Canal CSO outfalls RH-034 and OH-007. The construction cost estimates are summarized in Exhibit 1. The basis for these estimates is then described. The sizes of the tanks in the cost estimate are the sizes of the tanks that the City of New York (City) has presented in Table 7-4 of its 2009 addendum to its Gowanus Canal Waterbody/Watershed Facility Plan Report. The sizes of the tanks range from 2 million gallons (MG) to 17 MG at outfall RH-034 and 2 MG to 8.2 MG at outfall OH-007. The estimates presented herein are for underground storage facilities.

EXHIBIT 1
Conceptual Construction Cost Estimates for CSO Storage at RH-034 and OH-007

CSO	Tank Size (million gallons)	Class 5 Construction Cost Estimate (October 2012)	CSO	Tank Size (million gallons)	Class 5 Construction Cost Estimate (October 2012)
RH-034	2	$ 24,687,000	OH-007	2	$ 24,029,000
RH-034	4	$ 31,933,000	OH-007	4	$ 31,272,000
RH-034	6	$ 39,177,000	OH-007	6	$ 38,514,000
RH-034	8	$ 46,429,000	OH-007	8.2	$ 46,481,000
RH-034	10	$ 53,676,000			
RH-034	12	$ 60,918,000			
RH-034	15	$ 71,795,000			
RH-034	17	$ 79,037,000			

The cost estimates were prepared for conceptually locating a storage tank for RH-034 at New York City's Douglass & Degraw Pool/Thomas Green Playground one block away from RH-034. Estimates were also prepared for locating a storage tank for OH-007 on the triangular City-owned vacant lot adjacent to the CSO. Conceptual tank and conveyance locations are shown in the attachment. Allowing for a 10-foot property offset and a tank depth of 25 feet (based on average pipe depth of 15 feet and a tank invert of 40 feet below ground), maximum tank volumes were estimated to be 16.2 MG at RH-034 and 4.0 MG at OH-007. These estimated maximum volumes for the two sites are less than the maximum volumes used by the City of New York in its 2009 addendum to its Gowanus Canal Waterbody/Watershed Facility Plan Report (17 MG at RH-034, 6 and 8.2 MG at OH-007).

Construction Cost Development

It should be expressly understood the costs developed at this phase are planning level costs and should be used only for alternative comparison. Estimates are prepared based on the best available data and judgment at the time of development. The estimated construction costs are considered a modified Class 5 – Process Industry Planning Level estimate as defined by the Association for the Advancement of Cost Engineering (AACE) 17R-97 and as designated in its American Society of Testing Methods (ASTM) E 2516-06. The Process Industry range is applied because these are wet weather facilities that are not conventional commercial buildings and tend to not be consistently duplicated. Designs can vary greatly on each individual project due to variable flow rates, what is in the CSO that is being captured/treated/conveyed, the types and levels of treatments, types of controls, availability of other utilities to the site, crossing other utilities, as well as environmental issues and regulations. For Class 5 Estimates, the range is set through estimator judgment and can vary from (+30%/-20%) range up to (+100%/-50%) range. Based on the conceptual level of this estimate and having no detailed information on combined sewers and hydraulics in the area, site conditions, etc., the estimates are considered accurate from +75% to -40% based on less than 2% of the complete project definition.

Exhibit 2 below presents a summary of standard cost estimating level descriptions, accuracy and recommended contingencies based on the level of the project.

EXHIBIT 2
Standard AACE Cost Estimating Guidelines[a]

Cost Estimate Class [a]	Project Level Description	Estimate Accuracy Range	Recommended Estimate Contingency
Class 5	Planning (0 to 2% Design)	-20 to -50% +30 to +100%	30 to 50%
Class 4	Conceptual (1 to 15% Design)	-15 to -30% +20 to +50%	25 to 30%
Class 3	Preliminary (10 to 40% Design)	-10 to -20% +10 to +30%	15 to 20%
Class 2	Detailed (30 to 70% Design)	-5 to -15% +5 to +20%	10 to 15%
Class 1	Final (50 to 100% Design)	-3 to -10% +3 to +15%	5 to 10%

(a) Association for the Advancement of Cost Engineering E 2516-06. International Recommended Practices and Standards.

The following documents the costing methodology of open cut sewers, force mains, offline storage facilities, and pump stations used by the Program Alternative Cost Calculator (PACC) Tool developed by CH2M HILL for the Gowanus Canal Superfund Project. The PACC Tool generates planning level cost estimating for sanitary, storm, and combined sewer programs.

Unit costs are obtained from the RS Means index, USEPA documentation, company cost databases, vendor quotes, data hard bid information, data from similar projects, and local labor rates, but many assumptions are made based on multiple cities historical project data, . All unit costs presented herein have an Engineering News Record Construction Cost Index (ENRCCI) of 7770 which reflects construction costs in June 2006 for Cincinnati, OH. Once generated, these construction costs are converted to an ENRCCI of 14504.4 to reflect construction costs in September 2012 for New York City, New York.

Open Cut Sewers

Open cut sewers are laid through the excavation of trenches with bracing using sheeting or trench box methods. In general, this construction method is used for sewers at depths less than 25 feet. However, open cut construction can be a challenge if ground conditions are poor or if there are multiple utility lines in the easement area. Open cut sewers are sized for conveyance of sanitary or combined flow through the system to treatment and/or designed for in-line storage to reduce or eliminate flow released to the environment.

The majority of the costs for open cut sewer construction were originally based on the January 2004 Edition of the Metropolitan Sewer District of Greater Cincinnati (MSDGC) *Engineer's Estimated Prices*. The estimates from this document had been updated annually for 16 years. The PACC tool and associated documentation have been updated for the last eight years.

Open cut sewer base construction costs are calculated based on the sewer dimensions and the site location. The construction cost is then determined by applying markups to the base construction cost to account for assumed construction conditions.

Open Cut Sewer Base Construction Cost

This section details the components of the base construction cost of open cut sewers for the Gowanus Canal Superfund Project, including the cost basis and methodology.

- *Pipe Costs* are based on *Engineer's Estimated Prices* for the pipe size as shown Exhibit 3. Pipe prices are meant to reflect the highest end grade material required for a project. Therefore, the unit costs have been reviewed and revised to best reflect local unit cost prices. Pipe types may be PVC, concrete, clay, or glass-reinforced polymer types. Sizes vary from 8 inches to 144 inches. For this project, a pipe size of 36 inches was used for the OH-007 alternatives and a pipe size of 96 inches was used for the RH-034 alternatives. These pipe sizes are indicated in yellow in Exhibit 3.
- *Pipe Laying Costs* are based on the *Engineer's Estimated Prices* for the pipe size entered as shown in Exhibit 3. The pipe laying unit costs applied for open cut sewers in this project are indicated in yellow in Exhibit 3.
- *Pavement Opening and Repaving Costs* – The street opening cost, $14.78 per square yard, includes saw cutting, opening, and removing pavement for the length of pipe in the street and the width of the street. The repaving cost, $68.96 per square yard, is based on pavement of the entire street width with 9-inch thick PCC pavement for any required street opening and the length of pipe in the street.
- *Erosion Control Cost* adds a cost of $3.94 per foot of sewer to account for silt fencing, hay bales, screen catch basins or inlets, etc.
- *Clearing and Grubbing* adds a cost of $5.00 per foot of sewer to account for clearing and grubbing of curb strips.
- *Excavation Costs* are based on backhoe excavation of the soil volume to be removed using vertical walls with sheeting and bracing. The excavation volume is calculated using the average segment depth and length and the trench width, which is determined based on pipe size as shown in Exhibit 3. The cost of excavation per cubic yard is obtained from the MSDGC's *Engineer's Estimated Prices* matrix for excavation, shown in Exhibit 4, using the trench width and average depth. The excavation unit costs applied for open cut sewers in this project are indicated in yellow in Exhibit 4.
- *Backfill Costs* account for the cost to refill the trench after the pipe is placed. The backfill volume excludes the pipe volume in addition the volume of the granular pipe buffer, which consists of the cross-sectional area within a 6-inch radius below the pipe and up to 12 inches above the pipe. Controlled density backfill is used for the length of pipe in the street and earth backfill is used for length of pipe out of the street. The unit cost for each backfill material is shown in Exhibit 5.
- *Sheeting and Bracing Costs* are determined as a cost per linear foot obtained from the MSDGC's *Engineer's Estimated Prices* matrix based on the trench width required for the pipe size (obtained from Exhibit 3) and the average depth of trench as shown in Exhibit 6. The unit cost is then multiplied by the length of pipe to compute the total sheeting and bracing cost. The sheeting and bracing unit costs applied for open cut sewers in this project are indicated in yellow in Exhibit 6.
- *Manhole Costs* are estimated using the average pipe depth and number of manholes. Standard precast concrete manhole costs, obtained from the MSDGC's *Engineer's Estimated Prices* as shown in Exhibit 7, are used. The cost per vertical linear foot is based on manhole diameter which is determined from the pipe size. This unit cost includes the cost of base and casting. It is then multiplied by the average depth of the sewer and number of manholes. The cost for additional excavation and backfill, using controlled density fill as shown in the Exhibit 5, is also added. The cost is conservative for large pipes (54-inch diameter and up) that may require side saddle manholes. The unit costs applied for manholes in this project are indicated in yellow in Exhibit 7.

EXHIBIT 3

Pipe Price Cost, Pipe Laying Cost, and Trench Width

			Trench Width (feet)		
Pipe Diameter (inches)	Pipe Cost Per Foot*	Laying Cost Per Foot	Sewer Depths from 5 to 10 feet	Sewer Depths from 11 to 16 feet	Sewer Depths from 17 to 25 feet
8	$11.69	$15.40	4.5	4.5	5
10	$13.81	$15.40	4.5	4.5	5
12	$15.94	$15.40	4.5	4.5	5
15	$19.13	$15.40	4.5	5	5.5
18	$25.50	$15.40	5	5.5	5.5
21	$29.75	$15.40	5.5	5.5	6
24	$35.07	$15.40	5.5	6	6
27	$46.76	$15.40	6	6.5	6.5
30	$54.19	$17.60	6.5	6.5	7
33	$65.88	$19.70	7	7	7.5
36	$78.64	$20.70	7.5	7.5	8
42	$107.33	$25.50	8	8	8.5
48	$133.89	$27.60	8.5	8.5	9
54	$176.40	$28.70	9	9	9.5
60	$195.53	$32.90	9.5	10	10
66	$231.65	$35.10	10	10.5	11
72	$267.78	$37.20	11	11	11.5
78	$325.17	$39.70	11.5	12	12
84	$392.11	$42.20	12	12.5	13
90	$429.31	$44.70	13	13.5	14
96	$469.69	$47.20	14	14.5	15
102	$512.19	$49.70	15.5	16	16
108	$558.95	$52.20	16.5	16.5	17
120	$621.64	$54.70	17	17	17.5
132	$696.03	$57.20	17.5	17.5	18
144	$781.04	$59.70	18	18	18

* High end Price is usually for Class 5 RCP or Fiberglass Reinforced Pipe (HOBAS)

EXHIBIT 4

Trench Excavation

Cost per Cubic Yard

Depth (feet)	Trench Width (feet)																
	2.5	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
5	$9.56	$9.56															
6	$12.75	$10.63	$9.56	$9.56	$8.50	$8.50											
7	$14.88	$13.81	$12.75	$10.63	$10.63	$9.56	$9.56	$8.50	$8.50								
8	$17.00	$15.94	$13.81	$12.75	$12.75	$10.63	$10.63	$10.63	$10.63	$9.56	$9.56	$9.56	$8.50	$8.50			
9	$19.13	$17.00	$14.88	$13.81	$13.81	$12.75	$12.75	$12.75	$12.75	$10.63	$10.63	$10.63	$10.63	$10.63	$9.56	$9.56	$9.56
10	$21.25	$19.13	$17.00	$14.88	$14.88	$13.81	$13.81	$12.75	$12.75	$12.75	$12.75	$12.75	$12.75	$12.75	$10.63	$10.63	$10.63
11	$24.44	$21.25	$18.06	$17.00	$15.94	$14.88	$13.81	$13.81	$13.81	$13.81	$13.81	$13.81	$12.75	$12.75	$12.75	$12.75	$12.75
12	$26.57	$24.44	$20.19	$18.06	$17.00	$15.94	$14.88	$14.88	$14.88	$14.88	$13.81	$13.81	$13.81	$13.81	$13.81	$13.81	$13.81
13	$28.69	$26.57	$22.32	$20.19	$18.06	$17.00	$15.94	$14.88	$14.88	$14.88	$14.88	$14.88	$14.88	$14.88	$14.88	$13.81	$13.81
14	$30.82	$28.69	$25.50	$21.25	$19.13	$18.06	$17.00	$15.94	$15.94	$15.94	$15.94	$15.94	$14.88	$14.88	$14.88	$14.88	$14.88
15	$31.88	$30.82	$26.57	$24.44	$21.25	$19.13	$18.06	$17.00	$17.00	$17.00	$17.00	$17.00	$15.94	$15.94	$15.94	$15.94	$15.94
16	$35.07	$31.88	$28.69	$25.50	$22.32	$21.25	$19.13	$18.06	$18.06	$18.06	$18.06	$18.06	$17.00	$17.00	$17.00	$17.00	$17.00
17	$38.25	$34.00	$29.75	$27.63	$25.50	$22.32	$21.25	$19.13	$19.13	$19.13	$19.13	$19.13	$18.06	$18.06	$18.06	$18.06	$18.06
18	$40.38	$36.13	$30.82	$28.69	$26.57	$24.44	$22.32	$20.19	$20.19	$20.19	$21.25	$21.25	$19.13	$19.13	$19.13	$19.13	$19.13
19	$42.51	$39.32	$31.88	$29.75	$27.63	$25.50	$24.44	$22.32	$22.32	$22.32	$22.32	$22.32	$20.19	$20.19	$21.25	$21.25	$21.25
20	$44.63	$40.38	$35.07	$31.88	$28.69	$27.63	$25.50	$24.44	$24.44	$24.44	$24.44	$24.44	$22.32	$22.32	$22.32	$22.32	$22.32
21	$46.76	$41.44	$38.25	$32.94	$30.82	$28.69	$26.57	$25.50	$25.50	$25.50	$25.50	$25.50	$24.44	$24.44	$24.44	$24.44	$24.44
22	$47.82	$44.63	$39.32	$35.07	$31.88	$29.75	$27.63	$26.57	$26.57	$26.57	$26.57	$26.57	$25.50	$25.50	$25.50	$25.50	$25.50
23	$49.94	$46.76	$41.44	$36.13	$32.94	$30.82	$28.69	$27.63	$27.63	$27.63	$27.63	$27.63	$26.57	$26.57	$26.57	$26.57	$26.57
24	$53.13	$47.82	$42.51	$39.32	$35.07	$31.88	$30.82	$28.69	$28.69	$28.69	$28.69	$28.69	$27.63	$27.63	$27.63	$27.63	$27.63
25	$55.26	$49.94	$44.63	$40.38	$36.13	$34.00	$31.88	$29.75	$29.75	$29.75	$30.82	$30.82	$28.69	$28.69	$28.69	$28.69	$28.69

EXHIBIT 5

Backfill Material Unit Costs

Backfill Material	Cost (2006 $/yard)
Gravel	$26.57
Controlled Density Fill	$58.45
Soil	$15.94

EXHIBIT 6
Skeleton Sheeting And Bracing
Cost Per Linear Foot

Depth feet)	Trench Width (feet)						
	2.5 - 4.0	4.5 - 7.0	7.5 - 10.0	10.5 - 12.0	12.5 - 14.0	14.5-16.0	16.5-18.0
5	$4.78	$5.84	$7.01	$8.18	$10.52	$15.30	$18.70
6	$5.84	$7.01	$8.18	$10.52	$13.07	$18.70	$22.00
7	$7.01	$8.18	$10.52	$13.07	$15.30	$22.00	$26.03
8	$8.18	$9.35	$13.07	$15.30	$18.70	$26.03	$29.33
9	$9.35	$11.90	$15.30	$18.70	$22.00	$29.33	$32.73
10	$10.52	$13.07	$17.53	$22.00	$26.03	$32.73	$36.13
11	$13.07	$15.30	$19.77	$26.03	$29.33	$36.13	$40.59
12	$14.13	$17.53	$22.00	$29.33	$32.73	$40.59	$45.16
13	$16.36	$19.77	$26.03	$32.73	$36.13	$45.16	$49.63
14	$18.70	$22.00	$29.33	$36.13	$40.59	$49.63	$54.19
15	$20.93	$26.03	$32.73	$40.59	$45.16	$54.19	$60.89
16	$23.70	$29.33	$36.13	$45.16	$49.63	$60.89	$67.69
17	$27.10	$32.73	$40.59	$49.63	$54.19	$67.69	$73.32
18	$31.67	$37.30	$45.16	$54.19	$60.89	$73.32	$81.19
19	$34.96	$40.59	$49.63	$60.89	$67.69	$81.19	$90.22
20	$39.53	$46.22	$55.26	$67.69	$73.32	$90.22	$100.42
21	$43.99	$50.79	$63.23	$73.32	$81.19	$100.42	$109.45
22	$50.79	$58.66	$69.92	$81.19	$90.22	$109.45	$113.70
23	$56.43	$65.46	$76.72	$90.22	$100.42	$113.70	$119.02
24	$67.69	$74.49	$86.82	$100.42	$109.45	$119.02	$124.33
25	$73.32	$83.52	$95.85	$109.45	$113.70	$124.33	$131.77

EXHIBIT 7
Manholes

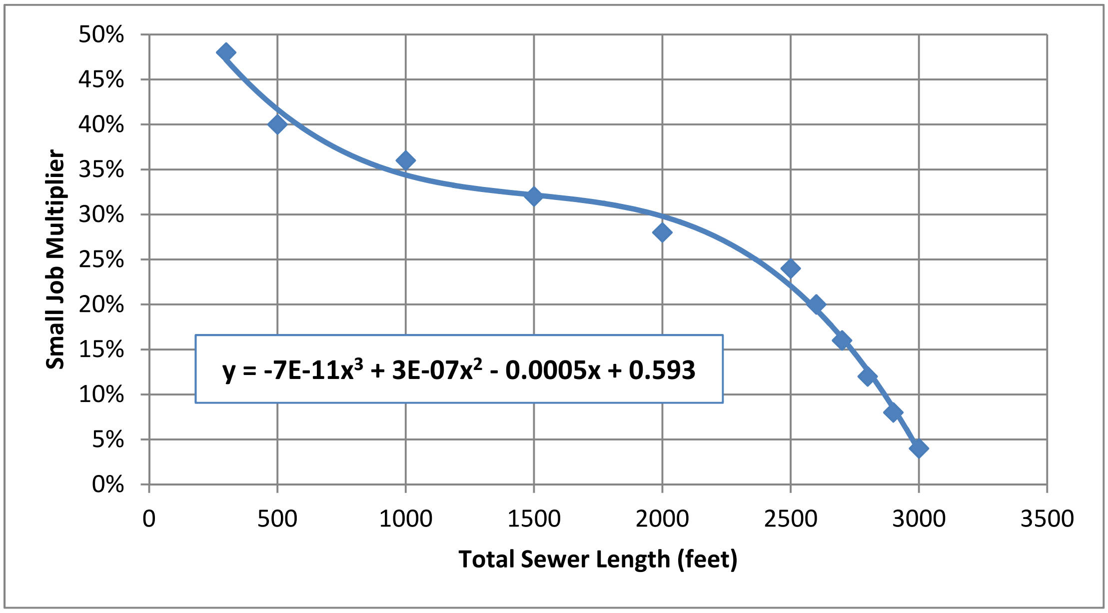
Sewer Diameter (inches)	Manhole Diameter (feet)	Construction Cost ($/VLF)
6 to 24	4	$456.80
27 to 36	5	$527.62
42 to 54	6	$702.36
60 to 72	7	$808.90
78 to 84	8	$1,093.54
90 to 108	9	$1,246.05
114 to 144	10	$1,398.57

Open Cut Sewer Markups

Seven markups are applied to the open cut sewer base construction costs to account for assumed construction conditions for the Gowanus Canal Superfund Project**.**

- A 10% multiplier is applied to account for dewatering of trenches during construction.
- A 5% multiplier is applied to account for pumping or other diversion requirements necessary to maintain flow. For example, flow maintenance may be necessary for a project that involves replacing an existing active sanitary sewer with a larger pipe size.
- A 5% multiplier is applied to account for the excavation, handling, transportation, and disposal of contaminated, but not hazardous, soil.
- A 1% multiplier is applied to account for the cost of a single lane traffic closure necessary during the construction of an open cut sewer segment placed within the street. This percentage was determined based on discussions with traffic maintenance consultants and a review of traffic maintenance costs for past jobs.
- A 35% multiplier is applied to account for sewer segments within the street that require difficult construction in a busy city setting. At such a location, the contractor is required to maintain local business access and is not able to procure a nearby area for storage of materials and equipment. This markup is intended to cover the use of tight sheeting (presuming that the base rate covers trench shield excavating), reduced productivity from additional utility interferences, and higher risk of restitution costs to mitigate settlement damage.
- A small job multiplier accounts for the extra cost associated with a small job. Many elements, such as mobilization and demobilization, make up a larger portion of the construction cost in small projects than for larger ones. Change orders cost a larger percentage as well. According to MSDGC's *Engineer's Estimated Prices*, any conveyance job consisting of less than 3,100 feet of sewer requires a percent cost increase. The percentage is determined based on the provided with small job multipliers varying from a "desirable" to a "less desirable" level. For preliminary estimating, a best fit equation was developed from a middle level of desirability. The resulting curve is show in Exhibit 8. This markup is applied to the base construction cost in addition to the markups above.

EXHIBIT 8
Small Job Multiplier Curve



Force Mains

Force main construction costs are based on values supplied and reviewed by MSDGC in *Engineers Estimated Prices*. The costing methodology for force mains is similar to open cut sewers aside from pipe material and the inclusion of air-release valves in manholes costs.

Force main base construction costs are calculated based on the force main dimensions and the site location. The construction cost is then determined by applying markups to the base construction cost to account for assumed construction conditions.

Force Main Base Construction Cost

This section details the components of the base construction cost of force mains for the Gowanus Canal Superfund Project, including the cost basis and methodology.

- *Pipe Costs* account for the cost of ductile iron pipe based on the pipe size entered according to MSDGC's *Engineer's Estimated Prices* for pipe sizes ranging from 6 inches to 120 inches as shown in Exhibit 9. Although other materials may be used for force mains, ductile iron pipe was chosen in order to provide a conservative preliminary cost. The force main pipe sizes used in the RH-034 alternatives in this project, ranging from 12 inches to 24 inches, are indicated in green in Exhibit 9.
- *Pipe Laying Costs* are based on MSDGC's *Engineer's Estimated Prices* for the pipe size shown in Exhibit 3. The pipe laying unit costs applied for force mains in this project are indicated in green in Exhibit 3.
- *Pavement Opening and Repaving Costs* – The street opening cost, $14.78 per square yard, includes saw cutting, opening, and removing pavement for the length of the force main in the street and the width of the street. The repaving cost, $68.96 per square yard, is based on pavement of the entire street width with 9" thick PCC pavement for any required street opening and the length of pipe in the street.
- *Erosion Control Cost* adds a cost of $3.94 per foot of sewer to account for silt fencing, hay bales, screen catch basins or inlets, etc.
- *Excavation Costs* are based on backhoe excavation of the soil volume to be removed using vertical walls with sheeting and bracing. The excavation volume is calculated using the average segment depth and length and

the trench width, determined based on pipe size as shown in Exhibit 3. The unit cost is obtained from the MSDGC's *Engineer's Estimated Prices* matrix for excavation using the trench width and average depth shown Exhibit 4. The excavation unit costs applied for force mains in this project are indicated in green in Exhibit 4.

- *Backfill Costs* account for the cost to refill the trench after the pipe is placed. The backfill volume excludes the pipe volume in addition the volume of the granular pipe buffer, which consists of the cross-sectional area within a 6 inches radius below the pipe and up to 12 inches above the pipe. Controlled density backfill is used for the length of pipe in the street and earth backfill is used for length of pipe out of the street. The unit cost for each backfill material is shown in Exhibit 5.
- *Sheeting and Bracing Costs* is determined based on the cost per linear foot is obtained from MSDGC's *Engineer's Estimated Prices* matrix that uses the trench width required, determined using Exhibit 3, for the pipe size and the average depth of trench, as shown in Exhibit 6. The unit cost is then multiplied by the length of pipe to compute the total sheeting and bracing cost. The sheeting and bracing unit costs applied for force mains in this project are indicated in green in Exhibit 6.
- *Manhole Costs* are estimated using the average pipe depth and number of manholes. Standard precast concrete manhole costs, obtained from the MSDGC's *Engineer's Estimated Prices*, are used. The cost of $456 per vertical linear foot is estimated based on a 4' diameter manhole. The unit cost is then multiplied by the average depth of the sewers and number of manholes. The cost for the base and casting, $1,020 per manhole, is also included. Next, the cost for additional excavation and backfill, using controlled density fill as shown in Exhibit 5, for the manhole is added. Additionally, the cost for air release valves, $15,940 per valve, is accounted for in manhole costs.

EXHIBIT 9
Force Main Unit Cost

Force Main Size (inches)	Force Main Cost Per Foot*
4	$13.99
6	$15.64
8	$19.89
10	$25.68
12	$31.00
14	$38.97
16	$42.15
18	$52.25
20	$60.75
24	$77.22
30	$115.48
36	$148.42
42	$189.86
48	$375.82
54	$507.59
60	$548.68
66	$600.03
72	$626.45

EXHIBIT 9
Force Main Unit Cost

Force Main Size (inches)	Force Main Cost Per Foot*
78	$648.45
84	$692.47
90	$780.51
96	$868.55
10	$928.71
108	$1,007.95
114	$1,112.13
120	$1,203.10

*RWP 350, CLASS 56 or Wound Steel for 60" and Larger. Includes all incidentals for delivery to and handling at the site

Force Main Markups

Four markups are applied to the force main base construction costs to account for assumed construction conditions for the Gowanus Canal Superfund Project.

- A 10% multiplier is applied to account for dewatering of trenches during construction.
- A 5% multiplier is applied to account for the excavation, handling, transportation, and disposal of contaminated, but not hazardous, soil.
- A 1% multiplier is applied to account for the cost of a single lane traffic closure necessary during the construction of a force main segment placed within the street. This percentage was determined based on discussions with traffic maintenance consultants and a review of traffic maintenance costs for past jobs.

Off-Line Storage

The intention of off-line storage facilities is to retain flow for later release into the sewer network or to a treatment facility in order to reduce the peak flow and, thus, sewer overflows. All tank estimates are based on underground storage facilities since the available property is currently a park and will remain a park on the surface after construction of the storage facility.

Off-line storage base construction costs are calculated using a unit construction cost curve dependent on the tank volume. The construction cost is then determined by applying markups to the base construction cost to account for assumed construction conditions.

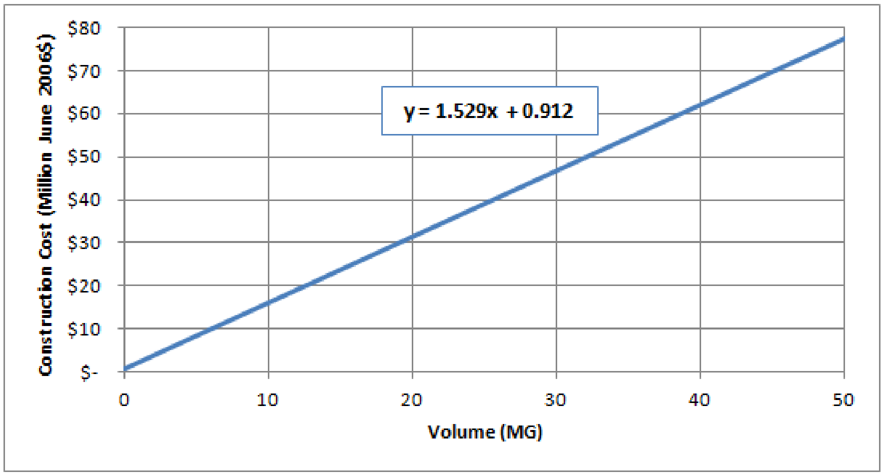
Off-Line Storage Base Construction Cost

The construction cost curve used to determine the base construction cost for underground storage facilities is dependent on the required storage tank volume, as shown in Exhibit 10. This curve includes the cost for excavation, sheeting and bracing, and backfill. It also includes 3-inch spacing coarse screening, automated flushing, instrumentation, SCADA, one grit pit, and dewatering pumps. Pumping to or from the facilities is not included and is estimated separately (as discussed above). The underground storage facility cost curve was selected from review of a collection of curves from the USEPA, MSDGC, other municipalities' storage facilities, and a review of detailed estimates.

The upper limit to the cost curve for storage tanks is 50 MG. Estimates for larger storage facilities are generated as the total cost of multiple tanks of an equivalent combined volume. For example, the base construction cost of a 125-MG facility is estimated as the sum of the costs of two 50-MG facilities and one 25-MG facility.

EXHIBIT 10

Underground Storage Facility Construction Cost Curve



Off-Line Storage Markups

Three markups are applied to the base construction cost obtained from the curve in Exhibit 10 to account for assumed construction conditions.

- A 2% multiplier applied to account for odor control.
- A fixed cost of $447,901, obtained from RS Means 2005, is added to account for dewatering during construction, which includes a detailed geotechnical investigation and 10 months of a single stage system.
- A 5% multiplier is applied to account for the excavation, handling, transportation, and disposal of contaminated, but not hazardous, soil.

Pump Stations

Pump stations are facilities that include pumps and equipment used to propel fluids from one place to another. Pump station base construction costs are calculated using a unit construction cost curve dependent on the peak flow rate. The construction cost is then determined by applying markups to the base construction cost to account for assumed construction conditions.

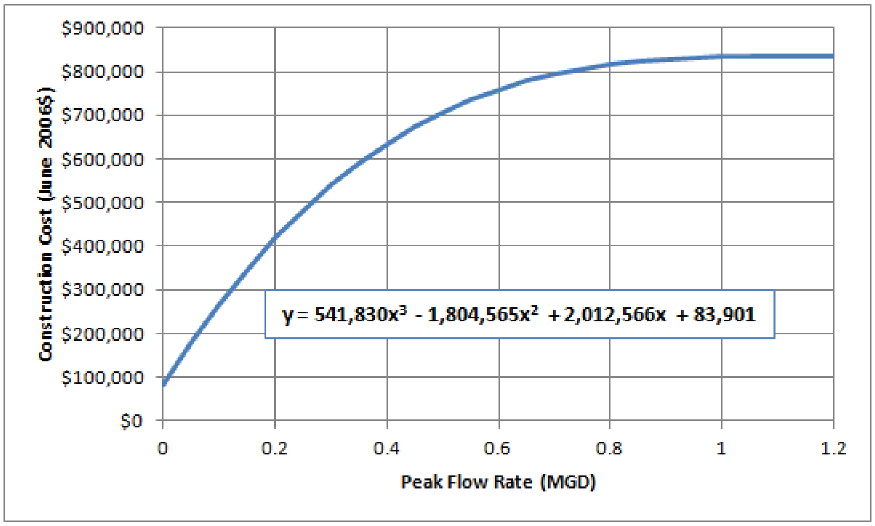
Pump Station Base Construction Cost

The construction costs for pumping to or from the storage facilities are estimated based on the cost of submersible pump stations, which are equipped with pumps that operate while submerged in a wet well and are most frequently used for pumping sewerage and storm water flows. The base construction costs are calculated from one of two curves depending on flow rate. Each curve accounts for excavation, structure, piping, valves, pumps, electronics including variable frequency drives, control room, instrumentation, site restoration, and a facility depth up to 20 feet.

The base construction costs of pump stations with peak flow rates less 1.2 million gallons per day (mgd) are estimated using the curve shown in Exhibit 11. This curve was developed as an average of two curves, one reflecting worst case construction conditions and one reflecting best case conditions.

EXHIBIT 11

Low Flow Rate Pump Station Construction Cost Curve

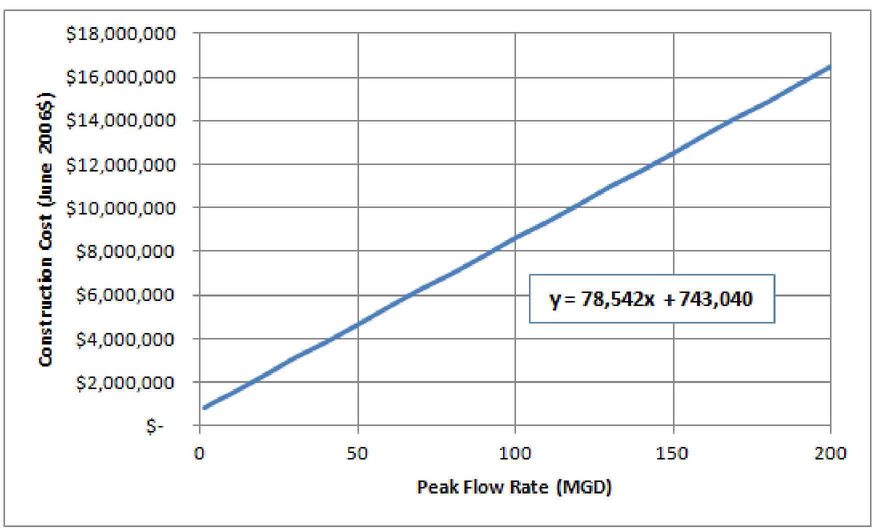


The base construction cost curve of submersible pump stations with flow rates greater than or equal to 1.2 mgd is shown in Exhibit 12. The submersible pump station cost curve was developed from several sources based on a design that includes below-ground wet wells, 3-inch spacing coarse bar screen, a superstructure, a hoist, submersible pumps, and a backup generator.

The maximum peak flow rate for the high flow submersible pump station cost curve is 200 mgd. Estimates for larger pump stations are generated as the total cost of multiple pump stations of an equivalent combined peak flow rate. For example, the base construction cost of a 250 mgd pump station is estimated as the sum of the costs of one 200 mgd pump station and one 50 mgd pump station.

EXHIBIT 12

High Flow Rate Submersible Pump Station Construction Cost Curve



The high flow rate submersible pump station construction cost curve, shown in Exhibit 12, was used for all pumping estimates in this project since the peak flow rates ranged from 2 MGD to 17 MGD.

Pump station depth has a large impact on construction costs because deeper pump stations require more excavation and larger pumps to overcome the static head. For pump stations constructed at depths greater than 20 feet, an additional unit cost is added to the base construction cost obtained from the curves per vertical linear foot depending on the depth entered, as shown in Exhibit 13. For this project, an estimated depth of 50 feet is assumed for each pump station, determined based on the assumed storage tank depth of 35 feet with 5 feet of cover for the storage facility and a pump station invert 10 feet below the storage invert. Therefore, a unit cost of $53,132 per vertical linear foot (indicated in blue in Exhibit 13), for a total of $2,656,592, is added to the base construction cost obtained from the curve.

EXHIBIT 13
Pump Station Depth Unit Construction Costs
Additional Unit Construction Cost Per Vertical Linear Foot for Deep Pump Stations

Pump Station Depth (ft)	Additional Cost ($/VLF)
20 to 49	$15,940
50 to 99	$53,132
100 to 149	$79,698
150 plus	$106,264

A fixed cost of $421,500 is added to account for dewatering during construction, including a detailed geotechnical investigation and 10 months of a single stage system, based on RS Means.

Pump Station Markups

Four markups are applied to the base construction cost to account for assumed construction conditions.

- A 50% multiplier is applied to account for the cost of construction in rock subsurface conditions in accordance with the MSDGC's *Engineer's Estimated Prices* estimating procedure.
- A multiplier of 2% is applied to account for odor control.
- A multiplier of 5% is applied to account for the cost of grinder pumps or systems necessary to grind waste into fine slurry ahead of sewerage lift station pumps.
- A 5% multiplier is applied to account for the excavation, handling, transportation, and disposal of contaminated, but not hazardous, soil.

Attachments

CLASS 5 CONSTRUCTION COST ESTIMATE SUMMARY

City	Month	ENRCCI
Cincinnati	Jun-06	7770
New York City	Sep-12	14504.4

Alternative Components						Construction Cost (NYC 9/12 $)									
										Total[(5),(6)]			Unit Cost[(5),(6)] ($/gal)		
ID	CSO	Storage Volume (MG)	Storage Pump Peak Flow Rate (MGD)	Opencut Sewer Dimensions (LF of pipe size in inches)	Force Main Dimensions (LF of pipe size in inches)	Storage Tank[(1)]	Storage Pump[(2)]	Opencut Sewer[(3)]	Force Main[(4)]	Class 5 Estimate	Upper Range (+75%)	Lower Range (-40%)	Class 5 Estimate	Upper Range (+75%)	Lower Range (-40%)
RH-034_2 MG	RH-034	2	2	500' of 96"	500' of 12"	$ 9,644,430	$13,233,491	$ 1,564,828	$ 243,424	**$ 24,687,000**	$ 43,202,250	$ 14,812,200	**$ 12.34**	$ 21.60	$ 7.41
RH-034_4 MG	RH-034	4	4	500' of 96"	500' of 14"	$16,364,298	$13,756,027	$ 1,564,828	$ 247,371	**$ 31,933,000**	$ 55,882,750	$ 19,159,800	**$ 7.98**	$ 13.97	$ 4.79
RH-034_6 MG	RH-034	6	6	500' of 96"	500' of 16"	$23,084,165	$14,278,563	$ 1,564,828	$ 248,520	**$ 39,177,000**	$ 68,559,750	$ 23,506,200	**$ 6.53**	$ 11.43	$ 3.92
RH-034_8 MG	RH-034	8	8	500' of 96"	500' of 18"	$29,804,033	$14,801,098	$ 1,564,828	$ 258,740	**$ 46,429,000**	$ 81,250,750	$ 27,857,400	**$ 5.80**	$ 10.16	$ 3.48
RH-034_10 MG	RH-034	10	10	500' of 96"	500' of 20"	$36,523,901	$15,323,634	$ 1,564,828	$ 262,864	**$ 53,676,000**	$ 93,933,000	$ 32,205,600	**$ 5.37**	$ 9.39	$ 3.22
RH-034_12 MG	RH-034	12	12	500' of 96"	500' of 20"	$43,243,768	$15,846,170	$ 1,564,828	$ 262,864	**$ 60,918,000**	$106,606,500	$ 36,550,800	**$ 5.08**	$ 8.88	$ 3.05
RH-034_15 MG	RH-034	15	15	500' of 96"	500' of 24"	$53,323,570	$16,629,973	$ 1,564,828	$ 275,647	**$ 71,795,000**	$125,641,250	$ 43,077,000	**$ 4.79**	$ 8.38	$ 2.87
RH-034_17 MG	RH-034	17	17	500' of 96"	500' of 24"	$60,043,437	$17,152,509	$ 1,564,828	$ 275,647	**$ 79,037,000**	$138,314,750	$ 47,422,200	**$ 4.65**	$ 8.14	$ 2.79
OH-007_2 MG	OH-007	2	2	900' of 36"		$ 9,644,430	$13,233,491	$ 1,150,815		**$ 24,029,000**	$ 42,050,750	$ 14,417,400	**$ 12.01**	$ 21.03	$ 7.21
OH-007_4 MG	OH-007	4	4	900' of 36"		$16,364,298	$13,756,027	$ 1,150,815		**$ 31,272,000**	$ 54,726,000	$ 18,763,200	**$ 7.82**	$ 13.68	$ 4.69
OH-007_6 MG	OH-007	6	6	900' of 36"		$23,084,165	$14,278,563	$ 1,150,815		**$ 38,514,000**	$ 67,399,500	$ 23,108,400	**$ 6.42**	$ 11.23	$ 3.85
OH-007_8.2 MG	OH-007	8.2	8.2	900' of 36"		$30,476,020	$14,853,352	$ 1,150,815		**$ 46,481,000**	$ 81,341,750	$ 27,888,600	**$ 5.67**	$ 9.92	$ 3.40

Assumptions:

(1) Storage tank cost based on below ground storage facility. The construction cost accounts for the cost for excavation, sheeting and bracing, backfill, 3-inch-spacing coarse screening, automated flushing, instrumentation, and SCADA. Markups added for odor control, dewatering, and brownfields.

(2) Pumping cost based on submersible pump stations at a 50' depth below the ground surface using a one day pump out rate. The construction cost accounts for excavation, structure, piping, valves, pumps, electronics including variable frequency drives, control room, instrumentation, and site restoration. Markups added for construction in rock, grinders, dewatering, odor control, and brownfields.

(3) Opencut sewer cost for OH-007 based on 900 linear feet of 36" pipe at an average depth of 15' with 4 manholes. Opencut sewer cost of OH-034 based on 500 linear feet of 96" pipe at an average depth of 20' with 3 manholes. Markups added for dewatering, mainentance of flow, brownfields, traffic maintenance, and urban alignment. Street width of 30' used for calculations.

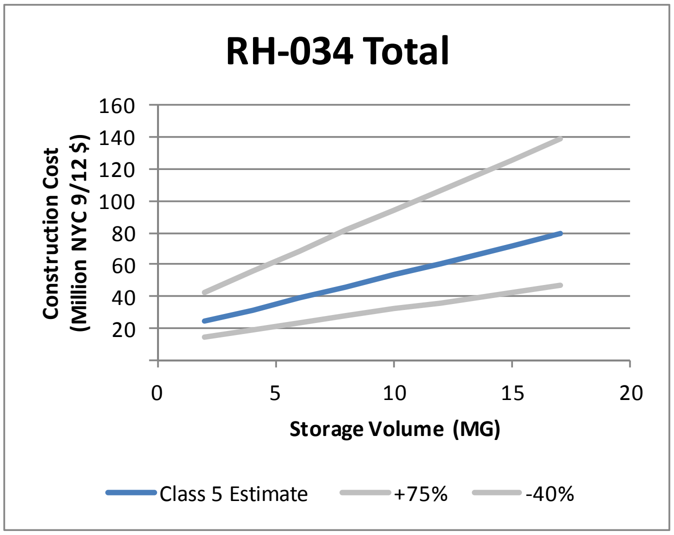
(4) Force main cost based on 500 linear feet of pipe with varying diameters at an average depth of 8' with 0 manholes and 0 air release valves. Pipe diameters calculated using Manning formula based on the peak flow rate of the storage pump, a pipe length of 500', a roughness coeffient of 0.012, an elevantion difference of 20', an inlet pressure of 5 PSI, and an outlet pressure of 0 PSI. Markups added for dewatering, brownfields, and traffic maintenance. Street width of 30' used for calculations.

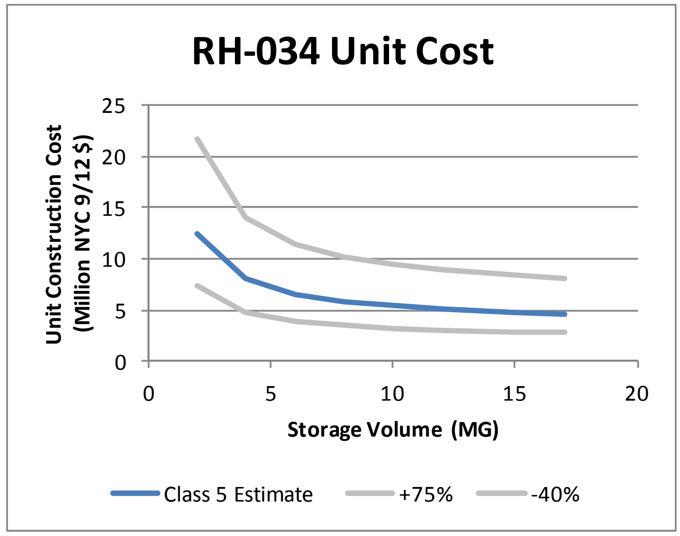
(5) The following are not included in the construction costs:

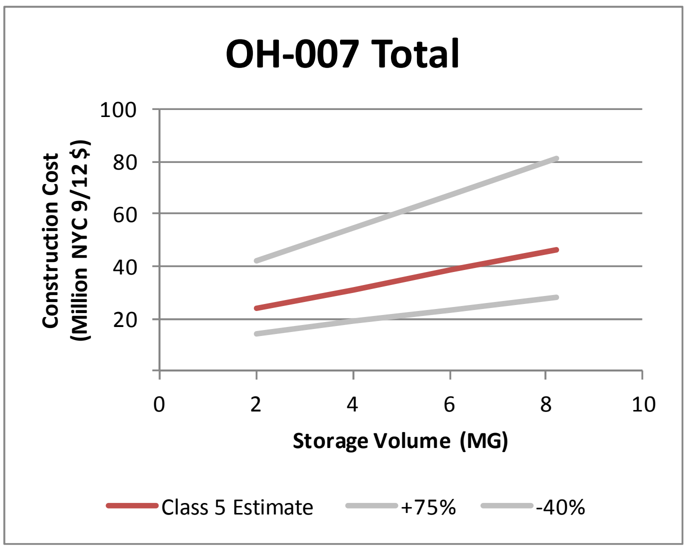
- Capital cost markups
- Property costs
- Demolition
- Rebuild of site surface
- Extra costs from unknown soil conditions
- Extra costs for staging and hauling
- Heavy dewatering costs involving ground-freezing

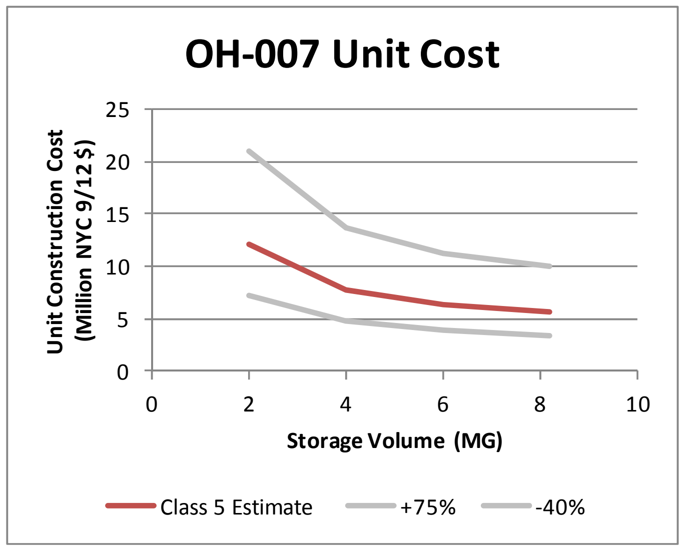
(6) These cost estimates are considered Class 5 - Planning Level estimates as defined by the American Association of Cost Engineering (AACE) and as designated in ASTM E 2516-06. They are considered accurate from +75% to -40% based on less than 2% of the complete project definition.

Class 5 Conceptual Construction Cost Curves with Upper and Lower Ranges

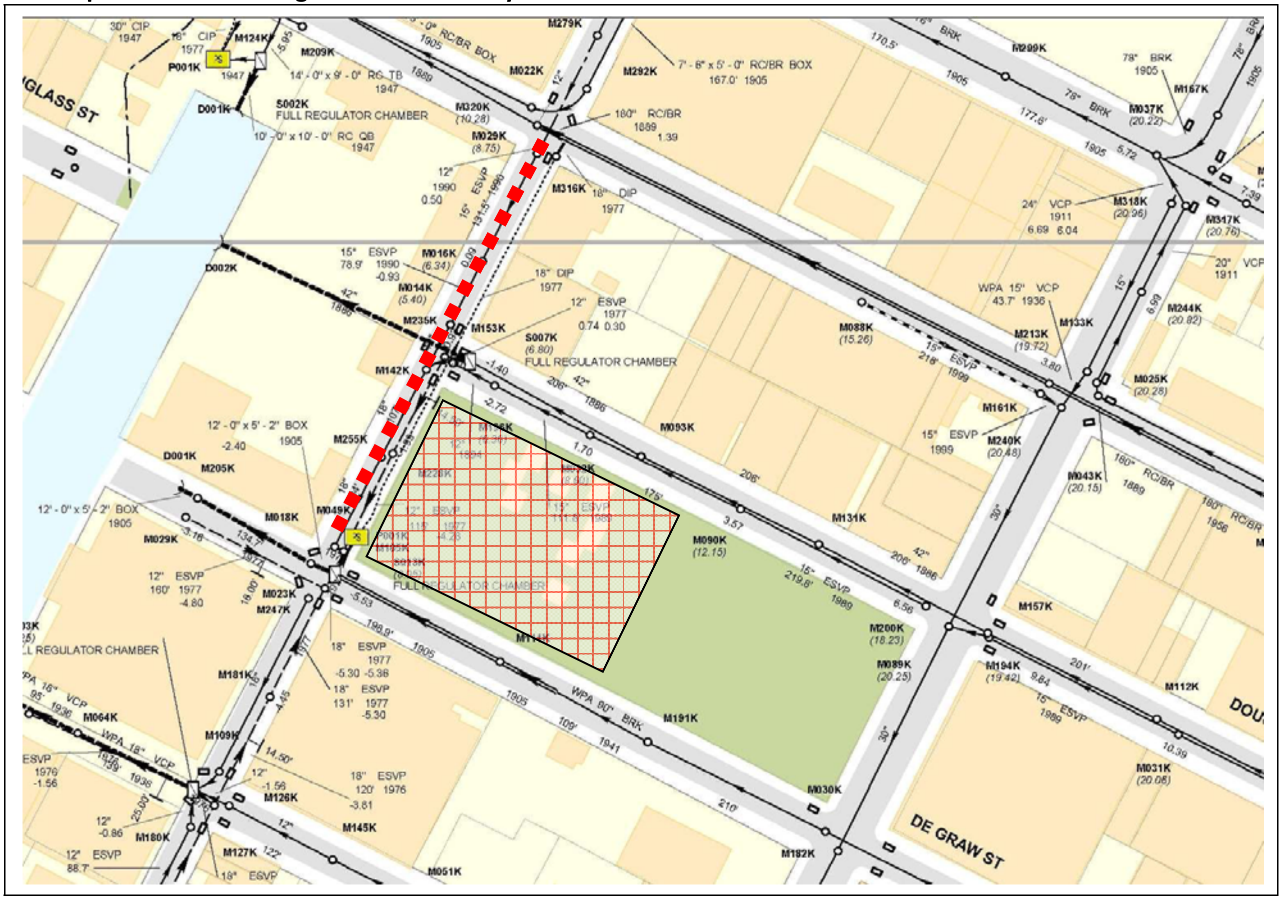






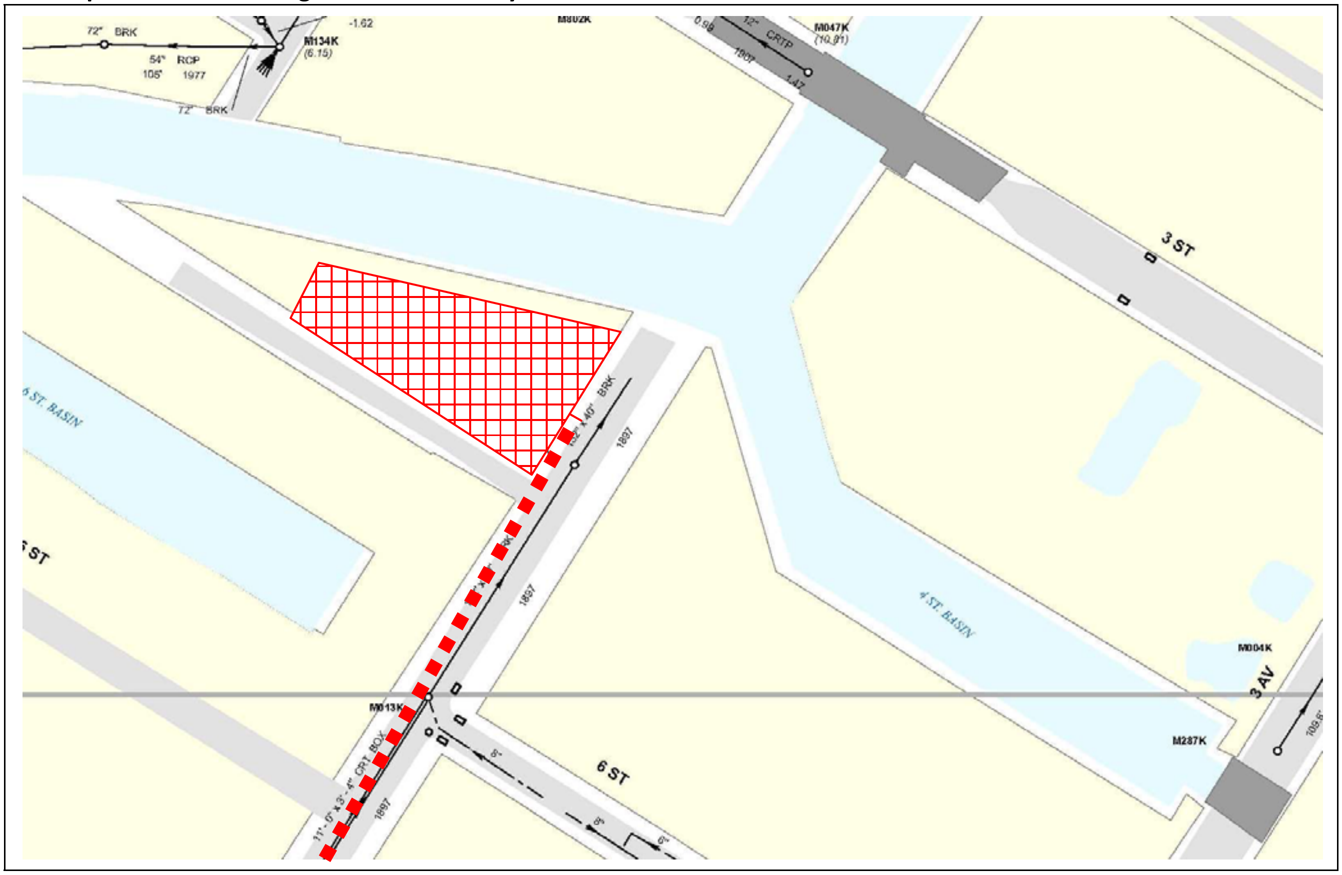


Conceptual RH-034 Storage Tank and Conveyance Location



Note: Red hashed area represents the conceptual footprint of the storage tank and the red dashed line represents the conceptual conveyance alignments for gravity sewers and force mains.

Conceptual OH-007 Storage Tank and Conveyance Location



Note: Red hashed area represents the conceptual footprint of the storage tank and the red dashed line represents the conceptual conveyance alignments for gravity sewers and force mains.

Excavation of Filled First Street Turning Basin Gowanus Canal, Brooklyn, New York

Prepared for

U.S. Environmental Protection Agency Region 2

Prepared under contract
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Architect and Engineering Services Contract
Contract No. 68-S7-04-01

Prepared by

CH2MHILL

Excavation of Filled First Street Turning Basin

Contents

1. Background

The former 1st Street basin was originally utilized to deliver coal via barges to the former Brooklyn Rapid Transit (BRT) Power House. The multi-building Romanesque Revival-style Power House complex was built in 1902 for the BRT, which operated various rail and streetcar lines in Brooklyn. The BRT was later incorporated into the New York City's (NYC) Transit system in 1940.

The Power House consumed large quantities of coal. During its operating era, large coal piles surrounded the building. As noted in the United States Environmental Protection Agency (USEPA)'s 2011 Archaeological Sensitivity Study:

> On the canal bank were a coal elevator and a cement coal pit, linked by tracks. A cement tunnel led from the coal pit to the larger boiler building. A note on the map described its operation: " Coal is fed automatically to boilers by chutes from coal pocket in roof of boiler ho[use]. Coal is carried to pocket by endless eye-bar cables and iron buckets through tunnel from coal pit."… By 1915… [a]dditional coalhandling equipment had been added canal-side.

The Power House's generating equipment underwent various modifications over time until the plant became obsolete and was removed from service. Based on aerial photographs, the 1st Street basin was filled between 1954 and 1966. The complex itself was 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 complex still standing. In 2012, the Power House was purchased for potential re-development as non-profit artist studios and display space.

Analytical data obtained during the remedial investigation at location MW-27 in the former 1st Street turning basin showed the existence of contamination in soil and groundwater above cleanup standards. As with other former basins along the Canal, it is believed that contaminated sediments within the 1st Street basin were left in place when the basin was filled in. In addition, there are indications that the fill itself may have included waste materials. The filled-in basin may also have been subject to later spills and dumping. The basin is hydraulically connected to the Canal, such that contaminants within the basin are an on-going source of contamination.

The 1st Street basin was also identified as an area of archaeological interest in USEPA's Archaeological Sensitivity Study. It is possible that a series of shipwrecks were buried in the 1st Street Basin when it was filled. One or more of the early mills and a burial site relating to the Battle of Brooklyn may also be located in the vicinity of the 1st Street basin.

This Technical Memorandum (TM) presents an evaluation of excavation of the 1st Street basin. Figure 1 shows the extent of the considered excavation.

2. Potential Excavation Approach

The filled-in former 1st Street turning basin is not a perfect rectangle, but the western 90% of the basin is somewhat rectangular and measures approximately 475 feet long by 50 feet wide. Thickness of filled in material is not certain, but native sediment in the canal near the former turning basin is at an elevation of approximately -18 ft NAVD88 (all elevations in this memorandum will be referenced to NAVD88). Ground surface elevation of the former turning basin is estimated to be +8 ft. The ground surface is vegetated with grass, brush, a few small trees, and asphalt. A fence is present along the southeastern side and half of the northeastern side of the property, and a large multistory brick building (known locally as the "Power Building") is present along most of the southwestern side.

Attachment A provides an assessment of potential shoring considerations for buildings and other areas along the perimeter of the former 1st Street basin, should the basin be excavated.

A potential excavation approach is described below and provides the basis for the estimated costs.

Prior to excavating the former turning basin, the area will be cleared and grubbed. Shoring will be installed using a land-based crane or similar installation equipment around the northeast, southeast, and southwest sides, which will be approximately 1,000 linear feet. Material removal will be performed as part of the sediment removal in remediation target area 1 (RTA1). Therefore, the equipment and methods will be as described in the Gowanus Canal Feasibility Study (FS) (USEPA, 2011) for the dredging of RTA1.

The final dredge depths for the canal adjacent to the former turning basin may be considered in deciding the excavation depth for the 1st street basin. If RTA1 is dredged to remove all soft sediment and then capped, the final cap elevation will be -14.5 ft. Maximum excavation depth in the former turning basin will be the same as RTA1. Assuming this final dredge depth, the final contour of the bottom of the former turning basin will be a 30-foot-wide center channel sloping up at a 4:1 (horizontal to vertical) ratio to the sides of the former turning basin. Approximately one-third of the way from the end of the former turning basin, the bottom would slope up at a 6:1 ratio so that existing grade is met.

Capping is assumed to be necessary in the former turning basin, so the existing cap for RTA1 will be extended over the footprint of the former turning basin. This cap would be 3.5 feet thick, and consists of 1.0 foot of oleophilic clay, 1.0 foot of sand and gravel, and 1.5 feet of cobbles. Note that since the cap thickness would be 3.5 feet, dredging will be done to an elevation of -18 ft in order to achieve a final elevation of -14.5 ft after capping (same as in RTA1).

Materials removed will be handled in the same manner as other dredged materials. They will be placed in a scow, and the scow will be transported to an upland staging area where free water will be pumped off and treated. Materials would then be transported in the same barge to a commercial dredge material transfer/treatment facility in New Jersey for stabilization prior to transport to an offsite landfill.

3. Restoration

Cap placement will extend over the entire footprint of the former turning basin, including the far southeastern end which will be above water. Consideration should be given to incorporating plantings that are appropriate for urban waterways, in order to establish submerged aquatic and emergent vegetation areas towards the southeastern end.

The moderate slope leading into the water at the southeastern end (6:1) will allow for local residents to launch canoes and other small recreational vessels. There should be sufficient permanent dry land to allow parking for a few vehicles as well.

4. Quantities

An estimated 25,000 cy^3 of materials would be removed from the former turning basin, dewatered, and disposed offsite at a landfill. The area of capping is estimated to be 24,000 square feet (sf^2). The area of submerged aquatic vegetation restoration is estimated to be between final elevations of -8 ft and -4 ft, and will be 2,200 ft^2. The area of emergent vegetation restoration is estimated to be between final elevations of -4 ft and 0 ft, and will also be 2,200 ft^2. Refer to Figure 2 for final elevations. The quantities include building shoring considerations as outlined in Attachment A.

5. Estimated Costs

Attachment B contains order-of-magnitude cost estimates that provide an accuracy of +50 percent to – 30 percent and are based on the quantities and assumptions presented in this TM.

6. Additional Benefits

In addition to addressing the contaminated source area, excavation of this turning basin would have several advantages:

(a) Contaminated materials present within the former turning basin could be removed, at least partially, and remaining contaminated materials could be left in place and capped.

(b) Shallow water habitat restoration could be incorporated to establish vegetative growth appropriate for an urban setting.

(c) Flood storage capacity within the canal would be increased.

(d) A boat launch can be constructed in the former turning basin so that members of the community can launch canoes or other shallow-draft recreational vessels.

7. Wetlands Mitigation

Excavation of the former 1st Street basin may provide an opportunity for mitigation of wetlands impacts that may be associated with the proposed cleanup. Wetlands impacts could arise from two actions under consideration: 1) a series of minor incremental intrusions into the Canal from cut-off walls and/or bulkhead restoration work; and 2) the construction of a confined disposal facility (CDF).

The Gowanus Canal FS included the potential use of a CDF as a disposal option for stabilized, lesser-contaminated dredged sediments. USEPA has identified a potential CDF location on privately owned property at the Gowanus Bay terminal on Columbia Street in Red Hook. A CDF could be constructed within an existing slip there or within other areas of the property. Lesser-contaminated, stabilized sediment could be placed in a specially-constructed CDF which would be filled and covered to match the existing ground surface elevation. More highly contaminated sediment removed from the canal would be stabilized and disposed offsite at a landfill or treated in a cogeneration facility and used elsewhere offsite.

8. References

Hunter Research, Inc. 2004. Final Report National Register of Historic Places Eligibility Evaluation and Cultural Resources Assessment for the Gowanus Canal, Borough of Brooklyn, Kings County, New York in Connection with the Proposed Ecosystem Restoration Study. Prepared by Hunter Research, Rabner Associates, and Northern Ecological Associates, December.

USEPA (U.S. Environmental Protection Agency). 2011a. *Draft Gowanus Canal Feasibility Study Report*. Prepared by CH2M HILL for USEPA Region 2. December.

Limit of Considered Excavation

0 50 100 Feet

Figure 1
Limits of Considered 1st Street Turning Basin Excavation
Gowanus Canal RI/FS
Brooklyn, New York

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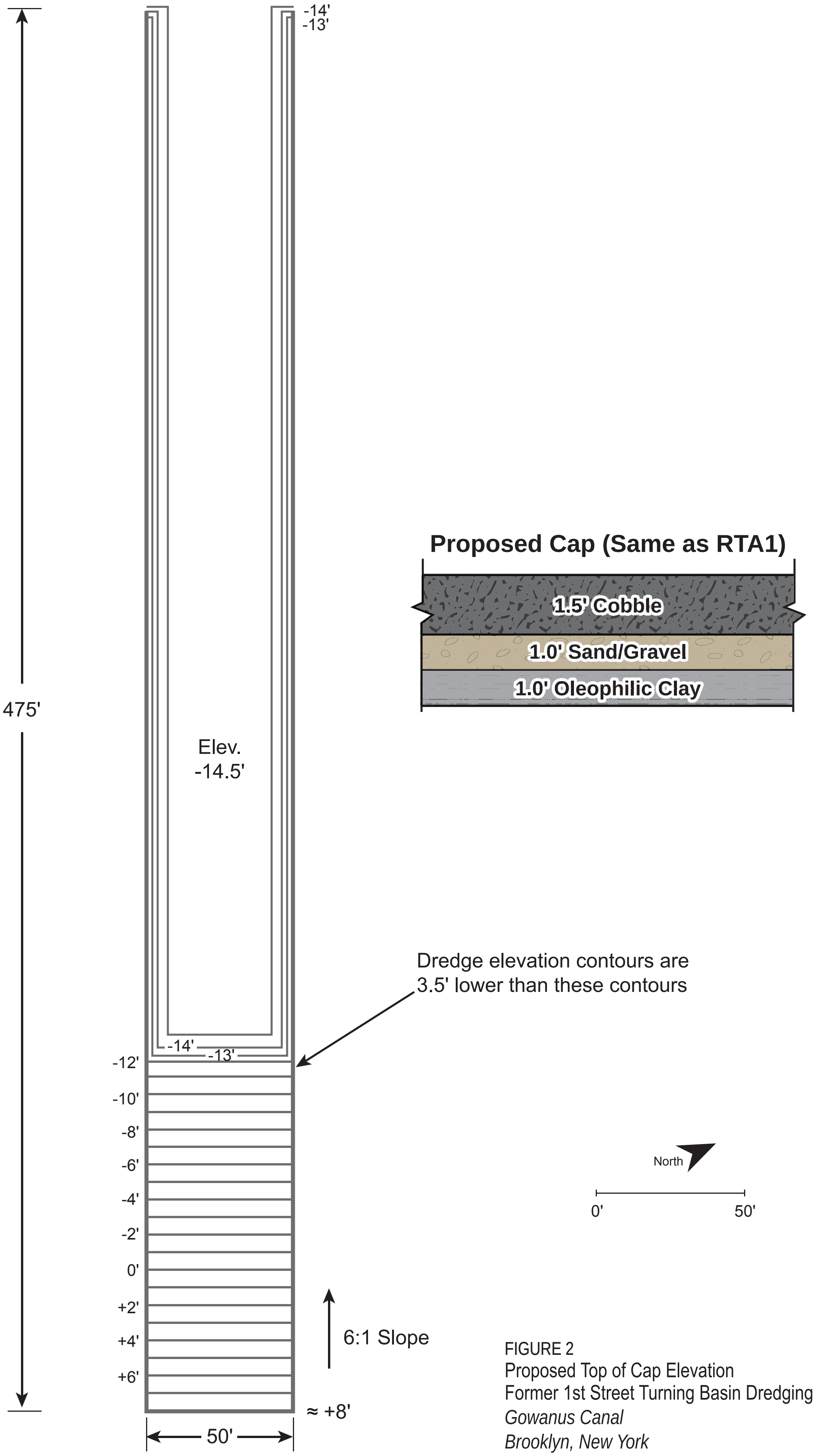

FIGURE 2
Proposed Top of Cap Elevation
Former 1st Street Turning Basin Dredging
Gowanus Canal
Brooklyn, New York

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Attachment A

Assessment of Potential Shoring Considerations for Buildings Along Filled First Street Turning Basin

Attachment A
Assessment of Potential Shoring Considerations for Buildings Along Filled First Street Turning Basin
Gowanus Canal, Brooklyn, New York

Contents

Introduction

The 1st Street turning basin is a 475 -foot-long by 50-foot wide side channel from the main Gowanus Canal channel.   It was presumably constructed in a manner similar to the main canal, including installation of bulkheads along the sides of the channel and excavating the area between the bulkheads to form a navigable turning basin.

In the early 1900's a power station building, referred to as the Power Building in this evaluation, was constructed adjacent to the southern side of the canal. The area between the western end of the building and the canal was used for coal storage.

The turning basin was filled between 1953 and 1965. The surface of the turning basin backfill is at approximate elevation +8 feet NAVD 88, the approximate elevation of the area surrounding the Power Building and adjacent properties. The type and total thickness of backfill is not certain, but native sediment in the Gowanus Canal near the former turning basin is at approximate elevation -18 NAQVD 88.

Considerations are given to excavating the 1st Stree basin.

The remainder of this evaluation addresses the potential impact on this and other buildings adjacent to the excavation and possible mitigation requirements that may be required.

Review of Existing Information

The evaluation of potential impacts included a review of the following information derived from an internet search:

- Figure 1 in this TM showing the limits of the considered excavation.

- A historical photograph showing the Gowanus Brooklyn Rapid Transit Power Station (e.g., current Power Building) as it looked in 1910.
- A BING Birdseye photographs showing the current Power Building and the surrounding area.
- Property maps dated 1886, 1904, 1915, 1938, 1950, and 1969 that show changes in the property and turning basin over a period of approximately 85 years.
- Two side-view photographs of the area taken from the Gowanus Canal during recent investigation activities.

A comparison of the 1886 and 1904 property maps indicate that the Gowanus Brooklyn Power Station was constructed prior to 1904. It consisted of two connected buildings, including a 200-foot by 130-foot (approximate) turbine building and a 200-foot by 95-foot (approximate) boiler building that contained the steam boilers and two smoke stacks. The northern edge of the boiler building appears to have been about 20 feet from the southern edge of the turning basin. The 1910 photograph shows the configuration of the Power Station, including the two buildings, the coal yard between the Power Station and the Gowanus Canal, and the 1st St turning basin in the background. The 1904 through 1938 property maps show the same facility configuration, including a "Cement Tunnel" extending beneath the coal yard and the boiler building. This was most likely the tunnel used to transfer coal to the boilers.

The boiler building was apparently decommissioned and removed sometime after 1938 since the 1950 and 1969 property maps show only the turbine building (current Power Building) remaining on the property. The 1950 map shows the existing Power Building approximately 115 feet away from the edge of the 1st Street Turning Basin. The 1969 map does not show the turning basin, confirming that the turning basin had been backfilled prior to 1969.

Additional observations from the photographs and maps indicate the following:

- The existing fence behind the Power Building is located generally along the southern edge of the 1st St turning basin.
- An existing masonry building (Building 453:1 on Figure 1) is located at the intersection of the northwest corner of the turning basin and the Gowanus Canal with the southern edge of the building being along the northern edge of the turning basin and the southern edge of the building being adjacent to the adjacent to the eastern shoreline of the canal. The length of the building along the turning basin is approximately 110 feet.
- Approximately 20 linear feet of another existing building (Buiding 453:54 on Figure 1) is adjacent to the eastern end of the proposed excavation.
- Another building (Building 967:24) is located approximately 100 feet beyond the eastern end of the proposed excavation.
- A masonry wall with possible timber cribbing is present along the Gowanus Canal at the western edge of the Power Building property. This wall appears to turn inward along the southern edge of the 1st St turning basin. Apparent turning basin backfill, however, precludes observation of its extent.

Assessment

The information review indicates that the existing Power Building is approximately 115 feet from the southern edge of the turning basin. This indicates that the canal could be excavated to the full 26-foot depth without requiring shoring of the building itself. There is, however, a potential that the building could experience some vibrations during proposed sheet pile installation. There is currently insufficient subsurface, building construction, or building condition information to determine if, and to what extent, vibrations from sheet pile installation might have on the building.

The existing masonry building at the intersection of the 1st St turning basin and the Gowanus Canal (Building 453-1) could be adversely affected by vibration and undercutting with proposed excavation or dredging within the canal or turning basin unless appropriate protective measures are taken. The building is also close enough to the southern edge of the turning basin that vibrations from proposed sheet piling operations along that edge could also adversely affect the building if not properly controlled.

Approximately 20 feet of the southwestern corner of Building 243:54 could also be adversely affected by vibration and undercutting with the proposed excavation. Building 467:24, like the Power Building is far enough from the excavation that shoring would not be required. However, depending upon the building construction, it could be susceptible to damage by vibrations during sheet pile installation.

Possible Mitigation Measures

Excavation of materials upto a depth of 26 feet will likely require some form of shoring. With the exception of the portions of the excavation adjacent to Building 453:1 and Building 453:54, sheet pile shoring is assumed. Conventional driving or vibratory methods of installation, however, could also have an adverse affect on adjacent structures. There is currently a direct push technology which provides for sheet pile installation with minimal vibration. This technology is being used extensively in Asia and has been used to a lesser extent in the United States. Since little is currently known about the subsurface conditions and the presence or condition of existing retaining structures along the edge of the backfilled canal, the following shoring system has been assumed based on general engineering practice:

- Sheet piles installed to a depth of 40 to 50 feet (e.g. 1.5 to 2 times the max excavation depth) using the direct push method
- A steel waler at the top of the wall
- Tie-backs installed at 5-foot to 10-foot centers.

Excavation or dredging along Building 453:1 and at the corner of Building 453:54 will require substantially more shoring and/or underpinning to prevent damage to the buildings. The extent of shoring and/or underpinning is dependent upon the type and depth of the foundation system existing beneath the building and existing subsurface conditions.

Since nothing is known about the subsurface and foundation conditions at Buildings 453:1 and 453:54, it is assumed that the buildings are founded on spread footings and that a shoring system providing lateral support and containment of materials beneath the building will be required. The assumed shoring system is a cast-in-place secant pile wall with tiebacks which can also be installed with minimal vibration to the building. The conceptual system would consist of the following:

- A line of 4-foot-diameter secant piles along the perimeter of the building up to 60 feet long and spaced at 3.5-foot center to center
- A near-surface tie-back on each secant pile to limit ground movement to less than 1 inch deflection.

It should be noted that the actual shoring systems for the areas adjacent to and away from the buildings may vary depending upon actual site conditions and technologies available at the time of project development. Detailed geotechnical and structural evaluations will be required to define these conditions and the most applicable system for the conditions identified.

Estimated Costs

The costs estimated for the shoring of the excavation are based upon the following assumptions:

- The estimate includes only the shoring within the limits of the 1st St turning basin. It does not include the costs of shoring along the portion of Building 453-1 along the Gowanus Canal.
- Excavation may be as deep as 26 feet below the existing ground surface.
- The total perimeter length of shoring within the turning basin is approximately 1,000 linear feet, including:
  - 120 feet adjacent to existing buildings
  - 880 linear feet not adjacent to existing buildings
- Shoring adjacent to buildings include :
  - 60-foot-long and 4-foot-diameter cast-in-place secant piles spaced at 3.5 feet center to center (approximately 37 secant piles, or approximately 2,220 linear feet)
  - A tie-back on each secant pile (approximately 37 tiebacks)
- Shoring outside the limits of the building include:
  - Sheet piles to a depth of 50 feet (approximately 44,000 square feet of sheets)
  - Tie-backs at 5-foot-centers (approximately 177 each)
- Sheet piles will be installed and removed. Secant piles will remain in-place after construction.
- Bulkhead construction is assumed to be performed by others and costs are not included in this estimate.

Attachment B

Estimated Costs

TABLE 1
Cost Estimate for Removal of Material from Former 1st St Turning Basin
Gowanus Canal Feasibility Study
Brooklyn, New York

PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL	
1	Pre-Design Testing/Site Investigation//Design Costs	**Remedial Design and Pre-Design Sampling & Testing**	**1**	**LS**	**$ 444,482.21**				**$ 444,482**	
		Pre-excavation survey	1	DAY	$ 3,000.00	$3,000.00	$450.00	$150.00		
		Full-Scale Remedial Design (4% of Rer	1	LS	$ 293,921.47	$293,921.47	$44,088.22	$14,696.07		
		Coordination With Agencies/Stakehold	1	LS	$ 73,480.37	$73,480.37	$11,022.06	$3,674.02		
2	Includes all labor,equipment, & odc costs to complete pre-remedial site work	**Pre-Remediation Site Work**	**1**	**LS**	**$ 8,556.00**				**$ 8,556**	
		Chain-Link Fence (Temporary)	1,000	LF	$ 7.13	$7,130.00	$1,069.50	$356.50		PER MEANS 01 56 26.50.0100
3	Includes all labor,equipment, & odc costs for project long facility costs	**Facility Costs**	**2**	**MO**	**$ 139,020.00**				**$ 278,040**	
		Office Facilities	2	MO	$ 5,200.00	$10,400.00	$1,560.00	$520.00		ALLOWANCE: (2) Trailers
		Jobsite Sanitation	2	MO	$ 750.00	$1,500.00	$225.00	$75.00		PER MEANS 01 56 26.50.0020
		Site Security	2	MO	$ 5,400.00	$10,800.00	$1,620.00	$540.00		PER MEANS 31 22 16.10.0010
		Site Utilities	2	MO	$ 4,500.00	$9,000.00	$1,350.00	$450.00		ALLOWANCE: Phone/Power/Misc
		Temporary Storage Area (10 Acres)	2	MO	$ 100,000.00	$200,000.00	$30,000.00	$10,000.00		ALLOWANCE: (3) Conex Boxes
4	Includes all labor,equipment, & odc costs for shoring during excavation	**Upgrade and Restore Existing Bulkheads**	**1,000**	**LF**	**$ 5,301.40**				**$ 5,301,403**	
		Debris Removal	32	HR	$ 230.00	$7,360.00	$1,104.00	$368.00		
		Secant Piling Installation	2,200	LF	$ 175.00	$385,000.00	$57,750.00	$19,250.00		
		Secant Piling Tie Back Installation	37	EA	$ 5,000.00	$185,000.00	$27,750.00	$9,250.00		
		Sheet Piling Installation (Outside Bldg Limits)	44,000	SF	$ 65.00	$2,860,000.00	$429,000.00	$143,000.00		UNIT RATE INCLUDES SHEET PILE REMOVAL
		Tie Back Installation (Outise Bldg Limits)	177	EA	$ 5,000.00	$885,000.00	$132,750.00	$44,250.00		
		6" Submersible Pumps	1	EA	$ 50,000.00	$50,000.00	$7,500.00	$2,500.00		ALLOWANCE
		Crushed Stone Backfill	1,065	CY	$ 42.70	$45,475.50	$6,821.33	$2,273.78		PER MEANS 32 11 23.23.1513
5	Includes all labor,equipment, & odc costs for Turbidity Monitoring Activities	**Monitoring Costs - Short Term**	**1**	**LS**	**$ 25,152.00**				**$ 25,152**	
		Sample Collection Labor	2.00	MO	$ 5,280.00	$10,560.00	$1,584.00	$528.00		
		Air Monitoring	2.00	MO	$ 3,600.00	$7,200.00	$1,080.00	$360.00		
		Air Monitoring Sample Analysis	2.00	MO	$ 1,600.00	$3,200.00	$480.00	$160.00		
6	Includes all labor,equipment, & odc costs for Cap Placement	**Cap Placement**	**2,639**	**CY**	**$ 117.32**				**$ 309,594**	
		Clay Import	880	CY	$ 200.00	$175,925.93	$26,388.89	$8,796.30		PER MEANS 31 23 23.15.6000
		Sand Import	880	CY	$ 23.00	$20,231.48	$3,034.72	$1,011.57		PER MEANS 04 05 13.95.0200
		Gravel Import	880	CY	$ 28.00	$24,629.63	$3,694.44	$1,231.48		
		Armor Import	0	CY	$ 31.50	$0.00	$0.00	$0.00		PER MEANS 31 37 13.10.0011
		Material Placement-Equipment	7	DAY	$ 2,580.00	$17,020.83	$2,553.13	$851.04		
		Material Placement-Labor	7	DAY	$ 3,060.00	$20,187.50	$3,028.13	$1,009.38		
7	Includes all labor,equipment, & odc costs for Dewatering & Treating Dredge Cell Water	**Dewatering/Dredge Cell Water Treatment**	**8,000,000**	**GAL**	**$ 0.018**				**$ 147,986**	
		Temporary Structure	2	MO	$ 2,000.00	$4,000.00	$600.00	$200.00		
		Power/Electric	2	MO	$ 3,500.00	$7,000.00	$1,050.00	$350.00		
		Treatment System Operation	1,440	HR	$ 74.53	$107,321.31	$16,098.20	$5,366.07		
		Replacement Carbon	2,500	LBS	$ 2.00	$5,000.00	$750.00	$250.00		
8	Includes all labor,equipment, & odc costs for Confirmation Sampling/Surveys	**Confirmation Sampling/Surveys**	**1**	**LS**	**$ 16,200.00**				**$ 16,200**	
		Sample Collection Labor	1.00	DAY	$ 4,500.00	$4,500.00	$675.00	$225.00		
		Bathymetric Survey	3	DAY	$ 3,000.00	$9,000.00	$1,350.00	$450.00		

TABLE 1
Cost Estimate for Removal of Material from Former 1st St Turning Basin
Gowanus Canal Feasibility Study
Brooklyn, New York

PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL
9	Includes all labor,equipment, & odc costs for Sediment Removal via Mechanical Dredge	**Dredging: Sediment Removal**	**25,000**	**CY**	**$ 29.31**				**$ 732,871**
		Transfer Pump	31	DAY	$ 1,000.00	$31,250.00	$4,687.50	$1,562.50	
		Barge With Clamshell	31	DAY	$ 1,380.00	$43,125.00	$6,468.75	$2,156.25	
		Barge With Excavator	31	DAY	$ 800.00	$25,000.00	$3,750.00	$1,250.00	
		Scow	31	DAY	$ 180.00	$5,625.00	$843.75	$281.25	
		Scow	31	DAY	$ 180.00	$5,625.00	$843.75	$281.25	
		Scow	31	DAY	$ 180.00	$5,625.00	$843.75	$281.25	
		Superintendent	31	DAY	$ 1,566.45	$48,951.63	$7,342.75	$2,447.58	
		Tug Operator	31	DAY	$ 1,213.83	$37,932.20	$5,689.83	$1,896.61	
		Tug Operator	31	DAY	$ 1,213.83	$37,932.20	$5,689.83	$1,896.61	
		Tug Operator	31	DAY	$ 1,213.83	$37,932.20	$5,689.83	$1,896.61	
		Crane Operator	31	DAY	$ 1,362.13	$42,566.64	$6,385.00	$2,128.33	
		Equipment Operator	31	DAY	$ 1,362.13	$42,566.64	$6,385.00	$2,128.33	
		Dredge Laborer	31	DAY	$ 945.51	$29,547.30	$4,432.09	$1,477.36	
		Dredge Laborer	31	DAY	$ 945.51	$29,547.30	$4,432.09	$1,477.36	
		FOGM	31	DAY	$ 6,000.00	$187,500.00	$28,125.00	$9,375.00	
10	Includes all labor,equipment, & odc costs for Dewatering Dredged Material	**Dredging: Dewatering**	**1**	**LS**	**$ 69,162.91**				**$ 69,163**
		Dewatering Pump	31	DAY	$ 750.00	$23,437.50	$3,515.63	$1,171.88	
		Pump Fuel	31	DAY	$ 200.00	$6,250.00	$937.50	$312.50	
		Pump Laborer	375	HR	$ 74.53	$27,948.26	$4,192.24	$1,397.41	
11	Includes all labor,equipment, & odc costs for Transporting Dredged Material to Solidification Facility	**Dredging: Transport For Staging/Solidification**	**1**	**LS**	**$ 420,000.00**				**$ 420,000**
		Soil Transport	35,000	TON	$ 10.00	$350,000.00	$52,500.00	$17,500.00	
12	Includes all labor,equipment, & odc costs for Restoration	**Restoration**	**4,400**	**SF**	**$ 8.88**				**$ 39,072**
		Submerged Aquatic Vegetation	2,200	SF	$ 3.60	$7,920.00	$1,188.00	$396.00	
		Emergent Vegetation	2,200	SF	$ 11.20	$24,640.00	$3,696.00	$1,232.00	
13	Includes all labor,equipment, & odc costs for Sediment Solidification	**Offsite Landfill Disposal: Sediment Solidification (assumes 7.5% by weight**	**35,000**	**TON**	**$ 47.25**				**$ 1,653,750**
		Portland Cement	2,625	TON	$ 125.00	$328,125.00	$49,218.75	$16,406.25	
		Soil Mixing	35,000	TON	$ 30.00	$1,050,000.00	$157,500.00	$52,500.00	
14	Includes all labor,equipment, & odc costs for Transporting to Thermal facility	**Offsite Landfill Disposal: Transport & Disposal (assumes transport distance of**	**37,625**	**TON**	**$ 127.20**				**$ 4,785,900**
		Soil Transport & Disposal	37,625	TON	$ 106.00	$3,988,250.00	$598,237.50	$199,412.50	
					ESTIMATED COST				**$ 14,232,169**
						Contingency	**30%**		**$ 4,269,651**
						Construction Management/Oversight	**6%**		**$ 853,930**
						Project Management	**5%**		**$ 711,608**
					TOTAL COST				**$ 20,067,358**

NOTES:

1. The costs to acquire the former 1st Street turning basin property, if this is necessary, is not included in this estimate.

2. Support for protection of adjacent structures is not included in the estimate.

3. This estimate is being classified as an AACE Class 4 estimate. The accuracy range for this estimate is +50%/-30%.

4. Performance and Payment Bond costs are included in the contractor fee markup.

5. Costs for water treatment system mobilization and demobilization are not included - only incremental costs for O&M are included.

Supplemental Evaluation of Upland Sites Gowanus Canal, Brooklyn, New York

Prepared for

U.S. Environmental Protection Agency
Region 2

Prepared under contract
AES10 Task Order 072-RI-FS-02ZP
Architect and Engineering Services Contract
Contract No. 68-S7-04-01

Prepared by

CH2MHILL

Supplemental Evaluation of Upland Sites[1]

The Remedial Investigation (RI) of the Gowanus Canal included an evaluation of the potential for contaminated groundwater discharge to the canal to recontaminate canal sediments following implementation of the selected remedy. This evaluation was based on groundwater sample data from 91 monitoring wells (including 42 shallow and intermediate well pairs) situated on upland properties along the canal. The RI Report (USEPA, 2011a) presents the results of the soil and groundwater samples collected from these locations (see Appendix O of the RI Report, Upland Investigation Summary).

The United States Environmental Protection Agency (USEPA) analyzed the data to determine whether contaminated groundwater discharge to the canal could potentially lead to sediment recontamination. This evaluation was performed by calculating Equilibrium-partitioning Sediment Benchmark (ESB) Toxic Units (TUs) for polycyclic aromatic hydrocarbons (PAHs) in each groundwater sample collected along the canal during the RI. Appendix B of the FS report (USEPA, 2011b) describes the approach used to calculate the TUs. Briefly, the TUs were calculated by comparing PAH concentrations in groundwater samples to their corresponding Final Chronic Values (FCV) based on USEPA's National Water Quality Criteria (USEPA, 2003). These FCVs represent the concentrations of the PAHs in water that are considered to be protective of the presence of aquatic life. Locations with TUs of less than 1 were considered to pose no potential for sediment recontamination. Locations with TUs between 1 and 10 were considered to pose minimal potential for sediment recontamination. Locations with TUs above 10 were identified as a concern.

The locations with TUs indicating a concern for sediment recontamination are shown in Table 1 and Figures 1 and 2 below. Based on this analysis, USEPA identified 16 locations that may represent ongoing sources of contamination to the Canal via groundwater discharge. In general, these sources are considerably smaller than the three former manufactured gas plant (MGP) source areas.

Of the 16 locations, six may be related to one or more of the three former MGP sites (Fulton, Public Place, and Metropolitan). Three additional locations are already being addressed within New York State's Brownfields or Spills programs. The remaining 6 locations are considered previously unidentified potential upland source areas. It should be noted that in some instances, contamination beneath a property may have migrated from another area. One of the six locations, the filled-in former 1st Street Basin, will be addressed under USEPA's proposed remedy for the Canal. The remaining five locations have been referred to the New York State Department of Environmental Conservation (NYSDEC) so that they can be addressed by the

[1] Supplement to Appendix O of the Gowanus Canal Remedial Investigation Report and Appendix B of the Gowanus Canal Feasibility Study Report

appropriate State program. Remediation schedules will be coordinated with the schedule for the Gowanus Canal remedy.

Because the upland contamination source areas which may impact groundwater have been referred to NYSDEC for investigation and remediation, if necessary, USEPA believes that no additional components of a separate groundwater remedy are required as part of the overall remedy for the Gowanus Canal.

References:

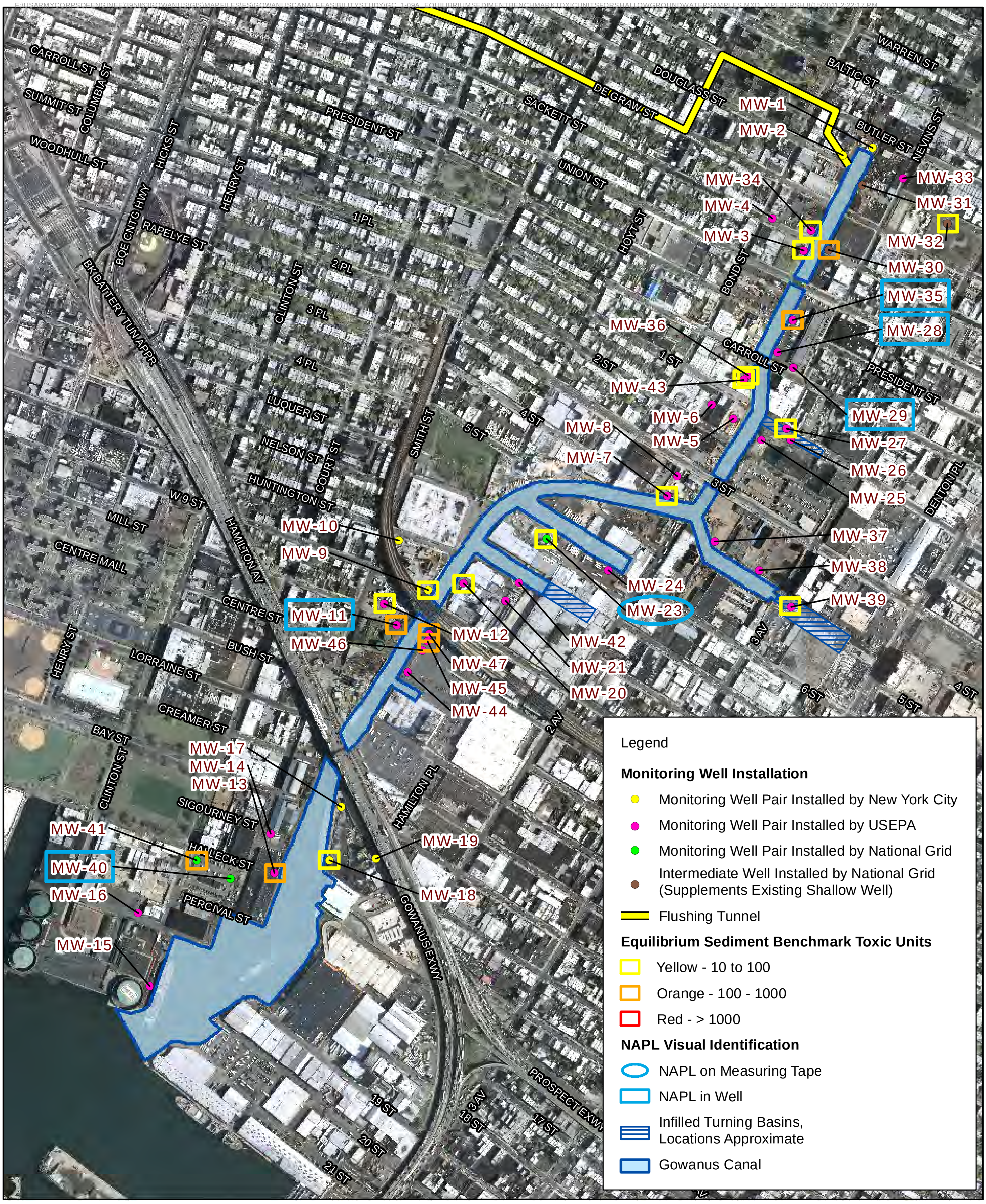
USEPA (U.S. Environmental Protection Agency). 2011a. *Draft Gowanus Canal Feasibility Study Report*. Prepared by CH2M HILL for USEPA Region 2. December.

USEPA (U.S. Environmental Protection Agency). 2011b. *Draft Gowanus Canal Remedial Investigation Report*. Prepared by HDR, CH2M HILL and GRB Environmental Services Inc. for USEPA Region 2. January.

USEPA. 2003. *Procedures for the Derivation of Equilibrium Partitioning Sediment Benchmarks (ESBs) for the Protection of Benthic Organisms: PAH Mixtures*. EPA-600-R-02-013. Office of Research and Development. Washington, D.C.

Table 1 Upland Sites - Toxic Units			
Property Address	**Monitoring Well**	**PAH Toxic Units**	**Monitoring Well Installed By**
New Location: MLV Concrete 160 3rd St.	MW-7I	> 1000	USEPA
491 Smith St.: May be Public Place-related	MW-9I	100-1000	NYC
503-537 Smith St.: May be Public Place-related	MW-11S	100-1000	USEPA
	MW-11I	> 1000	USEPA
627 Smith St.: Former Barrett Mfrg. -in NYSDEC Brownfields program	MW-13S	100-1000	USEPA
	MW-13I	100-1000	USEPA
New location: NYCDEP - Hamilton Ave. Asphalt Plant – may be existing DEC Spill site	MW-18I	100-1000	NYC
New location: B&A 9th St. Warehouse	MW-20I	100-1000	USEPA
National Grid: 6th St. Basin: May be Public Place-related	MW-23I	100-1000	National Grid
Filled In 1st St. Basin: Part of EPA canal remedy	MW-27I	100-1000	USEPA
National Grid: Fulton Site: May be Fulton MGP-related	MW-30S	100-1000	National Grid
	MW-30I	100-1000	National Grid
	MW-31I	100-1000	National Grid
	MW-32I	100-1000	National Grid
Nevins St. & Douglass St.: May be part of Fulton MGP	MW-33I	100-1000	USEPA
New location: Bayside Fuel, 495 & 510 Sackett St. Prior DEC Spill/VCP application	MW-34I	100-1000	USEPA
Verizon 318 Nevins St.: existing DEC Spills program	MW-35S	100-1000	USEPA
	MW-35I	100-1000	USEPA
400 Carroll St.: Existing DEC Spills program, potential EPA cleanup order	MW-36I	100-1000	USEPA

Table 1 Upland Sites - Toxic Units			
Property Address	**Monitoring Well**	**PAH Toxic Units**	**Monitoring Well Installed By**
New location, former 5th Street Basin U-Haul, 403 3rd Ave.	MW-39I	100-1000	USEPA
New location, National Grid, Smith St. – possibly related to 627 Smith St.	MW-41S	100-1000	National Grid
118 2nd Ave.: May be related to Metropolitan or Public Place MGPs	MW-45S MW-45I	100-1000 100-1000	USEPA USEPA
	MW-47S MW-47I	100-1000 100-1000	USEPA USEPA



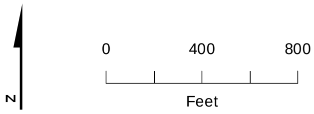


FIGURE 1
Equilibrium Sediment Benchmark Toxic Units for Shallow Groundwater Samples
Gowanus Canal Feasibility Study
Brooklyn, New York

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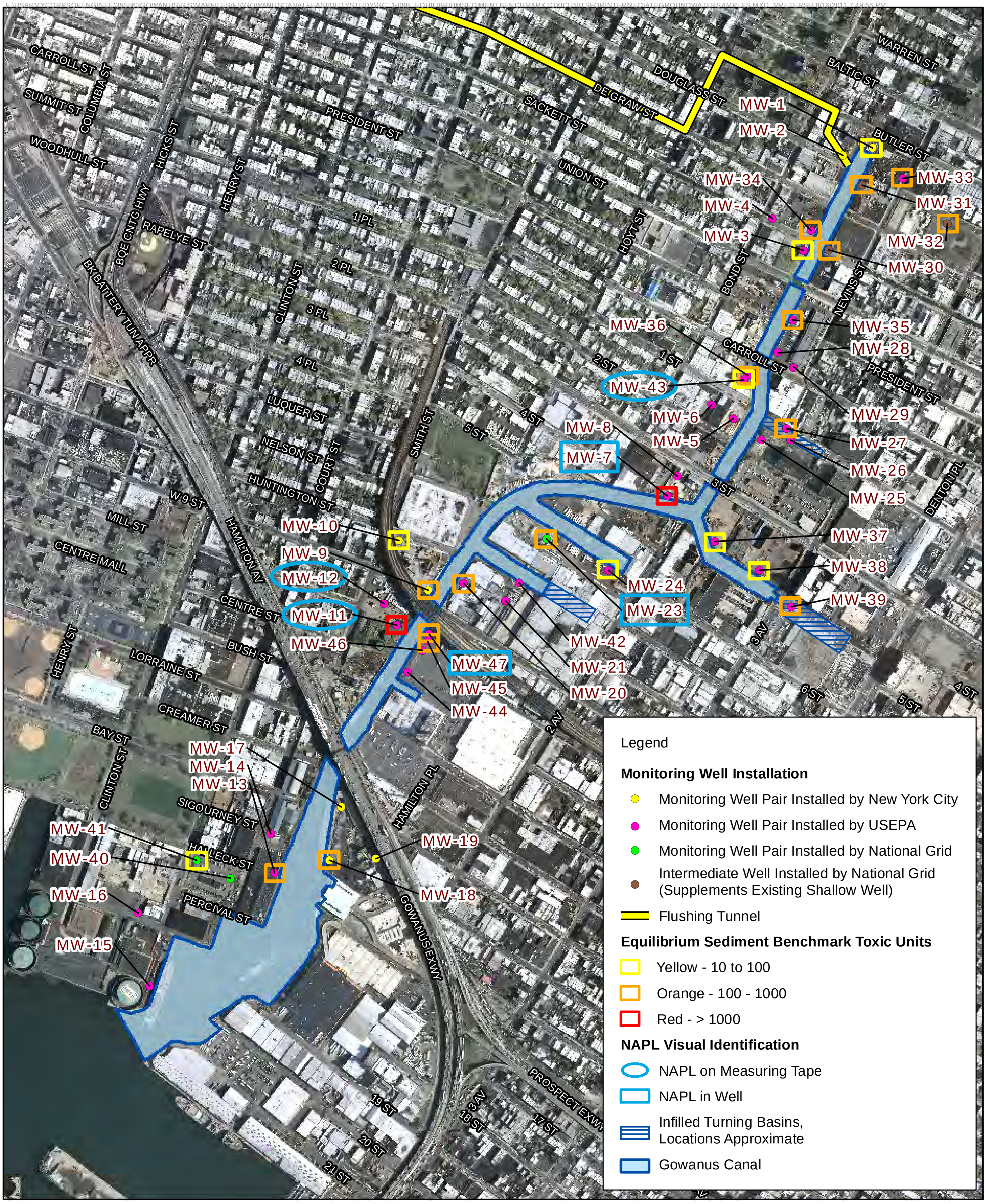

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FIGURE 2
Equilibrium Sediment Benchmark Toxic Units for Intermediate Groundwater Samples
Gowanus Canal Feasibility Study
Brooklyn, New York

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Revised Cost Estimate for Preferred Remedial Alternatives Gowanus Canal, Brooklyn, New York

Prepared for

U.S. Environmental Protection Agency
Region 2

Prepared under contract
AES10 Task Order 072-RI-FS-02ZP
Architect and Engineering Services Contract
Contract No. 68-S7-04-01

Prepared by

CH2MHILL

Revised Cost Estimate for Preferred Remedial Alternatives

Contents

Summary

This technical memorandum (TM) presents updated detailed cost estimates for the Gowanus Canal. These include: updated costs from the Gowanus Canal Feasibility Study (FS); costs for excavation of the 1st Street basin (details on the basis for these costs are presented in a separate TM included as a section in this FS addendum); and costs for providing storage tanks at Combined Sewer Overflows (CSOs) RH-034 and OH-007 (also presented in a separate TM included as a section in this FS addendum).

The cost estimates for the Gowanus Canal are based on the assumptions outlined in Section 4 of the FS Report (specifically, Table 4-4) and were prepared using USEPA's *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study* (USEPA, 2000). These estimates reflect an accuracy of +50 percent to -30 percent.

The initial cost estimate presented in the FS included present worth values based on real discount rates from Appendix C of the Office of Management and Budget (OMB) Circular A-94, Appendix C (revised December 2010). The 30-year value of 2.3 percent was initially selected since any operations and maintenance (O&M) durations are assumed to be over 30 years. The revised costs presented herein utilize a 30-year value of 7 percent.

All other support information outlined in the FS related to estimated costs remains as presented in the FS.

The basis for the estimated costs for the excavation of the 1st Street basin and the storage tanks at CSOs RH-034 and OH-007 are described in the respective TMs. The costs for the storage tanks reflect the following tank sizes: 8 million gallon tank at RH-034 and 4 million gallon tank at OH-007.

This technical memorandum contains the following tables:

TABLE 1	Summary of Detailed Components and Key Assumptions for Basis of Estimate
TABLE 2a	Summary of Alternative, Disposal, and O&M Costs by RTA
TABLE 2b	Summary of Representative Total Cost Ranges
TABLE 3	Summary of Sediment Volumes Removed, Capping Material Quantities, and In Situ Solidification Areas in Alternatives 5 and 7
TABLE 4	Prevailing Wage Rates for 07/01/2011 through 06/30/2012 (New York State Department of Labor)
TABLE 5a	Alternative 5 Base Implementation and Removal Costs
TABLE 5b	Alternative 7 Base Implementation and Removal Costs
TABLE 6a	Treatment and Disposal Costs by RTA
TABLE 6b	Base Implementation Costs for Onsite Stabilization (Disposal Options E and G)
TABLE 7	Long-Term Sediment Cap O&M
TABLE 8	Confined Disposal Facility O&M (Disposal Options F and G)
TABLE 9	Long-Term O&M Costs for Onsite Stabilization and Beneficial Use Disposal (Option E)

Table 1 lists detailed components (also presented as Table 4-4 of the FS) and any associated assumptions that were integral to the cost estimates. The unit rates and quantities used are provided in the estimate tables for each alternative.

References:

OMB (Office of Management and Budget). 2011. Memorandum for the Heads of Departments and Agencies: 2011 Discount Rates for Circular No. A-94. Revised December 2010. February.

USEPA. 2000. *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*. EPA 540-R-00-002/OSWER 9344.0-75. July.

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USEPA. 2000. *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*. EPA 540-R-00-002/OSWER 9344.0-75. July.

TABLE 1
Detailed Description of Components for Alternatives 5 and 7
Gowanus Canal Feasibility Study
Brooklyn, New York

Base Component and Sequence	Key Differences Between Alternatives 5 and 7
Source Control Measures	
Upland sources of contamination to the canal, including NAPL and groundwater contamination are addressed to prevent recontamination of the canal. Contaminant contributions from CSOs and other pipe outfalls are reduced or eliminated. Source control measures are in the process of being developed and the source control strategy is included by reference in this FS. Specific source control measures that would support the sustainability of the sediment remedy include: – Sealing pipe outfalls to the canal. The existing pipe outfalls should be reviewed to identify those that are not permitted to discharge to the canal. Pipe outfalls that are not permitted should be sealed to prevent continuing contaminant releases to the canal. – Controlling PAH- and metal-containing discharges of suspended solids from CSOs. Examples of methods that can be used to reduce or eliminate the discharge of CSO solids include deep tunnels or retention tanks to temporarily store discharges during storms.	NA
Institutional Controls	
Institutional controls would be implemented to specify limitations on anchoring, mooring, dredging, and construction to minimize damage to cap. Institutional controls will also need to be implemented for any disposal and treatment options that include onsite disposal or beneficial use of dredged and treated sediments.	NA
Predesign Sampling and Testing	
Collect sediments for treatability testing to determine appropriate reagent mixes required to stabilize sediment ex situ. Perform additional waste characterization testing to determine disposal requirements for dredged materials (may vary from one reach of canal to another). Perform any additional characterization needed to support the remedial design. Perform bathymetric survey to determine sediment surface elevation for design purposes	NA
Remedial Design	
Identify beneficial uses for treated sediment and identify end-use requirements. Perform treatability testing and pilot testing for ex situ treatment options (e.g., solidification/stabilization, thermal treatment, and cogeneration).	Alternative 7 would require treatability testing and pilot

TABLE 1
Detailed Description of Components for Alternatives 5 and 7
Gowanus Canal Feasibility Study
Brooklyn, New York

Base Component and Sequence	Key Differences Between Alternatives 5 and 7
Perform inspections to evaluate condition of bulkheads. Complete full-scale remedy design and identify appropriate subcontractors and vendors for implementation. Coordinate with agencies and stakeholders (USEPA, USACE, NYSDEC, New York City, PRPs, property owners along the canal, et al.). Identify staging areas—this FS assumes that a staging area will be identified near the mouth of the canal.	testing for in situ solidification/ stabilization.
Preremediation Site Work	
Construct any temporary access roads needed and fencing/security around staging area(s). Prepare upland staging area (site offices, parking areas, equipment storage area, and sanitation facilities). Prepare docking/staging areas for barges and work boats. Establish required vertical control points and tide gages. Perform preremediation bathymetry survey to confirm current conditions. Set up temporary onsite water treatment system with estimated 750 gpm capacity that would include an influent holding tank, mixing tank, inclined plate clarifier, sand filters, GAC filters, effluent holding tank, and filter presses (area 100 ft × 200 ft). This FS assumes that this treatment system would be on land, adjacent to the canal. This treatment system would treat water pumped out of remedial cells once work in the cells is completed, as well as water pumped off of barges before they are transported offsite for treatment. Discharge would be to Gowanus Bay and would need to meet ARARs. Set up temporary onsite solidification/stabilization facility, if required for the selected disposal option(s). This facility would be approximately 2 acres and would include a docking area to stage and offload barges, a vibratory grizzly screen/feeder module, a pugmill, a radial conveyor to move stabilized sediment into discrete piles and adequate reagent storage. Space for haul roads and stabilized sediment storage would also be included. This FS assumes that this facility would be on land, adjacent to the canal. This facility would process dredged, dewatered sediment prior to onsite beneficial use or disposal in an onsite CDF. This FS assumes a facility that can process 800 yd^3 of dredged material per day on average to maintain projected removal rates. Preremediation site work would take approximately 12 weeks.	NA
Debris Removal	
Debris removal will be performed as part of the sediment removal; additional detail is presented in that section.	NA

TABLE 1
Detailed Description of Components for Alternatives 5 and 7
Gowanus Canal Feasibility Study
Brooklyn, New York

Base Component and Sequence	Key Differences Between Alternatives 5 and 7
Upgrading/Restoration of Existing Bulkheads	
Existing bulkheads identified as degraded during predesign surveys would require replacement, repair, or reinforcement prior to remedy implementation to prevent failure during sediment removal.	NA
Total canal shoreline is approximately 21,000 LF (RTA 1: 4,600 ft; RTA 2 and turning basins: 11,100 ft; and RTA 3: 5,200 ft).	
Assume bulkhead installation would include targeted debris removal, installation of sheet piling, installation of tieback anchors, and backfill behind the sheet piling with crushed stone. In RTAs 1 and 2, the sheet piling would be installed to a depth of 10 feet into native sediment (cap thickness of 3 feet would result in ~13 feet of sediment at the base of the sheet piling). For purposes of the FS, assume that sheet piles would be 35 feet long. In RTA 3, assume that 50-ft-long sheets are required. Assume 80% of the bulkheads require replacement in each RTA.	
Assume two sheet piling installation operations proceed simultaneously and can install 30 LF/day each, for a total of 60 LF/day. Estimated duration is 280 days to install 16,800 LF (80% of 21,000 LF).	
Installation and Removal of Sheet Pile Cells	
Sheet piling would be installed down the middle of RTA 1 and would extend to the sides of the canal to create remedial cells.	NA
Six separate cells would be used to remediate RTA 1—one cell at a time would be remediated. Each cell would be approximately 750 ft long; after the southeast side of the canal is remediated, the sheet piling dividing the middle of the canal would be left in place, and the northwest side of the canal would be remediated. Sheet piling would then be extracted and installed further down the canal.	
Within RTA 1, due to the shallow water depths at the head of the canal, work may be sequenced to progress from the downstream to upstream to allow work to proceed throughout the tidal cycle.	
Sheet pile cells would be installed within RTA 2 using the same means and methods as described for RTA 1, with the following differences: – The turning basins each are treated as an individual remedial cell and would be created by installing sheet piling at the confluence of the basin(s) with the canal. – A total of 12 separate cells are assumed to be used for RTA 2 for the purposes of this FS: four turning basin cells and eight cells along the canal (four on each side). – The turning basins would be remediated first, followed by the southeast side of the canal, and then the northwest side of the canal. – The remedial design would address management of the gas line crossing in RTA 2.	
Installation and extraction of sheet piling would be performed using a vibratory hammer/extractor; no impact driving would be necessary.	

Base Component and Sequence	Key Differences Between Alternatives 5 and 7
Sheet piling would be used to contain turbidity and NAPL release during remedial activities, but would not be designed to withstand differential head pressures created by lowering water within the cell (except for up to 5 feet differential due to tidal fluctuation). Sheet pile wall joints would not need to be completely watertight because no significant pressure differential would exist. Overflow weirs would be cut into the top of the sheet pile wall to allow water to flow from the remedial cell during times of extreme flow to prevent upland flooding. Overflow weirs would be designed to trap oil sheens and allow them to be captured during remedial activities. Sheet piling would not be utilized or installed in RTA 3 because the potential for NAPL release is much lower and sheet piling would interfere with the federal navigation channel. Turbidity concerns would be managed with silt curtains. It is assumed that RTA 3 would be divided into three dredge units or dredge management areas. For the purposes of this FS, it is assumed that 1,500 LF of silt curtain to a depth of 30 ft would be used to control turbidity in RTA 3.	
Sediment Removal	
Large debris and obstructions would be removed from sediment using mechanical means (e.g., barge-mounted long-reach excavators). Larger debris, such as the sunken barge in the 6th Street turning basin, may require removal using a crane and clamshell bucket. Debris removal would be done within each enclosed remedial cell in order to control sheens and turbidity. All soft sediment would be removed using mechanical dredging (e.g., dredge to native sediment surface). A standard clamshell dredge bucket is assumed to be used in RTAs 1 and 2 because the work would be done inside an enclosed remedial cell. Scows for material transport would be staged outside of the remedial cell, and the dredge bucket would be swung over the sheet pile wall to place the dredged material in the material scow. RTA 3 would be dredged using an environmental bucket because enclosed sheet pile cells would not be used. In the turning basins, a two-step sediment transfer process would be performed. Dredged sediment would be placed in a scow within the turning basin; when full, it would be pushed over to the sheet pile wall, and dredged material would be hydraulically pumped into an empty scow on the canal side of the sheet piling. The sediment removal volumes and durations are estimated to be: RTA 1—82,000 yd^3/3.5 months; RTA 2—225,000 yd^3/ 9.5 months; and RTA 3—281,000 yd^3/ 12 months. The removal durations were determined using the assumption that work would be performed 12 hours/day, 7 days/week, and that a production rate of 800 yd^3/day would be achieved.	NA
Sediment Dewatering	
Dredged sediment would be transported in the scow over to the onsite staging area.	NA

Base Component and Sequence	Key Differences Between Alternatives 5 and 7
Free water on top of the sediment would be pumped out of the scow and treated at the onsite temporary water treatment system before being discharged to Gowanus Canal or Gowanus Bay. Eighty gallons of free water are assumed to be generated per cubic yard of sediment removed (or 64,000 gallons of water per day). This assumption is applied to all three RTAs. For the disposal options that include offsite stabilization, the dewatered sediment would then be transported in the same barge to a commercial dredge material transfer / treatment facility in New Jersey for stabilization prior to transport by barge back to the site for placement in the onsite CDF, or transport by truck to offsite landfill and treatment facilities, or to beneficial-use locations. If disposal options utilizing an onsite stabilization facility are selected, the dewatered sediment would be transferred to the temporary onsite facility for stabilization prior to placement in the onsite CDF or onsite beneficial use. ***In Situ Stabilization*** After the soft sediment has been removed and prior to cap placement, ISS would be performed on the remaining native sediment in targeted areas. The reagents would be delivered using barge-mounted deep-soil augers. Reagents would be delivered to a depth of 5 ft below the dredge surface. Pilot testing is needed to determine the appropriate reagents and dosage for the canal, but for purposes of this FS it is assumed 15% by weight reagent would be used for solidification, and the reagent itself would be 75% blast furnace slag (BFS120) and 25% portland cement. The proposed areas to be treated with ISS are: – RTA 1—60,000 ft^2 – RTA 2—190,000 ft^2 – RTA 2—4th Street and 6th Street turning basins—50,000 ft^2 – RTA 2—7th Street turning basin—30,000 ft^2 A production rate of approximately 1,400 ft^2 per day has been assumed for this cost estimate. The cost estimate assumes two delivery platforms will be working simultaneously, 12 hours/day, 7 days/week.	ISS is only a component in Alternative 7. This component is not included in Alternative 5.
Sediment Capping Upon completion of the removal of the soft sediment (Alternative 5) or upon completion of ISS (Alternative 7), a three-layer cap would be placed in RTAs 1, 2, and 3.	Cap would be placed after

TABLE 1
Detailed Description of Components for Alternatives 5 and 7
Gowanus Canal Feasibility Study
Brooklyn, New York

Base Component and Sequence	Key Differences Between Alternatives 5 and 7
The conceptual cap design consists of 1 ft of granular oleophilic clay material, 6 inches of sand, 6 inches of gravel, and 1.5 ft of riprap armoring (9-inch average diameter) to prevent direct contact and NAPL migration from native sediments. In order to facilitate establishment of a benthic community, the FS assumes that approximately 6 inches of sand will be placed on top of the armor layer and allowed to fill the gaps between the stones. Based on conceptual cap design, approximately 8,000 yd^3 of clay (treatment layer), 4,000 yd^3 each of sand and gravel (isolation layer), and 12,000 yd^3 of riprap and 4,000 yd^3 of sand (armor layer) would be used for the cap in RTA 1; placement is expected to take approximately 80 days. Based on conceptual cap design, approximately 19,100 yd^3 of clay (treatment layer), 9,600 yd^3 each of sand and gravel (isolation layer), and 28,800 yd^3 of riprap and 9,600 yd^3 of sand (armor layer) would be used for the cap in RTA 2; placement is expected to take approximately 6 months. Conceptual cap design for RTA 3 consists of a 6-inch clay treatment layer, a 6-inch sand layer, a 6-inch gravel layer, and 1.5 ft armor layer. Based on conceptual design, approximately 13,600 yd^3 each of clay, sand, and gravel would make up the treatment and isolation layers. Approximately 40,700 yd^3 of riprap and 13,600 yd^3 of sand would be used for the armor layer; cap placement in RTA 3 expected to take approximately 8 months. Capping materials would be transported to the canal by barge. Capping materials would be placed using a broadcast spreader. A production rate of 400 yd^3 per 12-hour workday is assumed. Final cap design will be determined during remedial design.	dredging in Alternative 5. In Alternative 7, the cap would be placed after ISS is implemented.
Dredge Cell Water Treatment After sediment and cap placement is completed, the water within the dredge unit would be pumped out, treated at the onsite water treatment system, and discharged to the canal. It is assumed that two volumes of water would be pumped and treated from each dredge cell. Water would be pumped to the temporary water treatment facility through high-density polyethylene piping. Estimated treatment rate is 750 gpm. In RTA 1, approximately 63 million gallons of water would require treatment. This would be expected to take approximately 60 days. In RTA 2, approximately 160 million gallons of water would require treatment. This would be expected to take approximately 150 days.	NA

TABLE 1
Detailed Description of Components for Alternatives 5 and 7
Gowanus Canal Feasibility Study
Brooklyn, New York

Base Component and Sequence	Key Differences Between Alternatives 5 and 7
Dredge cells would not be constructed for RTA 3; therefore, this step is not applicable.	
Short-Term Monitoring (During Construction)	
Down-current turbidity monitoring would be performed with readings collected within the water column down-current of the work cell manually once every 3 hours (use of an automatic recording station may not be feasible due to concerns about vandalism). Sheens would be monitored visually. Assume collection of air samples for volatiles, semivolatiles, and PM_{10} (particulate matter with diameter greater than or equal to 10 µm) concentrations. Samples collected from four monitoring stations once per week.	NA
Confirmation Sampling	
Confirmation field surveys would be performed after dredging and before either cap placement or ISS implementation to verify that all soft sediment has been removed. Final bathymetric survey would be completed following verification of dredging completion via confirmation sampling to assure that all soft sediment has been removed. ISS confirmation sampling would consist of collecting sediment from within the ISS areas in Shelby tubes after stabilization and prior to cap placement. A collection frequency of one sample for approximately every 500–1000 yd^3 of treated material would be used. Samples would be analyzed for compressive strength, hydraulic conductivity, and leachability. Physical surveys would be performed after placement of each of the cap layers to confirm that cap is placed to design elevation/thickness and covers entire area (assume four surveys for each dredge cell in RTAs 1 and 2 and three surveys per dredge area in RTA 3) Sampling would also be performed after placement to verify that no contaminated sediment was deposited on top of the cap surface during installation.	Since ISS will not be implemented under Alternative5, ISS confirmation sampling is not included in Alternative 5.
Long-Term Monitoring and Operation and Maintenance[a]	
Long term monitoring would include evaluating cap integrity every five years. Sediment deposited on top of the cap would also be sampled to assess recontamination. Maintenance costs are assumed to include replacement of 5% of the cap footprint (entire cap thickness) every ten years. Maintenance dredging may be required to maintain depths required for navigation purposes; however, this is not considered as part of this FS. For purposes of this FS, costs for a bathymetric survey and sediment sampling and analysis every 5 years are assumed.	NA

Base Component and Sequence	Key Differences Between Alternatives 5 and 7
Perform 5 year reviews.	
Dredged Material Treatment and Disposal Options for Alternatives 5 and 7	
Option A: Thermal Desorption, Offsite Beneficial Use • Dredged sediment would be treated at an offsite commercial facility by mixing with a stabilization agent and then transported by truck to a thermal desorption facility. Depending on the selected thermal facility, transport could be by rail, but for the purposes of developing estimated costs, this FS assumes approximately 60 miles of transport by truck (the higher of the two costs). • For estimating purposes, it is assumed 7.5% by weight portland cement would be used to stabilize the material in order to pass the paint filter test prior to transport for further treatment. • Following thermal desorption, the treated sediment would be used either as daily cover for a landfill, elsewhere as backfill, or otherwise beneficially. • For cost estimating purposes, it is assumed that the material would be provided to the end user free of charge and would be transported approximately 60 miles via truck. • Predesign testing would need to be performed, including bench testing of composite samples to make sure that the material would be accepted for treatment.	NA
Option B: Offsite Disposal (Landfill) • Dredged sediment would be treated at an offsite commercial facility by mixing with a stabilization agent and then be transported by truck to a Subtitle D disposal facility. • For estimating purposes, it is assumed 7.5% by weight portland cement would be used to stabilize the material in order to pass the paint filter test. • For estimating purposes, it is assumed that the sediment would be transported approximately 110 miles by truck for disposal. • Based on TCLP data collected during the RI, it is assumed that the sediment is not a characteristic hazardous waste under RCRA and would be accepted at a Subtitle D disposal facility; however, predesign testing needs to be performed using composite samples to confirm waste characteristics and obtain preapproval/preacceptance from disposal facilities. The costs presented herein assume that sediment from the canal would not be classified as PCB-remediation waste.	NA

TABLE 1
Detailed Description of Components for Alternatives 5 and 7
Gowanus Canal Feasibility Study
Brooklyn, New York

Base Component and Sequence	Key Differences Between Alternatives 5 and 7
Option C: Cogeneration, Offsite Beneficial Use • Dredged sediment would be treated at an offsite commercial facility by mixing with a stabilization agent and then transported by truck to a cogeneration facility (350 mile trip assumed; Jersey City, NJ, to Clarion, PA). Depending on the selected cogeneration facility, transport could be by rail, but for the purposes of developing estimated costs, this FS assumes transport by truck (the higher of the two costs). • For estimating purposes, it is assumed 7.5% by weight portland cement would be used to stabilize the material to pass the paint filter test prior to transport for further treatment. • Following treatment, the treated sediment would be used either as daily cover for a landfill, elsewhere as clean backfill, or otherwise beneficially. • For cost estimating purposes, the material would be provided to the end user free of charge and would be transported 60 miles via truck. • Predesign testing would need to be performed including testing of composite samples to make sure that the material would be accepted for treatment.	NA
Option D: Offsite Stabilization and Offsite Beneficial Use • This FS assumes the stabilized material would be used as daily cover at a landfill; however, an end use has not yet been identified and other beneficial uses may be considered. • Dredged sediment would be dewatered onsite and then transported via barge to an offsite commercial stabilization facility. After treatment, the sediment would be transported by truck to the end use location. Transport could potentially occur via rail, but for the purposes of developing estimated costs, this FS assumes transport by truck (the higher of the two costs). • Dredged sediment would be treated at the offsite dredge-material-processing facility by mixing with a stabilization agent. The sediment would then be transported to the final use location. • For estimating purposes, it is assumed 15% by weight reagent would be used for stabilization, and the reagent itself would be 75% blast furnace slag (BFS120) and 25% portland cement. • For cost estimating purposes, the material would be provided to the end user free of charge and would be transported 110 miles via truck. • No additional O&M costs are assumed for this disposal option. • Predesign testing would need to be performed to determine stabilization requirements based on beneficial use.	—

Base Component and Sequence	Key Differences Between Alternatives 5 and 7
Option E: Onsite Stabilization and Onsite Beneficial Use • Dewatered sediment would be stabilized at a temporary dredge material processing facility constructed onsite. • For estimating purposes, it is assumed 30% by weight reagent would be used for solidification, and the reagent itself would be 75% blast furnace slag (BFS120) and 25% portland cement. • Institutional controls would be required to limit exposures to stabilized material beneficially used onsite. • Long-term O&M activities would include periodic sampling of the stabilized material to assess leachability and periodic surveys to assure that exposure through direct contact is prevented. • Final disposition of the stabilized sediment is assumed to be adjacent to the canal and will be a net zero cost under this disposal option. • Predesign testing would need to be performed to determine stabilization requirements based on beneficial use.	
Option F: Offsite stabilization, Transport of Treated Material Back to Site, Placement in Onsite Constructed CDF • During preconstruction site work, a confined disposal facility (CDF) would be constructed. This FS assumes that space will be available to construct a CDF that will contain all the material from RTA 3, estimated to be 281,000 yd^3. • An expansion factor of 1.15 is assumed to determine the CDF capacity, which will need to be approximately 323,000 yd^3. It has been assumed that the CDF will be constructed so that the dewatered, stabilized sediment will be placed in a layer 20 ft thick. The area required for a CDF of this size is 436,000 ft^2, or 10 acres. – The FS assumes that the CDF will be surrounded on three sides by land and that those sides of the CDF will consist of a single sheet pile wall. The fourth side of the CDF will consist of a double sheet pile wall, 3 ft apart, filled with bentonite-augmented soil. – A total of 5,400 LF of 45-ft-long sheet piles are estimated. • Dredged sediment would be treated at an offsite dredge-material-processing-facility by mixing with a stabilization agent. The sediment would then be transported back to the site by barge and placed in the CDF. • For estimating purposes, it is assumed 15% by weight reagent would be used for stabilization, and the reagent itself would be 75% blast furnace slag (BFS120) and 25% portland cement. • The CDF would be capped with asphalt pavement to allow use of the surface. • CDF O&M would include cap integrity surveys and periodic repairs. Predesign testing would need to be performed to determine stabilization requirements and contaminant leachability. The results would be used to determine the appropriate design for the CDF.	NA

TABLE 1
Detailed Description of Components for Alternatives 5 and 7
Gowanus Canal Feasibility Study
Brooklyn, New York

Base Component and Sequence	Key Differences Between Alternatives 5 and 7
Option G: Onsite Stabilization and Placement in Onsite Constructed CDF	NA
• The description of Option F is applicable to this disposal option. The only difference between Options F and G is that under Option G the dewatered sediment would be stabilized at the temporary onsite facility. This FS assumes that the onsite stabilization facility would be located adjacent to the CDF and that an additional transport step between stabilization and placement in the CDF would not be required.	

ARAR—applicable or relevant and appropriate requirement
BFS—blast furnace slag
CDF—confined disposal facility
CSO—combined sewer overflow
FS—feasibility study
ft^2—square foot
GAC—granulated activated carbon
gpm—gallon per minute
lb—pound
LF—linear feet
NAPL—non aqueous phase liquid
NYSDEC—New York State Department of Environmental Conservation
O&M—operations and maintenance
PRP—potentially responsible party
RCRA – Resource Conservation and Recovery Act
RI—remedial investigation
RTA—remediation target area
USACE—United States Army Corps of Engineers
USEPA—United States Environmental Protection Agency
yd^3—cubic yard

[a]Of cap only. O&M for disposal options included in disposal/treatment components, if applicable.

TABLE 2A

Summary of Costs for Alternatives Undergoing Detailed Evaluation -Dredging, Treatment and Disposal, and O&M Cost by RTA

Gowanus Canal Feasibility Study

Brooklyn, New York

Alternative Description	Base Implementation Capital Cost[1]	Dredging, Capping, Treatment and Disposal Capital Cost by RTA[2,3]			Present Worth O&M Cost[4]	Estimated Total Cost
		RTA 1	RTA 2	RTA 3		
Dredging and Capping Alternatives						
No Action	$0	$0	$0	$0	$0	$0
Dredge entire column of soft sediment Cap with treatment layer, isolation sand layer, and armor layer	$190,700,000	$15,000,000	$35,000,000	$29,000,000	$2,000,000	$272,000,000
Dredge entire column of soft sediment Solidify top 3-5 feet of underlying native sediment in targeted areas Cap with treatment layer, isolation sand layer, and armor layer	$190,700,000	$18,000,000	$48,000,000	$29,000,000	$2,000,000	$288,000,000
Treatment and Disposal Options						
A - Offsite thermal desorption, beneficial use	NA	$30,000,000	$82,000,000	$102,000,000	NA	$214,000,000
B - Offsite disposal (landfill)	NA	$32,000,000	$87,000,000	$108,000,000	NA	$227,000,000
C - Offsite Co-gen	NA	$37,000,000	$101,000,000	$126,000,000	NA	$264,000,000
D - Offsite stabilization, beneficial use	NA	$30,000,000	NA	$104,000,000	NA	$104,000,000
E - Onsite stabilization, beneficial use	$5,400,000	$23,000,000	NA	$78,000,000	$2,000,000	$108,000,000
F - Offsite stabilization and disposal in on-site constructed CDF	NA	NA	NA	$74,000,000	$160,000	$74,000,000
G - Onsite stabilization and disposal in on-site constructed CDF	$5,400,000	NA	NA	$67,000,000	$160,000	$73,000,000

Notes:

1. Base implementation costs for the dredging and capping alternatives consist of the following cost items: remedial design and pre-design sampling and testing; pre-remediation site work, facility costs, bulkhead upgrade/stabilization, short term morning costs, and confirmation sampling costs. The base implementation cost for disposal options E and G includes setting up the onsite sediment stabilization facility. These costs include costs for excavation of the former 1st Street Basin (details are presented in a separate technical memorandum, costs are estimated at approximately $20 million) and costs for storage tanks at CSOs RH-034 and OH-007 (8 million and 4 million tanks, respectively, estimated to cost $77.7 million; details presented in a separate technical memorandum).

2. Dredging and Capping costs consist of the following cost items: installation and removal of sheet pile cells (RTAs 1 and 2), silt curtain (RTA 3 only), sediment removal, cap placement, dewatering, and dewatering/dredge cell water treatment.

3. Treatment and Disposal costs are summarized by RTA and include the costs associated with transport to the stabilization facility, stabilization, treatment or disposal, and transport to end destination.

4. O&M costs are included under the dredging and capping alternatives are for the cap. Costs included for the treatment and disposal options are for the CDF associated with options F and G and for monitoring associated with the onsite beneficial use in Option E. The present worth cost is determined using a discount rate of 7%.

TABLE 2B

Summary of Representative Total Cost Range

Gowanus Canal Feasibility Study

Brooklyn, New York

Alternative Description	Base Implementation Capital Cost[1]	Dredging, Capping, Treatment and Disposal Capital Cost by RTA[2,3]			Present Worth O&M Cost[4]	Estimated Total Cost
		RTA 1	RTA 2	RTA 3		
Lower End of Cost Range						
Dredge entire column of soft sediment Cap with treatment layer, isolation sand layer, and armor layer	$190,700,000	$15,000,000	$35,000,000	$29,000,000	$2,000,000	$350,000,000
Disposal Option (Lowest cost) RTA 1 and 2 - Offsite thermal desorption, beneficial use RTA 3 - Onsite stabilization and disposal in onsite CDF	$5,400,000	$23,000,000	$82,000,000	$67,000,000	$160,000	
Higher End of Cost Range						
Dredge entire column of soft sediment Solidify top 3-5 feet of underlying native sediment in targeted areas Cap with treatment layer, isolation sand layer, and armor layer	$190,700,000	$18,000,000	$48,000,000	$29,000,000	$2,000,000	$454,000,000
Disposal Option (highest cost) RTA 1, 2, and 3 - Offsite cogeneration	NA	$37,000,000	$101,000,000	$126,000,000	NA	

Notes:

1. Base implementation costs for the dredging and capping alternatives consist of the following cost items: remedial design and pre-design sampling and testing; pre-remediation site work, facility costs, bulkhead upgrade/stabilization, short term morning costs, and confirmation sampling costs. The base implementation cost for disposal options E and G includes setting up the onsite sediment stabilization facility. These costs include costs for excavation of the former 1st Street Basin (details are presented in a separate technical memorandum, costs are estimated at approximately $20 million) and costs for storage tanks at CSOs RH-034 and OH-007 (8 million and 4 million tanks, respectively, estimated to cost $77.7 million; details presented in a separate technical memorandum).

2. Dredging and Capping costs consist of the following cost items: installation and removal of sheet pile cells (RTAs 1 and 2), silt curtain (RTA 3 only), sediment removal, cap placement, dewatering, and dewatering/dredge cell water treatment.

3. Treatment and Disposal costs are summarized by RTA and include the costs associated with transport to the stabilization facility, stabilization, treatment or disposal, and transport to end

4. O&M costs are included under the dredging and capping alternatives are for the cap. Costs included for the treatment and disposal options are for the CDF associated with options F and G and for monitoring associated with the onsite beneficial use in Option E. The present worth cost is determined using a discount rate of 2.3%.

TABLE 3

Summary of Sediment Volumes Removed, Capping Material Quantities, and In-situ Solidification Areas in Alternatives 5 and 7

Gowanus Canal Feasibility Study

Brooklyn, New York

Area	Sediment Type	Sediment Removal Volume - Alternatives 5 and 7	Capping Material Quantities (cubic yards) Oleophilic Clay	Sand (isolation layer)	Gravel (isolation layer)	Armor	Habitat Sand
RTA 1	Soft	82,000	7,930	3,965	3,965	11,896	3,965
RTA 2	Soft	174,000	19,194	9,597	9,597	28,791	9,597
	Native[1]	51,000					
RTA 3	Soft	281,000	13,562	13,562	13,562	40,687	13,562
	Total (cy)	**588,000**	**40,687**	**27,125**	**27,125**	**81,374**	**27,125**

1. Some native sediment will be removed in RTA 2 in order to accommodate the proposed cap thickness in order to allow commercial vessels to utilize the canal.

Area	Component	Perimeter	Area	Acres
RTA 1	Canal Reach 1	4,695	214,119	4.9
RTA 2	Canal Reach 2	7,082	327,193	7.5
	6th Street Basin	1,673	73,067	1.7
	7th Street Basin	1,163	45,103	1
	11th Street Basin	450	9,168	0.2
	4th Street Basin	1,635	63,714	1.5
RTA 3	Canal Reach 3a	1,276	74,379	1.7
	Canal Reach 3b	4,852	657,982	15.1

Summary of Areas Proposed For ISS Application

RTA	ISS Area (Square Feet)	Depth (Feet)	Volume (Cubic Yards)	Volume (Tons)
RTA 1	60,000	5	11,111	15,556
RTA 2 - Main Canal	190,000	5	35,185	49,259
RTA 2 - 4th Street and 6th Street Turning Basins	50,000	5	9,259	12,963
RTA 2 - 7th Street Turning Basin	30,000	5	5,556	7,778

TABLE 4

Prevailing Wage Rates for 07/01/2011 - 06/30/2012, New York State Department Of Labor

Gowanus Canal Feasibility Study

Brooklyn, New York

POSITION	HOURLY RATE	BENEFIT #1	BENEFIT #2	UNION PREMIUM	STRAIGHT TIME RATE	OVERTIME RATE	50 HR RATE	60 HR RATE
OPERATOR	$32.89	$8.05	$2.30	$54.05	$97.30	$145.94	$107.02	$113.51
LEVERMAN	$32.89	$8.05	$2.30	$54.05	$97.30	$145.94	$107.02	$113.51
LEAD DREDGEMAN	$32.89	$8.05	$2.30	$54.05	$97.30	$145.94	$107.02	$113.51
DOZER/FRONT LOADER OPERATOR	$32.89	$8.05	$2.30	$54.05	$97.30	$145.94	$107.02	$113.51
SPIDER/SPILL BARGE OPERATOR	$28.49	$8.05	$1.99	$48.17	$86.70	$130.05	$95.37	$101.15
TUG OPERATOR (OVER 1000 HP)	$28.49	$8.05	$1.99	$48.17	$86.70	$130.05	$95.37	$101.15
OPERATOR II	$28.49	$8.05	$1.99	$48.17	$86.70	$130.05	$95.37	$101.15
FILL PLACER	$28.49	$8.05	$1.99	$48.17	$86.70	$130.05	$95.37	$101.15
DERRICK OPERATOR	$28.49	$8.05	$1.99	$48.17	$86.70	$130.05	$95.37	$101.15
ENGINEER	$28.49	$8.05	$1.99	$48.17	$86.70	$130.05	$95.37	$101.15
CHIEF MATE	$28.49	$8.05	$1.99	$48.17	$86.70	$130.05	$95.37	$101.15
ELECTRICIAN	$28.49	$8.05	$1.99	$48.17	$86.70	$130.05	$95.37	$101.15
CHIEF WELDER	$28.49	$8.05	$1.99	$48.17	$86.70	$130.05	$95.37	$101.15
MAINTENANCE ENGINEER	$28.49	$8.05	$1.99	$48.17	$86.70	$130.05	$95.37	$101.15
BOAT OPERATOR (LICENSED)	$28.49	$8.05	$1.99	$48.17	$86.70	$130.05	$95.37	$101.15
DRAG BARGE OPERATOR	$26.14	$7.75	$1.83	$44.65	$80.37	$120.55	$88.41	$93.76
STEWARD/MATE	$26.14	$7.75	$1.83	$44.65	$80.37	$120.55	$88.41	$93.76
ASSISTANT FILL PLACER	$26.14	$7.75	$1.83	$44.65	$80.37	$120.55	$88.41	$93.76
WELDER	$26.20	$7.75	$1.83	$44.73	$80.51	$120.77	$88.57	$93.93
BOAT OPERATOR	$25.29	$7.75	$1.77	$43.51	$78.32	$117.48	$86.16	$91.38
SHOREMAN	$21.09	$7.45	$1.48	$37.52	$67.54	$101.31	$74.29	$78.79
DECKHAND	$21.09	$7.45	$1.48	$37.52	$67.54	$101.31	$74.29	$78.79
RODMAN	$21.09	$7.45	$1.48	$37.52	$67.54	$101.31	$74.29	$78.79
SCOWMAN	$21.09	$7.45	$1.48	$37.52	$67.54	$101.31	$74.29	$78.79
COOK	$21.09	$7.45	$1.48	$37.52	$67.54	$101.31	$74.29	$78.79
MESSMAN	$21.09	$7.45	$1.48	$37.52	$67.54	$101.31	$74.29	$78.79
PORTER/JANTOR	$21.09	$7.45	$1.48	$37.52	$67.54	$101.31	$74.29	$78.79
OILER	$21.18	$7.45	$1.48	$37.64	$67.75	$101.63	$74.53	$79.05

Note: Not all positions included on this table are used within this cost estimate.

TABLE 5A

Base Implementation and Removal Costs for Alternative 5: Dredging entire soft sediment column and capping with treatment layer, isolation layer, and armor layer.

Gowanus Canal Feasibility Study

Brooklyn, New York

BASE IMPLEMENTATION COSTS										
PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL	
1	**Pre-Design Testing/Site Investigation//Design Costs**	**Remedial Design and Pre-Design Sampling & Testing**	**1**	**LS**	**$4,351,516.62**	**$3,626,263.85**	**$543,939.58**	**$181,313.19**	**$ 4,351,517**	
		Bathymetric Survey	3	DAY	$3,000.00	$9,000.00	$1,350.00	$450.00		
		Pre-Design Treatability/Pilot Studies	1	LS	$500,000.00	$500,000.00	$75,000.00	$25,000.00		
		Full-Scale Remedial Design (4% of Remediation Costs)	1	LS	$2,453,811.08	$2,453,811.08	$368,071.66	$122,690.55		
		Coordination With Agencies/Stakeholders/Permitting (1% of Remediation Costs)	1	LS	$613,452.77	$613,452.77	$92,017.92	$30,672.64		
		Geophysical Survey	20	DAY	$2,500.00	$50,000.00	$7,500.00	$2,500.00		
2	**Includes all labor, equipment, & odc costs to complete pre-remedial site work**	**Pre-Remediation Site Work**	**9,500**	**LF**	**$42.16**	**$333,805.40**	**$50,070.81**	**$16,690.27**	**$ 400,566**	
		Temporary Access Road Constructi	23,464	SY	$11.35	$266,316.40	$39,947.46	$13,315.82		PER MEANS 01 55 23.50.0100
		Chain-Link Fence (Temporary)	2,000	LF	$7.13	$14,260.00	$2,139.00	$713.00		PER MEANS 01 56 26.50.0100
		Prepare Docking/Staging Area	933	SY	$11.80	$11,009.40	$1,651.41	$550.47		PER MEANS 31 22 16.10.0010
		Establish Required Vertical Control Points & Tide Gauges	1	LS	$10,000.00	$10,000.00	$1,500.00	$500.00		ALLOWANCE
		Set-Up Temporary Water Treatment System-Site Prep	1	LS	$32,219.60	$32,219.60	$4,832.94	$1,610.98		ALLOWANCE
3	**Includes all labor, equipment, & odc costs for Dewatering & Treating Dredge Cell Water**	**Dewatering/Dredge Cell Water Treatment**	**1**	**LS**	**$612,000.00**	**$510,000.00**	**$803,000.00**	**$803,000.00**	**$ 612,000**	
		Mobilization/Demobilization	1	LS	$ 150,000.00	$150,000.00	$22,500.00	$7,500.00		
		Installation of Surface water Treatm	1	LS	$ 200,000.00	$200,000.00	$30,000.00	$10,000.00		
		Power Drop	1	LS	$ 75,000.00	$75,000.00	$11,250.00	$3,750.00		
		Instrumentation & Control Allowance	1	LS	$ 25,000.00	$25,000.00	$3,750.00	$1,250.00		
		Treatment System Building	1	LS	$ 60,000.00	$60,000.00	$9,000.00	$3,000.00		

TABLE 5A

Base Implementation and Removal Costs for Alternative 5: Dredging entire soft sediment column and capping with treatment layer, isolation layer, and armor layer.

Gowanus Canal Feasibility Study

Brooklyn, New York

BASE IMPLEMENTATION COSTS										
PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL	
4	**Includes all labor, equipment, & odc costs for project long facility costs**	**Facility Costs**	**72**	**MO**	**$139,020.00**	**$8,341,200.00**	**$1,251,180.00**	**$417,060.00**	**$ 10,009,440**	
		Office Facilities	72	MO	$5,200.00	$374,400.00	$56,160.00	$18,720.00		ALLOWANCE: (2) Trailers
		Jobsite Sanitation	72	MO	$750.00	$54,000.00	$8,100.00	$2,700.00		PER MEANS 01 56 26.50.0020
		Site Security	72	MO	$5,400.00	$388,800.00	$58,320.00	$19,440.00		PER MEANS 31 22 16.10.0010
		Site Utilities	72	MO	$4,500.00	$324,000.00	$48,600.00	$16,200.00		ALLOWANCE: Phone/Power/Misc
		Temporary Storage Area (10 Acres)	72	MO	$100,000.00	$7,200,000.00	$1,080,000.00	$360,000.00		ALLOWANCE: (3) Conex Boxes
5	**Includes all labor, equipment, & odc costs for upgrading and restoring Existing Bulkheads**	**Upgrade and Restore Existing Bulkheads**	**16,800**	**LF**	**$2,951.21**	**$41,316,958.80**	**$6,197,543.82**	**$2,065,847.94**	**$ 49,580,351**	
		Debris Removal	320	HR	$230.00	$73,600.00	$11,040.00	$3,680.00		
		Sheet Piling Installation	647,600	SF	$60.00	$38,856,000.00	$5,828,400.00	$1,942,800.00		PER MEANS 31 41 16.10.1800
		Tie Back Installation	648	TON	$2,250.00	$1,457,100.00	$218,565.00	$72,855.00		PER MEANS 31 41 16.10.3000
		6" Submersible Pumps	2	EA	$50,000.00	$100,000.00	$15,000.00	$5,000.00		ALLOWANCE
		Crushed Stone Backfill	19,444	CY	$42.70	$830,258.80	$124,538.82	$41,512.94		PER MEANS 32 11 23.23.1513
6	**Includes all labor, equipment, & odc costs for Turbidity Monitoring Activities**	**Monitoring Costs - Short Term**	**1**	**LS**	**$480,120.00**	**$400,100.00**	**$60,015.00**	**$20,005.00**	**$ 480,120**	
		YSI Unit Rental	1	LS	$6,500.00	$6,500.00	$975.00	$325.00		
		Jon Boat Purchase	1	LS	$15,000.00	$15,000.00	$2,250.00	$750.00		
		Sample Collection Labor	36.25	MO	$5,280.00	$191,400.00	$28,710.00	$9,570.00		
		Air Monitoring	36.00	MO	$3,600.00	$129,600.00	$19,440.00	$6,480.00		
		Air Monitoring Sample Analysis	36.00	MO	$1,600.00	$57,600.00	$8,640.00	$2,880.00		

TABLE 5A

Base Implementation and Removal Costs for Alternative 5: Dredging entire soft sediment column and capping with treatment layer, isolation layer, and armor layer.

Gowanus Canal Feasibility Study

Brooklyn, New York

BASE IMPLEMENTATION COSTS									
PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL
7	**Includes all labor, equipment, & odc costs for ISS Sampling**	**ISS Confirmation Sampling**	**1**	**LS**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$ -**
		Sampling Boat Rental	0	DAY	$6,500.00	$0.00	$0.00	$0.00	
		Crane	0	DAY	$3,750.00	$0.00	$0.00	$0.00	
		Sample Collection Labor	0.00	MO	$5,280.00	$0.00	$0.00	$0.00	
		Sampling (ASTM D1633/ASTM D5084/APLC/TCLP)	0.00	EA	$800.00	$0.00	$0.00	$0.00	
8	**Includes all labor, equipment, & odc costs for Confirmation Sampling/Surveys**	**Confirmation Sampling/Surveys**	**1**	**LS**	**$262,800.00**	**$219,000.00**	**$32,850.00**	**$10,950.00**	**$ 262,800**
		Jon Boat Purchase	1	LS	$15,000.00	$15,000.00	$2,250.00	$750.00	
		Sample Collection Labor	12.00	DAY	$4,500.00	$54,000.00	$8,100.00	$2,700.00	
		Bathymetric Survey	50	DAY	$3,000.00	$150,000.00	$22,500.00	$7,500.00	
		ESTIMATED COST							**$ 65,696,794**
						Contingency	**30%**		**$ 19,709,038**
						Construction Management/ Oversight	**6%**		**$ 3,941,808**
						Project Management	**5%**		**$ 3,284,840**
		TOTAL BASE IMPLEMENTATION COSTS							**$ 92,632,479**

TABLE 5A

Base Implementation and Removal Costs for Alternative 5: Dredging entire soft sediment column and capping with treatment layer, isolation layer, and armor layer.

Gowanus Canal Feasibility Study

Brooklyn, New York

BASE IMPLEMENTATION COSTS										
PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL	
REMEDIATION: RTA#1										
PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL	
1	**Design Costs & Permitting Costs**	**Remedial Design and Permitting Costs**	**1**	**LS**	**$599,381.61**	**$499,484.68**	**$74,922.70**	**$24,974.23**	**$ 599,382**	
		Full-Scale Remedial Design (4% of Remediation Costs)	1	LS	$399,587.74	$399,587.74	$59,938.16	$19,979.39		
		Coordination With Agencies/Stakeholders/Permitting (1% of Remediation Costs)	1	LS	$99,896.94	$99,896.94	$14,984.54	$4,994.85		
2	**Includes all labor, equipment, & odc costs for constructing Sheetpile Cells**	**Installation and Removal of Sheet Pile Cells**	**1,100**	**LF**	**$1,264.25**	**$1,158,900.00**	**$173,835.00**	**$57,945.00**	**$ 1,390,680**	
		Sheet Piling Installation	15,000	SF	$39.53	$592,950.00	$88,942.50	$29,647.50		PER MEANS 31 41 16.10.1800
		Sheet Piling Extraction/Reinstallatio	33,000	SF	$17.15	$565,950.00	$84,892.50	$28,297.50		PER MEANS 31 41 16.10.1300
3	**Includes all labor, equipment, & odc costs for Cap Placement**	**Cap Placement**	**31,721**	**CY**	**$102.20**	**$2,701,471.82**	**$405,220.77**	**$135,073.59**	**$ 3,241,766**	
		Clay Import	7,930	CY	$200.00	$1,586,068.88	$237,910.33	$79,303.44		PER MEANS 31 23 23.15.6000
		Sand Import	3,965	CY	$23.00	$91,198.96	$13,679.84	$4,559.95		PER MEANS 04 05 13.95.0200
		Habitat Sand Import	3,965	CY	$23.00	$91,198.96	$13,679.84	$4,559.95		PER MEANS 04 05 13.95.0200
		Gravel Import	3,965	CY	$28.00	$111,024.82	$16,653.72	$5,551.24		
		Armor Import	11,896	CY	$31.50	$374,708.77	$56,206.32	$18,735.44		PER MEANS 31 37 13.10.0011
		Material Placement-Equipment	79	DAY	$2,580.00	$204,602.89	$30,690.43	$10,230.14		
		Material Placement-Labor	79	DAY	$3,060.00	$242,668.54	$36,400.28	$12,133.43		
4	**Includes all labor, equipment, & odc costs for Dewatering & Treating Dredge Cell Water**	**Dewatering/Dredge Cell Water Treatment**	**69,160,000**	**GAL**	**$0.04**	**$2,272,145.90**	**$340,821.88**	**$113,607.29**	**$ 2,726,575**	
		Power/Electric	3.42	MO	$10,000.00	$34,166.67	$5,125.00	$1,708.33		
		Treatment System Operation	2,460	HR	$74.53	$183,340.57	$27,501.08	$9,167.03		
		Treatment System Rental	3.42	MO	$75,000.00	$256,250.00	$38,437.50	$12,812.50		
		Treatment Chemicals	3.42	MO	$10,000.00	$34,166.67	$5,125.00	$1,708.33		
		Replacement Carbon	882,111	LBS	$2.00	$1,764,222.00	$264,633.30	$88,211.10		

TABLE 5A

Base Implementation and Removal Costs for Alternative 5: Dredging entire soft sediment column and capping with treatment layer, isolation layer, and armor layer.

Gowanus Canal Feasibility Study

Brooklyn, New York

BASE IMPLEMENTATION COSTS									
PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL
5	Includes all labor, equipment, & odc costs for Sediment Removal via Mechanical Dredge	Dredging: Debris and Sediment Removal	82,000	CY	$29.31	$2,003,181.64	$300,477.25	$100,159.08	$ 2,403,818
		Transfer Pump	103	DAY	$1,000.00	$102,500.00	$15,375.00	$5,125.00	
		Barge With Clamshell	103	DAY	$1,380.00	$141,450.00	$21,217.50	$7,072.50	
		Barge With Excavator	103	DAY	$800.00	$82,000.00	$12,300.00	$4,100.00	
		Scow	103	DAY	$180.00	$18,450.00	$2,767.50	$922.50	
		Scow	103	DAY	$180.00	$18,450.00	$2,767.50	$922.50	
		Scow	103	DAY	$180.00	$18,450.00	$2,767.50	$922.50	
		Superintendent	103	DAY	$1,566.45	$160,561.36	$24,084.20	$8,028.07	
		Tug Operator	103	DAY	$1,213.83	$124,417.62	$18,662.64	$6,220.88	
		Tug Operator	103	DAY	$1,213.83	$124,417.62	$18,662.64	$6,220.88	
		Tug Operator	103	DAY	$1,213.83	$124,417.62	$18,662.64	$6,220.88	
		Crane Operator	103	DAY	$1,362.13	$139,618.58	$20,942.79	$6,980.93	
		Equipment Operator	103	DAY	$1,362.13	$139,618.58	$20,942.79	$6,980.93	
		Dredge Laborer	103	DAY	$945.51	$96,915.13	$14,537.27	$4,845.76	
		Dredge Laborer	103	DAY	$945.51	$96,915.13	$14,537.27	$4,845.76	
		FOGM	103	DAY	$6,000.00	$615,000.00	$92,250.00	$30,750.00	
6	Includes all labor, equipment, & odc costs for Dewatering Dredged Material	Dredging: Dewatering	1	LS	$226,854.34	$189,045.28	$28,356.79	$9,452.26	$ 226,854
		Dewatering Pump	103	DAY	$750.00	$76,875.00	$11,531.25	$3,843.75	
		Pump Fuel	103	DAY	$200.00	$20,500.00	$3,075.00	$1,025.00	
		Pump Laborer	1,230	HR	$74.53	$91,670.28	$13,750.54	$4,583.51	
		ESTIMATED COST							$ 10,589,075
						Contingency	30%		$ 3,176,723
						Construction Management/ Oversight	6%		$ 635,345
						Project Management	5%		$ 529,454
		TOTAL RTA#1 REMEDIATION							$ 14,930,596

TABLE 5A

Base Implementation and Removal Costs for Alternative 5: Dredging entire soft sediment column and capping with treatment layer, isolation layer, and armor layer.

Gowanus Canal Feasibility Study

Brooklyn, New York

BASE IMPLEMENTATION COSTS

PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL	

REMEDIATION: RTA#2

PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL	
1	**Design Costs & Permitting Costs**	**Remedial Design and Pre-Design Sampling & Testing**	**1**	**LS**	**$1,388,252.74**	**$1,156,877.28**	**$173,531.59**	**$57,843.86**	**$ 1,388,253**	
		Full-Scale Remedial Design (4% of Remediation Costs)	1	LS	$925,501.83	$925,501.83	$138,825.27	$46,275.09		
		Coordination With Agencies/Stakeholders/Permitting (1% of Remediation Costs)	1	LS	$231,375.46	$231,375.46	$34,706.32	$11,568.77		
2	**Includes all labor, equipment, & odc costs for constructing Sheetpile Cells**	**Installation and Removal of Sheet Pile Cells**	**1,400**	**LF**	**$1,256.69**	**$1,466,140.00**	**$219,921.00**	**$73,307.00**	**$ 1,759,368**	
		Sheet Piling Installation	18,000	SF	$39.53	$711,540.00	$106,731.00	$35,577.00		PER MEANS 31 41 16.10.1800
		Sheet Piling Extraction/Reinstallatio	44,000	SF	$17.15	$754,600.00	$113,190.00	$37,730.00		PER MEANS 31 41 16.10.1300
3	**Includes all labor, equipment, & odc costs for Cap Placement**	**Cap Placement**	**76,777**	**CY**	**$102.20**	**$6,538,516.59**	**$980,777.49**	**$326,925.83**	**$ 7,846,220**	
		Clay Import	19,194	CY	$200.00	$3,838,847.26	$575,827.09	$191,942.36		PER MEANS 31 23 23.15.6000
		Sand Import	9,597	CY	$23.00	$220,733.72	$33,110.06	$11,036.69		PER MEANS 04 05 13.95.0200
		Habitat Sand Import	9,597	CY	$23.00	$220,733.72	$33,110.06	$11,036.69		PER MEANS 04 05 13.95.0200
		Gravel Import	9,597	CY	$28.00	$268,719.31	$40,307.90	$13,435.97		
		Armor Import	28,791	CY	$31.50	$906,927.66	$136,039.15	$45,346.38		PER MEANS 31 37 13.10.0011
		Material Placement-Equipment	192	DAY	$2,580.00	$495,211.30	$74,281.69	$24,760.56		
		Material Placement-Labor	192	DAY	$3,060.00	$587,343.63	$88,101.54	$29,367.18		

TABLE 5A

Base Implementation and Removal Costs for Alternative 5: Dredging entire soft sediment column and capping with treatment layer, isolation layer, and armor layer.

Gowanus Canal Feasibility Study

Brooklyn, New York

BASE IMPLEMENTATION COSTS

PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL
4	**Includes all labor, equipment, & odc costs for Dewatering & Treating Dredge Cell Water**	**Dewatering/Dredge Cell Water Treatment**	**181,200,000**	**GAL**	**$0.04**	**$5,512,909.00**	**$826,936.35**	**$275,645.45**	**$ 6,615,491**
		Power/Electric	9.38	MO	$10,000.00	$93,750.00	$14,062.50	$4,687.50	
		Treatment System Operation	6,750	HR	$0.00	$0.00	$0.00	$0.00	
		Treatment System Rental	9.38	MO	$75,000.00	$703,125.00	$105,468.75	$35,156.25	
		Treatment Chemicals	9.38	MO	$10,000.00	$93,750.00	$14,062.50	$4,687.50	
		Replacement Carbon	2,311,142	LBS	$2.00	$4,622,284.00	$693,342.60	$231,114.20	
5	**Includes all labor, equipment, & odc costs for Sediment Removal via Mechanical Dredge**	**Dredging: Debris and Sediment Removal**	**225,000**	**CY**	**$29.31**	**$5,496,534.98**	**$824,480.25**	**$274,826.75**	**$ 6,595,842**
		Transfer Pump	281	DAY	$1,000.00	$281,250.00	$42,187.50	$14,062.50	
		Barge With Clamshell	281	DAY	$1,380.00	$388,125.00	$58,218.75	$19,406.25	
		Barge With Excavator	281	DAY	$800.00	$225,000.00	$33,750.00	$11,250.00	
		Scow	281	DAY	$180.00	$50,625.00	$7,593.75	$2,531.25	
		Scow	281	DAY	$180.00	$50,625.00	$7,593.75	$2,531.25	
		Scow	281	DAY	$180.00	$50,625.00	$7,593.75	$2,531.25	
		Superintendent	281	DAY	$1,566.45	$440,564.71	$66,084.71	$22,028.24	
		Tug Operator	281	DAY	$1,213.83	$341,389.81	$51,208.47	$17,069.49	
		Tug Operator	281	DAY	$1,213.83	$341,389.81	$51,208.47	$17,069.49	
		Tug Operator	281	DAY	$1,213.83	$341,389.81	$51,208.47	$17,069.49	
		Crane Operator	281	DAY	$1,362.13	$383,099.75	$57,464.96	$19,154.99	
		Equipment Operator	281	DAY	$1,362.13	$383,099.75	$57,464.96	$19,154.99	
		Dredge Laborer	281	DAY	$945.51	$265,925.66	$39,888.85	$13,296.28	
		Dredge Laborer	281	DAY	$945.51	$265,925.66	$39,888.85	$13,296.28	
		FOGM	281	DAY	$6,000.00	$1,687,500.00	$253,125.00	$84,375.00	

TABLE 5A

Base Implementation and Removal Costs for Alternative 5: Dredging entire soft sediment column and capping with treatment layer, isolation layer, and armor layer.

Gowanus Canal Feasibility Study

Brooklyn, New York

BASE IMPLEMENTATION COSTS									
PAY ITEM No.	**PAY ITEM DESCRIPTION**	**LINE ITEM DESCRIPTION**	**QUANTITY**	**UNIT**	**UNIT PRICE**	**CONTRACTOR COST**	**CONTRACTOR FEE**	**CONTRACTOR PM/OH**	**TOTAL**
6	Includes all labor, equipment, & odc costs for Dewatering Dredged Material	Dredging: Dewatering	1	LS	$320,625.00	$267,187.50	$40,078.13	$13,359.38	$ 320,625
		Dewatering Pump	281	DAY	$750.00	$210,937.50	$31,640.63	$10,546.88	
		Pump Fuel	281	DAY	$200.00	$56,250.00	$8,437.50	$2,812.50	
		Pump Laborer	3,375	HR	$0.00	$0.00	$0.00	$0.00	
		ESTIMATED COST							$ 24,525,798
						Contingency	30%		$ 7,357,740
						Construction Management/ Oversight	6%		$ 1,471,548
						Project Management	5%		$ 1,226,290
		TOTAL RTA#2 REMEDIATION							$ 34,581,376

TABLE 5A

Base Implementation and Removal Costs for Alternative 5: Dredging entire soft sediment column and capping with treatment layer, isolation layer, and armor layer.

Gowanus Canal Feasibility Study

Brooklyn, New York

BASE IMPLEMENTATION COSTS

PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL	

REMEDIATION: RTA#3

PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL	
1	**Design Costs & Permitting Costs**	**Remedial Design and Pre-Design Sampling & Testing**	**1**	**LS**	**$1,144,331.20**	**$953,609.34**	**$143,041.40**	**$47,680.47**	**$ 1,144,331**	
		Full-Scale Remedial Design (4% of Remediation Costs)	1	LS	$762,887.47	$762,887.47	$114,433.12	$38,144.37		
		Coordination With Agencies/Stakeholders/Permitting (1% of Remediation Costs)	1	LS	$190,721.87	$190,721.87	$28,608.28	$9,536.09		
2	**Includes all labor, equipment, & odc costs for constructing Sheetpile Cells**	**Installation and Removal of Sheet Pile Cells**	**0**	**LF**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$ -**	
		Sheet Piling Installation	0	SF	$39.53	$0.00	$0.00	$0.00		PER MEANS 31 41 16.10.1800
		Sheet Piling Extraction/Reinstallatio	0	SF	$17.15	$0.00	$0.00	$0.00		PER MEANS 31 41 16.10.1300
3	**Includes all labor, equipment, & odc costs for placing Silt Curtain in RTA 3**	**Silt Curtain**	**1,500**	**LF**	**$36.00**	**$45,000.00**	**$6,750.00**	**$2,250.00**	**$ 54,000**	
		Silt Curtain	45,000	SF	$1.00	$45,000.00	$6,750.00	$2,250.00		
4	**Includes all labor, equipment, & odc costs for Cap Placement**	**Cap Placement**	**94,935**	**CY**	**$80.09**	**$6,336,223.51**	**$950,433.53**	**$316,811.18**	**$ 7,603,468**	
		Clay Import	13,562	CY	$200.00	$2,712,400.00	$406,860.00	$135,620.00		PER MEANS 31 23 23.15.6000
		Sand Import	13,562	CY	$23.00	$311,931.19	$46,789.68	$15,596.56		PER MEANS 04 05 13.95.0200
		Habitat Sand Import	13,562	CY	$23.00	$311,931.19	$46,789.68	$15,596.56		PER MEANS 04 05 13.95.0200
		Gravel Import	13,562	CY	$28.00	$379,742.32	$56,961.35	$18,987.12		
		Armor Import	40,687	CY	$31.50	$1,281,630.32	$192,244.55	$64,081.52		PER MEANS 31 37 13.10.0011
		Material Placement-Equipment	237	DAY	$2,580.00	$612,333.03	$91,849.95	$30,616.65		
		Material Placement-Labor	237	DAY	$3,060.00	$726,255.46	$108,938.32	$36,312.77		

TABLE 5A

Base Implementation and Removal Costs for Alternative 5: Dredging entire soft sediment column and capping with treatment layer, isolation layer, and armor layer.

Gowanus Canal Feasibility Study

Brooklyn, New York

BASE IMPLEMENTATION COSTS									
PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL
5	**Includes all labor, equipment, & odc costs for Dewatering & Treating Dredge Cell Water**	**Dewatering/Dredge Cell Water Treatment**	**22,480,000**	**GAL**	**$0.12**	**$2,314,016.48**	**$347,102.47**	**$115,700.82**	**$ 2,776,820**
		Power/Electric	11.71	MO	$10,000.00	$117,083.33	$17,562.50	$5,854.17	
		Treatment System Operation	8,430	HR	$74.53	$628,276.81	$94,241.52	$31,413.84	
		Treatment System Rental	11.71	MO	$75,000.00	$878,125.00	$131,718.75	$43,906.25	
		Treatment Chemicals	11.71	MO	$10,000.00	$117,083.33	$17,562.50	$5,854.17	
		Replacement Carbon	286,724	LBS	$2.00	$573,448.00	$86,017.20	$28,672.40	
6	**Includes all labor, equipment, & odc costs for Sediment Removal via Mechanical Dredge**	**Dredging: Debris and Sediment Removal**	**281,000**	**CY**	**$29.31**	**$6,864,561.46**	**$1,029,684.22**	**$343,228.07**	**$ 8,237,474**
		Transfer Pump	351	DAY	$1,000.00	$351,250.00	$52,687.50	$17,562.50	
		Barge With Clamshell	351	DAY	$1,380.00	$484,725.00	$72,708.75	$24,236.25	
		Barge With Excavator	351	DAY	$800.00	$281,000.00	$42,150.00	$14,050.00	
		Scow	351	DAY	$180.00	$63,225.00	$9,483.75	$3,161.25	
		Scow	351	DAY	$180.00	$63,225.00	$9,483.75	$3,161.25	
		Scow	351	DAY	$180.00	$63,225.00	$9,483.75	$3,161.25	
		Superintendent	351	DAY	$1,566.45	$550,216.38	$82,532.46	$27,510.82	
		Tug Operator	351	DAY	$1,213.83	$426,357.95	$63,953.69	$21,317.90	
		Tug Operator	351	DAY	$1,213.83	$426,357.95	$63,953.69	$21,317.90	
		Tug Operator	351	DAY	$1,213.83	$426,357.95	$63,953.69	$21,317.90	
		Crane Operator	351	DAY	$1,362.13	$478,449.02	$71,767.35	$23,922.45	
		Equipment Operator	351	DAY	$1,362.13	$478,449.02	$71,767.35	$23,922.45	
		Dredge Laborer	351	DAY	$945.51	$332,111.60	$49,816.74	$16,605.58	
		Dredge Laborer	351	DAY	$945.51	$332,111.60	$49,816.74	$16,605.58	
		FOGM	351	DAY	$6,000.00	$2,107,500.00	$316,125.00	$105,375.00	

TABLE 5A

Base Implementation and Removal Costs for Alternative 5: Dredging entire soft sediment column and capping with treatment layer, isolation layer, and armor layer.

Gowanus Canal Feasibility Study

Brooklyn, New York

BASE IMPLEMENTATION COSTS									
PAY ITEM No.	**PAY ITEM DESCRIPTION**	**LINE ITEM DESCRIPTION**	**QUANTITY**	**UNIT**	**UNIT PRICE**	**CONTRACTOR COST**	**CONTRACTOR FEE**	**CONTRACTOR PM/OH**	**TOTAL**
7	**Includes all labor, equipment, & odc costs for Dewatering Dredged Material**	**Dredging: Dewatering**	**1**	**LS**	**$400,425.00**	**$333,687.50**	**$50,053.13**	**$16,684.38**	**$ 400,425**
		Dewatering Pump	351	DAY	$750.00	$263,437.50	$39,515.63	$13,171.88	
		Pump Fuel	351	DAY	$200.00	$70,250.00	$10,537.50	$3,512.50	
		Pump Laborer	4,215	HR	$0.00	$0.00	$0.00	$0.00	
		ESTIMATED COST							**$ 20,216,518**
						Contingency	**30%**		**$ 6,064,955**
						Construction Management/ Oversight	**6%**		**$ 1,212,991**
						Project Management	**5%**		**$ 1,010,826**
		TOTAL RTA#3 REMEDIATION							**$ 28,505,290**

TABLE 5B

Base Implementation, Removal, and In-Situ Stabilization Costs for Alternative 7: Dredging entire soft sediment column, stabilize 3-5 feet of native sediment in targeted areas, and capping with treatment layer, isolation layer, and armor layer.

Gowanus Canal Feasibility Study

Brooklyn, New York

BASE IMPLEMENTATION COSTS										
PAY ITEM No.	**PAY ITEM DESCRIPTION**	**LINE ITEM DESCRIPTION**	**QUANTITY**	**UNIT**	**UNIT PRICE**	**CONTRACTOR COST**	**CONTRACTOR FEE**	**CONTRACTOR PM/OH**	**TOTAL**	
1	**Pre-Design Testing/Site Investigation//Design Costs**	**Remedial Design and Pre-Design Sampling & Testing**	**1**	**LS**	**$4,374,992.22**	**$3,645,826.85**	**$546,874.03**	**$182,291.34**	**$ 4,374,992**	
		Bathymetric Survey	3	DAY	$3,000.00	$9,000.00	$1,350.00	$450.00		
		Pre-Design Treatability/Pilot Studies	1	LS	$500,000.00	$500,000.00	$75,000.00	$25,000.00		
		Full-Scale Remedial Design (4% of Remediation Costs)	1	LS	$2,469,461.48	$2,469,461.48	$370,419.22	$123,473.07		
		Coordination With Agencies/Stakeholders/Permitting (1% of Remediation Costs)	1	LS	$617,365.37	$617,365.37	$92,604.81	$30,868.27		
		Geophysical Survey	20	DAY	$2,500.00	$50,000.00	$7,500.00	$2,500.00		
2	**Includes all labor, equipment, & odc costs to complete pre-remedial site work**	**Pre-Remediation Site Work**	**9,500**	**LF**	**$42.16**	**$333,805.40**	**$50,070.81**	**$16,690.27**	**$ 400,566**	
		Temporary Access Road Constructi	23,464	SY	$11.35	$266,316.40	$39,947.46	$13,315.82		PER MEANS 01 55 23.50.0100
		Chain-Link Fence (Temporary)	2,000	LF	$7.13	$14,260.00	$2,139.00	$713.00		PER MEANS 01 56 26.50.0100
		Prepare Docking/Staging Area	933	SY	$11.80	$11,009.40	$1,651.41	$550.47		PER MEANS 31 22 16.10.0010
		Establish Required Vertical Control Points & Tide Gauges	1	LS	$10,000.00	$10,000.00	$1,500.00	$500.00		ALLOWANCE
		Set-Up Temporary Water Treatment System-Site Prep	1	LS	$32,219.60	$32,219.60	$4,832.94	$1,610.98		ALLOWANCE
3	**Includes all labor, equipment, & odc costs for Dewatering & Treating Dredge Cell Water**	**Dewatering/Dredge Cell Water Treatment**	**1**	**LS**	**$612,000.00**	**$510,000.00**	**$76,500.00**	**$25,500.00**	**$ 612,000**	
		Mobilization/Demobilization	1	LS	$ 150,000.00	$150,000.00	$22,500.00	$7,500.00		
		Installation of Surface water Treatm	1	LS	$ 200,000.00	$200,000.00	$30,000.00	$10,000.00		
		Power Drop	1	LS	$ 75,000.00	$75,000.00	$11,250.00	$3,750.00		
		Instrumentation & Control Allowance	1	LS	$ 25,000.00	$25,000.00	$3,750.00	$1,250.00		
		Treatment System Building	1	LS	$ 60,000.00	$60,000.00	$9,000.00	$3,000.00		

TABLE 5B

Base Implementation, Removal, and In-Situ Stabilization Costs for Alternative 7: Dredging entire soft sediment column, stabilize 3-5 feet of native sediment in targeted areas, and capping with treatment layer, isolation layer, and armor layer.

Gowanus Canal Feasibility Study

Brooklyn, New York

BASE IMPLEMENTATION COSTS										
PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL	
4	Includes all labor, equipment, & odc costs for project long facility costs	Facility Costs	72	MO	$139,020.00	$8,341,200.00	$1,251,180.00	$417,060.00	$ 10,009,440	
		Office Facilities	72	MO	$5,200.00	$374,400.00	$56,160.00	$18,720.00		ALLOWANCE: (2) Trailers
		Jobsite Sanitation	72	MO	$750.00	$54,000.00	$8,100.00	$2,700.00		PER MEANS 01 56 26.50.0020
		Site Security	72	MO	$5,400.00	$388,800.00	$58,320.00	$19,440.00		PER MEANS 31 22 16.10.0010
		Site Utilities	72	MO	$4,500.00	$324,000.00	$48,600.00	$16,200.00		ALLOWANCE: Phone/Power/Misc
		Temporary Storage Area (10 Acres)	72	MO	$100,000.00	$7,200,000.00	$1,080,000.00	$360,000.00		ALLOWANCE: (3) Conex Boxes
5	Includes all labor, equipment, & odc costs for upgrading and restoring Existing Bulkheads	Upgrade and Restore Existing Bulkheads	16,800	LF	$2,951.21	$41,316,958.80	$6,197,543.82	$2,065,847.94	$ 49,580,351	
		Debris Removal	320	HR	$230.00	$73,600.00	$11,040.00	$3,680.00		
		Sheet Piling Installation	647,600	SF	$60.00	$38,856,000.00	$5,828,400.00	$1,942,800.00		PER MEANS 31 41 16.10.1800
		Tie Back Installation	648	TON	$2,250.00	$1,457,100.00	$218,565.00	$72,855.00		PER MEANS 31 41 16.10.3000
		6" Submersible Pumps	2	EA	$50,000.00	$100,000.00	$15,000.00	$5,000.00		ALLOWANCE
		Crushed Stone Backfill	19,444	CY	$42.70	$830,258.80	$124,538.82	$41,512.94		PER MEANS 32 11 23.23.1513
6	Includes all labor, equipment, & odc costs for Turbidity Monitoring Activities	Monitoring Costs - Short Term	1	LS	$480,120.00	$400,100.00	$60,015.00	$20,005.00	$ 480,120	
		YSI Unit Rental	1	LS	$6,500.00	$6,500.00	$975.00	$325.00		
		Jon Boat Purchase	1	LS	$15,000.00	$15,000.00	$2,250.00	$750.00		
		Sample Collection Labor	36.25	MO	$5,280.00	$191,400.00	$28,710.00	$9,570.00		
		Air Monitoring	36.00	MO	$3,600.00	$129,600.00	$19,440.00	$6,480.00		
		Air Monitoring Sample Analysis	36.00	MO	$1,600.00	$57,600.00	$8,640.00	$2,880.00		

TABLE 5B

Base Implementation, Removal, and In-Situ Stabilization Costs for Alternative 7: Dredging entire soft sediment column, stabilize 3-5 feet of native sediment in targeted areas, and capping with treatment layer, isolation layer, and armor layer.

Gowanus Canal Feasibility Study

Brooklyn, New York

BASE IMPLEMENTATION COSTS									
PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL
7	**Includes all labor, equipment, & odc costs for ISS Sampling**	**ISS Confirmation Sampling**	**1**	**LS**	**$391,260.00**	**$326,050.00**	**$48,907.50**	**$16,302.50**	**$ 391,260**
		Sampling Barge/Drill Rig	30	DAY	$6,500.00	$195,000.00	$29,250.00	$9,750.00	
		Crane	15	DAY	$3,750.00	$56,250.00	$8,437.50	$2,812.50	
		Sample Collection Labor	2.05	MO	$5,280.00	$10,800.00	$1,620.00	$540.00	
		Sampling (ASTM D1633/ASTM D5084/APLC/TCLP)	80	EA	$800.00	$64,000.00	$9,600.00	$3,200.00	
8	**Includes all labor, equipment, & odc costs for Confirmation Sampling/Surveys**	**Confirmation Sampling/Surveys**	**1**	**LS**	**$262,800.00**	**$219,000.00**	**$32,850.00**	**$10,950.00**	**$ 262,800**
		Jon Boat Purchase	1	LS	$15,000.00	$15,000.00	$2,250.00	$750.00	
		Sample Collection Labor	12.00	DAY	$4,500.00	$54,000.00	$8,100.00	$2,700.00	
		Bathymetric Survey	50	DAY	$3,000.00	$150,000.00	$22,500.00	$7,500.00	
		ESTIMATED COST							**$ 66,111,529**
						Contingency	**30%**		**$ 19,833,459**
						Construction Management/ Oversight	**6%**		**$ 3,966,692**
						Project Management	**5%**		**$ 3,305,576**
		TOTAL BASE IMPLEMENTATION COSTS							**$ 93,217,256**

TABLE 5B

Base Implementation, Removal, and In-Situ Stabilization Costs for Alternative 7: Dredging entire soft sediment column, stabilize 3-5 feet of native sediment in targeted areas, and capping with treatment layer, isolation layer, and armor layer.

Gowanus Canal Feasibility Study

Brooklyn, New York

BASE IMPLEMENTATION COSTS

PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL	

REMEDIATION: RTA#1

PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL	
1	**Design Costs & Permitting Costs**	**Remedial Design and Permitting Costs**	**1**	**LS**	**$599,381.61**	**$499,484.68**	**$74,922.70**	**$24,974.23**	**$ 599,382**	
		Full-Scale Remedial Design (4% of Remediation Costs)	1	LS	$399,587.74	$399,587.74	$59,938.16	$19,979.39		
		Coordination With Agencies/Stakeholders/Permitting (1% of Remediation Costs)	1	LS	$99,896.94	$99,896.94	$14,984.54	$4,994.85		
2	**Includes all labor, equipment, & odc costs for constructing Sheetpile Cells**	**Installation and Removal of Sheet Pile Cells**	**1,100**	**LF**	**$1,264.25**	**$1,158,900.00**	**$173,835.00**	**$57,945.00**	**$ 1,390,680**	
		Sheet Piling Installation	15,000	SF	$39.53	$592,950.00	$88,942.50	$29,647.50		PER MEANS 31 41 16.10.1800
		Sheet Piling Extraction/Reinstallatio	33,000	SF	$17.15	$565,950.00	$84,892.50	$28,297.50		PER MEANS 31 41 16.10.1300
3	**Includes all labor, equipment, & odc costs for placing Silt Curtain in RTA 3**	**Silt Curtain**	**0**	**LF**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$ -**	
		Silt Curtain	0	SF	$1.00	$0.00	$0.00	$0.00		
4	**Includes all labor, equipment, & odc costs for Cap Placement**	**Cap Placement**	**31,721**	**CY**	**$102.20**	**$2,701,471.82**	**$405,220.77**	**$135,073.59**	**$ 3,241,766**	
		Clay Import	7,930	CY	$200.00	$1,586,068.88	$237,910.33	$79,303.44		PER MEANS 31 23 23.15.6000
		Sand Import	3,965	CY	$23.00	$91,198.96	$13,679.84	$4,559.95		PER MEANS 04 05 13.95.0200
		Habitat Sand Import	3,965	CY	$23.00	$91,198.96	$13,679.84	$4,559.95		PER MEANS 04 05 13.95.0200
		Gravel Import	3,965	CY	$28.00	$111,024.82	$16,653.72	$5,551.24		
		Armor Import	11,896	CY	$31.50	$374,708.77	$56,206.32	$18,735.44		PER MEANS 31 37 13.10.0011
		Material Placement-Equipment	79	DAY	$2,580.00	$204,602.89	$30,690.43	$10,230.14		
		Material Placement-Labor	79	DAY	$3,060.00	$242,668.54	$36,400.28	$12,133.43		

TABLE 5B

Base Implementation, Removal, and In-Situ Stabilization Costs for Alternative 7: Dredging entire soft sediment column, stabilize 3-5 feet of native sediment in targeted areas, and capping with treatment layer, isolation layer, and armor layer.

Gowanus Canal Feasibility Study

Brooklyn, New York

BASE IMPLEMENTATION COSTS									
PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL
5	**Includes all labor, equipment, & odc costs for Dewatering & Treating Dredge Cell Water**	**Dewatering/Dredge Cell Water Treatment**	**69,160,000**	**GAL**	**$0.04**	**$2,272,145.90**	**$340,821.88**	**$113,607.29**	**$ 2,726,575**
		Power/Electric	3.42	MO	$10,000.00	$34,166.67	$5,125.00	$1,708.33	
		Treatment System Operation	2,460	HR	$74.53	$183,340.57	$27,501.08	$9,167.03	
		Treatment System Rental	3.42	MO	$75,000.00	$256,250.00	$38,437.50	$12,812.50	
		Treatment Chemicals	3.42	MO	$10,000.00	$34,166.67	$5,125.00	$1,708.33	
		Replacement Carbon	882,111	LBS	$2.00	$1,764,222.00	$264,633.30	$88,211.10	
6	**Includes all labor, equipment, & odc costs for Sediment Removal via Mechanical Dredge**	**Dredging: Debris and Sediment Removal**	**82,000**	**CY**	**$29.31**	**$2,003,181.64**	**$300,477.25**	**$100,159.08**	**$ 2,403,818**
		Transfer Pump	103	DAY	$1,000.00	$102,500.00	$15,375.00	$5,125.00	
		Barge With Clamshell	103	DAY	$1,380.00	$141,450.00	$21,217.50	$7,072.50	
		Barge With Excavator	103	DAY	$800.00	$82,000.00	$12,300.00	$4,100.00	
		Scow	103	DAY	$180.00	$18,450.00	$2,767.50	$922.50	
		Scow	103	DAY	$180.00	$18,450.00	$2,767.50	$922.50	
		Scow	103	DAY	$180.00	$18,450.00	$2,767.50	$922.50	
		Superintendent	103	DAY	$1,566.45	$160,561.36	$24,084.20	$8,028.07	
		Tug Operator	103	DAY	$1,213.83	$124,417.62	$18,662.64	$6,220.88	
		Tug Operator	103	DAY	$1,213.83	$124,417.62	$18,662.64	$6,220.88	
		Tug Operator	103	DAY	$1,213.83	$124,417.62	$18,662.64	$6,220.88	
		Crane Operator	103	DAY	$1,362.13	$139,618.58	$20,942.79	$6,980.93	
		Equipment Operator	103	DAY	$1,362.13	$139,618.58	$20,942.79	$6,980.93	
		Dredge Laborer	103	DAY	$945.51	$96,915.13	$14,537.27	$4,845.76	
		Dredge Laborer	103	DAY	$945.51	$96,915.13	$14,537.27	$4,845.76	
		FOGM	103	DAY	$6,000.00	$615,000.00	$92,250.00	$30,750.00	

TABLE 5B

Base Implementation, Removal, and In-Situ Stabilization Costs for Alternative 7: Dredging entire soft sediment column, stabilize 3-5 feet of native sediment in targeted areas, and capping with treatment layer, isolation layer, and armor layer.

Gowanus Canal Feasibility Study

Brooklyn, New York

BASE IMPLEMENTATION COSTS									
PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL
7	Includes all labor, equipment, & odc costs for Dewatering Dredged Material	Dredging: Dewatering	1	LS	$226,854.34	$189,045.28	$28,356.79	$9,452.26	$ 226,854
		Dewatering Pump	103	DAY	$750.00	$76,875.00	$11,531.25	$3,843.75	
		Pump Fuel	103	DAY	$200.00	$20,500.00	$3,075.00	$1,025.00	
		Pump Laborer	1,230	HR	$74.53	$91,670.28	$13,750.54	$4,583.51	
		ESTIMATED COST							$ 10,589,075
						Contingency	30%		$ 3,176,723
						Construction Management/ Oversight	6%		$ 635,345
						Project Management	5%		$ 529,454
		TOTAL RTA#1 REMEDIATION							$ 14,930,596

TABLE 5B

Base Implementation, Removal, and In-Situ Stabilization Costs for Alternative 7: Dredging entire soft sediment column, stabilize 3-5 feet of native sediment in targeted areas, and capping with treatment layer, isolation layer, and armor layer.

Gowanus Canal Feasibility Study

Brooklyn, New York

BASE IMPLEMENTATION COSTS

PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL	

REMEDIATION: RTA#2

PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL	
1	**Design Costs & Permitting Costs**	**Remedial Design and Pre-Design Sampling & Testing**	**1**	**LS**	**$1,424,473.68**	**$1,187,061.40**	**$178,059.21**	**$59,353.07**	**$ 1,424,474**	
		Full-Scale Remedial Design (4% of Remediation Costs)	1	LS	$949,649.12	$949,649.12	$142,447.37	$47,482.46		
		Coordination With Agencies/Stakeholders/Permitting (1% of Remediation Costs)	1	LS	$237,412.28	$237,412.28	$35,611.84	$11,870.61		
2	**Includes all labor, equipment, & odc costs for constructing Sheetpile Cells**	**Installation and Removal of Sheet Pile Cells**	**1,400**	**LF**	**$1,256.69**	**$1,466,140.00**	**$219,921.00**	**$73,307.00**	**$ 1,759,368**	
		Sheet Piling Installation	18,000	SF	$39.53	$711,540.00	$106,731.00	$35,577.00		PER MEANS 31 41 16.10.1800
		Sheet Piling Extraction/Reinstallatio	44,000	SF	$17.15	$754,600.00	$113,190.00	$37,730.00		PER MEANS 31 41 16.10.1300
3	**Includes all labor, equipment, & odc costs for placing Silt Curtain in RTA 3**	**Silt Curtain**	**0**	**LF**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$ -**	
		Silt Curtain	0	SF	$1.00	$0.00	$0.00	$0.00		

TABLE 5B

Base Implementation, Removal, and In-Situ Stabilization Costs for Alternative 7: Dredging entire soft sediment column, stabilize 3-5 feet of native sediment in targeted areas, and capping with treatment layer, isolation layer, and armor layer.

Gowanus Canal Feasibility Study

Brooklyn, New York

BASE IMPLEMENTATION COSTS										
PAY ITEM No.	**PAY ITEM DESCRIPTION**	**LINE ITEM DESCRIPTION**	**QUANTITY**	**UNIT**	**UNIT PRICE**	**CONTRACTOR COST**	**CONTRACTOR FEE**	**CONTRACTOR PM/OH**	**TOTAL**	
4	**Includes all labor, equipment, & odc costs for Cap Placement**	**Cap Placement**	**76,777**	**CY**	**$102.20**	**$6,538,516.59**	**$980,777.49**	**$326,925.83**	**$ 7,846,220**	
		Clay Import	19,194	CY	$200.00	$3,838,847.26	$575,827.09	$191,942.36		PER MEANS 31 23 23.15.6000
		Sand Import	9,597	CY	$23.00	$220,733.72	$33,110.06	$11,036.69		PER MEANS 04 05 13.95.0200
		Habitat Sand Import	9,597	CY	$23.00	$220,733.72	$33,110.06	$11,036.69		PER MEANS 04 05 13.95.0200
		Gravel Import	9,597	CY	$28.00	$268,719.31	$40,307.90	$13,435.97		
		Armor Import	28,791	CY	$31.50	$906,927.66	$136,039.15	$45,346.38		PER MEANS 31 37 13.10.0011
		Material Placement-Equipment	192	DAY	$2,580.00	$495,211.30	$74,281.69	$24,760.56		
		Material Placement-Labor	192	DAY	$3,060.00	$587,343.63	$88,101.54	$29,367.18		
5	**Includes all labor, equipment, & odc costs for Dewatering & Treating Dredge Cell Water**	**Dewatering/Dredge Cell Water Treatment**	**181,200,000**	**GAL**	**$0.04**	**$6,015,977.62**	**$902,396.64**	**$300,798.88**	**$ 7,219,173**	
		Power/Electric	9.38	MO	$10,000.00	$93,750.00	$14,062.50	$4,687.50		
		Treatment System Operation	6,750	HR	$74.53	$503,068.62	$75,460.29	$25,153.43		
		Treatment System Rental	9.38	MO	$75,000.00	$703,125.00	$105,468.75	$35,156.25		
		Treatment Chemicals	9.38	MO	$10,000.00	$93,750.00	$14,062.50	$4,687.50		
		Replacement Carbon	2,311,142	LBS	$2.00	$4,622,284.00	$693,342.60	$231,114.20		

TABLE 5B

Base Implementation, Removal, and In-Situ Stabilization Costs for Alternative 7: Dredging entire soft sediment column, stabilize 3-5 feet of native sediment in targeted areas, and capping with treatment layer, isolation layer, and armor layer.

Gowanus Canal Feasibility Study

Brooklyn, New York

BASE IMPLEMENTATION COSTS									
PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL
6	**Includes all labor, equipment, & odc costs for Sediment Removal via Mechanical Dredge**	**Dredging: Debris and Sediment Removal**	**225,000**	**CY**	**$29.31**	**$5,496,534.98**	**$824,480.25**	**$274,826.75**	**$ 6,595,842**
		Transfer Pump	281	DAY	$1,000.00	$281,250.00	$42,187.50	$14,062.50	
		Barge With Clamshell	281	DAY	$1,380.00	$388,125.00	$58,218.75	$19,406.25	
		Barge With Excavator	281	DAY	$800.00	$225,000.00	$33,750.00	$11,250.00	
		Scow	281	DAY	$180.00	$50,625.00	$7,593.75	$2,531.25	
		Scow	281	DAY	$180.00	$50,625.00	$7,593.75	$2,531.25	
		Scow	281	DAY	$180.00	$50,625.00	$7,593.75	$2,531.25	
		Superintendent	281	DAY	$1,566.45	$440,564.71	$66,084.71	$22,028.24	
		Tug Operator	281	DAY	$1,213.83	$341,389.81	$51,208.47	$17,069.49	
		Tug Operator	281	DAY	$1,213.83	$341,389.81	$51,208.47	$17,069.49	
		Tug Operator	281	DAY	$1,213.83	$341,389.81	$51,208.47	$17,069.49	
		Crane Operator	281	DAY	$1,362.13	$383,099.75	$57,464.96	$19,154.99	
		Equipment Operator	281	DAY	$1,362.13	$383,099.75	$57,464.96	$19,154.99	
		Dredge Laborer	281	DAY	$945.51	$265,925.66	$39,888.85	$13,296.28	
		Dredge Laborer	281	DAY	$945.51	$265,925.66	$39,888.85	$13,296.28	
		FOGM	281	DAY	$6,000.00	$1,687,500.00	$253,125.00	$84,375.00	
7	**Includes all labor, equipment, & odc costs for Dewatering Dredged Material**	**Dredging: Dewatering**	**1**	**LS**	**$320,625.00**	**$267,187.50**	**$40,078.13**	**$13,359.38**	**$ 320,625**
		Dewatering Pump	281	DAY	$750.00	$210,937.50	$31,640.63	$10,546.88	
		Pump Fuel	281	DAY	$200.00	$56,250.00	$8,437.50	$2,812.50	
		Pump Laborer	3,375	HR	$0.00	$0.00	$0.00	$0.00	
		ESTIMATED COST							**$ 25,165,702**
						Contingency	**30%**		**$ 7,549,711**
						Construction Management/ Oversight	**6%**		**$ 1,509,942**
						Project Management	**5%**		**$ 1,258,285**
		TOTAL RTA#2 REMEDIATION							**$ 35,483,639**

TABLE 5B

Base Implementation, Removal, and In-Situ Stabilization Costs for Alternative 7: Dredging entire soft sediment column, stabilize 3-5 feet of native sediment in targeted areas, and capping with treatment layer, isolation layer, and armor layer.

Gowanus Canal Feasibility Study

Brooklyn, New York

BASE IMPLEMENTATION COSTS

PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL

REMEDIATION: RTA#3

PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL	
1	**Design Costs & Permitting Costs**	**Remedial Design and Pre-Design Sampling & Testing**	**1**	**LS**	**$1,144,331.20**	**$953,609.34**	**$143,041.40**	**$47,680.47**	**$ 1,144,331**	
		Full-Scale Remedial Design (4% of Remediation Costs)	1	LS	$762,887.47	$762,887.47	$114,433.12	$38,144.37		
		Coordination With Agencies/Stakeholders/Permitting (1% of Remediation Costs)	1	LS	$190,721.87	$190,721.87	$28,608.28	$9,536.09		
2	**Includes all labor, equipment, & odc costs for constructing Sheetpile Cells**	**Installation and Removal of Sheet Pile Cells**	**0**	**LF**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$ -**	
		Sheet Piling Installation	0	SF	$39.53	$0.00	$0.00	$0.00		PER MEANS 31 41 16.10.1800
		Sheet Piling Extraction/Reinstallatio	0	SF	$17.15	$0.00	$0.00	$0.00		PER MEANS 31 41 16.10.1300
3	**Includes all labor, equipment, & odc costs for placing Silt Curtain in RTA 3**	**Silt Curtain**	**1,500**	**LF**	**$36.00**	**$45,000.00**	**$6,750.00**	**$2,250.00**	**$ 54,000**	
		Silt Curtain	45,000	SF	$1.00	$45,000.00	$6,750.00	$2,250.00		

TABLE 5B

Base Implementation, Removal, and In-Situ Stabilization Costs for Alternative 7: Dredging entire soft sediment column, stabilize 3-5 feet of native sediment in targeted areas, and capping with treatment layer, isolation layer, and armor layer.

Gowanus Canal Feasibility Study

Brooklyn, New York

BASE IMPLEMENTATION COSTS										
PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL	
4	**Includes all labor, equipment, & odc costs for Cap Placement**	**Cap Placement**	**94,935**	**CY**	**$80.09**	**$6,336,223.51**	**$950,433.53**	**$316,811.18**	**$ 7,603,468**	
		Clay Import	13,562	CY	$200.00	$2,712,400.00	$406,860.00	$135,620.00		PER MEANS 31 23 23.15.6000
		Sand Import	13,562	CY	$23.00	$311,931.19	$46,789.68	$15,596.56		PER MEANS 04 05 13.95.0200
		Habitat Sand Import	13,562	CY	$23.00	$311,931.19	$46,789.68	$15,596.56		PER MEANS 04 05 13.95.0200
		Gravel Import	13,562	CY	$28.00	$379,742.32	$56,961.35	$18,987.12		
		Armor Import	40,687	CY	$31.50	$1,281,630.32	$192,244.55	$64,081.52		PER MEANS 31 37 13.10.0011
		Material Placement-Equipment	237	DAY	$2,580.00	$612,333.03	$91,849.95	$30,616.65		
		Material Placement-Labor	237	DAY	$3,060.00	$726,255.46	$108,938.32	$36,312.77		
5	**Includes all labor, equipment, & odc costs for Dewatering & Treating Dredge Cell Water**	**Dewatering/Dredge Cell Water Treatment**	**22,480,000**	**GAL**	**$0.12**	**$2,314,016.48**	**$347,102.47**	**$115,700.82**	**$ 2,776,820**	
		Power/Electric	11.71	MO	$10,000.00	$117,083.33	$17,562.50	$5,854.17		
		Treatment System Operation	8,430	HR	$74.53	$628,276.81	$94,241.52	$31,413.84		
		Treatment System Rental	11.71	MO	$75,000.00	$878,125.00	$131,718.75	$43,906.25		
		Treatment Chemicals	11.71	MO	$10,000.00	$117,083.33	$17,562.50	$5,854.17		
		Replacement Carbon	286,724	LBS	$2.00	$573,448.00	$86,017.20	$28,672.40		

TABLE 5B

Base Implementation, Removal, and In-Situ Stabilization Costs for Alternative 7: Dredging entire soft sediment column, stabilize 3-5 feet of native sediment in targeted areas, and capping with treatment layer, isolation layer, and armor layer.

Gowanus Canal Feasibility Study

Brooklyn, New York

BASE IMPLEMENTATION COSTS									
PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL
6	**Includes all labor, equipment, & odc costs for Sediment Removal via Mechanical Dredge**	**Dredging: Debris and Sediment Removal**	**281,000**	**CY**	**$29.31**	**$6,864,561.46**	**$1,029,684.22**	**$343,228.07**	**$ 8,237,474**
		Transfer Pump	351	DAY	$1,000.00	$351,250.00	$52,687.50	$17,562.50	
		Barge With Clamshell	351	DAY	$1,380.00	$484,725.00	$72,708.75	$24,236.25	
		Barge With Excavator	351	DAY	$800.00	$281,000.00	$42,150.00	$14,050.00	
		Scow	351	DAY	$180.00	$63,225.00	$9,483.75	$3,161.25	
		Scow	351	DAY	$180.00	$63,225.00	$9,483.75	$3,161.25	
		Scow	351	DAY	$180.00	$63,225.00	$9,483.75	$3,161.25	
		Superintendent	351	DAY	$1,566.45	$550,216.38	$82,532.46	$27,510.82	
		Tug Operator	351	DAY	$1,213.83	$426,357.95	$63,953.69	$21,317.90	
		Tug Operator	351	DAY	$1,213.83	$426,357.95	$63,953.69	$21,317.90	
		Tug Operator	351	DAY	$1,213.83	$426,357.95	$63,953.69	$21,317.90	
		Crane Operator	351	DAY	$1,362.13	$478,449.02	$71,767.35	$23,922.45	
		Equipment Operator	351	DAY	$1,362.13	$478,449.02	$71,767.35	$23,922.45	
		Dredge Laborer	351	DAY	$945.51	$332,111.60	$49,816.74	$16,605.58	
		Dredge Laborer	351	DAY	$945.51	$332,111.60	$49,816.74	$16,605.58	
		FOGM	351	DAY	$6,000.00	$2,107,500.00	$316,125.00	$105,375.00	
7	**Includes all labor, equipment, & odc costs for Dewatering Dredged Material**	**Dredging: Dewatering**	**1**	**LS**	**$400,425.00**	**$333,687.50**	**$50,053.13**	**$16,684.38**	**$ 400,425**
		Dewatering Pump	351	DAY	$750.00	$263,437.50	$39,515.63	$13,171.88	
		Pump Fuel	351	DAY	$200.00	$70,250.00	$10,537.50	$3,512.50	
		Pump Laborer	4,215	HR	$0.00	$0.00	$0.00	$0.00	
		ESTIMATED COST							**$ 20,216,518**
						Contingency	**30%**		**$ 6,064,955**
						Construction Management/ Oversight	**6%**		**$ 1,212,991**
						Project Management	**5%**		**$ 1,010,826**
		TOTAL RTA#3 REMEDIATION							**$ 28,505,290**

TABLE 5B

Base Implementation, Removal, and In-Situ Stabilization Costs for Alternative 7: Dredging entire soft sediment column, stabilize 3-5 feet of native sediment in targeted areas, and capping with treatment layer, isolation layer, and armor layer.

Gowanus Canal Feasibility Study

Brooklyn, New York

BASE IMPLEMENTATION COSTS

PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL	

ISS: RTA#1

PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL	
1	**Pre-Design Testing/Site Investigation/Design Costs**	**Remedial Design and Pre-Design Sampling & Testing**	**1**	**LS**	**$614,528.88**	**$512,107.40**	**$76,816.11**	**$25,605.37**	**$ 614,529**	
		Pre-Design Treatability Sampling	1	LS	$ 100,000.00	$100,000.00	$15,000.00	$5,000.00		
		Pilot Test	1	LS	$ 400,000.00	$400,000.00	$60,000.00	$20,000.00		
		Coordination With Agencies/Stakeholders/Permitting (1% of Remediation Costs)	1	LS	$ 12,107.40	$12,107.40	$1,816.11	$605.37		
2	**Includes all labor, equipment, & odc costs to complete pre-remedial site work**	**Pre-Remediation Site Work**	**1**	**LS**	**$39,947.46**	**$33,289.55**	**$4,993.43**	**$1,664.48**	**$ 39,947**	
		Temporary Access Road Constructi	2,933	SY	$ 11.35	$33,289.55	$4,993.43	$1,664.48		PER MEANS 01 55 23.50.0100
3	**Includes all labor, equipment, & odc costs for project long facility costs**	**Facility Costs**	**1.4**	**MO**	**$20,220.00**	**$23,298.77**	**$3,494.81**	**$1,164.94**	**$ 27,959**	
		Office Facilities	1.4	MO	$ 5,200.00	$7,190.12	$1,078.52	$359.51		ALLOWANCE: (2) Trailers
		Jobsite Sanitation	1.4	MO	$ 750.00	$1,037.04	$155.56	$51.85		PER MEANS 01 56 26.50.0020
		Site Security	1.4	MO	$ 5,400.00	$7,466.67	$1,120.00	$373.33		PER MEANS 31 22 16.10.0010
		Site Utilities	1.4	MO	$ 4,500.00	$6,222.22	$933.33	$311.11		ALLOWANCE: Phone/Power/Misc
		Temporary Storage	1.4	MO	$ 1,000.00	$1,382.72	$207.41	$69.14		ALLOWANCE: (3) Conex Boxes

TABLE 5B

Base Implementation, Removal, and In-Situ Stabilization Costs for Alternative 7: Dredging entire soft sediment column, stabilize 3-5 feet of native sediment in targeted areas, and capping with treatment layer, isolation layer, and armor layer.

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BASE IMPLEMENTATION COSTS									
PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL
4	**Includes all labor, equipment, & odc costs for Sediment Solidification**	**RTA #1: In-Situ Sediment Solidification**	**15,556**	**TON**	**$73.47**	**$952,361.92**	**$142,854.29**	**$47,618.10**	**$ 1,142,834**
		Blast Furnace Slag	1,750	TON	$ 50.00	$87,500.00	$13,125.00	$4,375.00	
		Portland Cement	583	TON	$ 125.00	$72,916.67	$10,937.50	$3,645.83	
		Barge With Deep Soil Auger	41	DAY	$ 1,380.00	$57,244.44	$8,586.67	$2,862.22	
		Barge With Deep Soil Auger	41	DAY	$ 1,380.00	$57,244.44	$8,586.67	$2,862.22	
		Scow	41	DAY	$ 180.00	$7,466.67	$1,120.00	$373.33	
		Scow	41	DAY	$ 180.00	$7,466.67	$1,120.00	$373.33	
		Superintendent	41	DAY	$ 1,566.45	$64,978.76	$9,746.81	$3,248.94	
		Tug Operator	41	DAY	$ 1,213.83	$50,351.49	$7,552.72	$2,517.57	
		Tug Operator	41	DAY	$ 1,213.83	$50,351.49	$7,552.72	$2,517.57	
		Auger Operator	41	DAY	$ 1,362.13	$56,503.27	$8,475.49	$2,825.16	
		Equipment Operator	41	DAY	$ 1,362.13	$56,503.27	$8,475.49	$2,825.16	
		Equipment Operator	41	DAY	$ 1,362.13	$56,503.27	$8,475.49	$2,825.16	
		Scowman	41	DAY	$ 945.51	$39,221.30	$5,883.19	$1,961.06	
		Scowman	41	DAY	$ 945.51	$39,221.30	$5,883.19	$1,961.06	
		FOGM	41	DAY	$ 6,000.00	$248,888.89	$37,333.33	$12,444.44	
5	**Includes all labor, equipment, & odc costs for Dewatering & Treating Dredge Cell Water**	**ISS RTA Cell Water Treatment (Costs assume that startup and initial purchase costs are captured under the base alternative. Costs included for ISS are for system operation and reagent replacement.)**	**1.4**	**MO**	**$251,658.30**	**$289,976.64**	**$43,496.50**	**$14,498.83**	**$ 347,972**
		Power Drop	1.0	LS	$75,000.00	$75,000.00	$11,250.00	$3,750.00	
		Power/Electric	1.4	MO	$10,000.00	$13,827.16	$2,074.07	$691.36	
		Treatment System Operation	720	HR	$74.53	$53,660.65	$8,049.10	$2,683.03	
		Treatment Chemicals	1.4	MO	$10,000.00	$13,827.16	$2,074.07	$691.36	
		Replacement Carbon	66,831	LBS	$2.00	$133,661.67	$20,049.25	$6,683.08	
		ESTIMATED COST							**$ 2,173,241**
						Contingency	**30%**		**$ 651,972**
						Remedial Design	**6%**		**$ 130,394**
						Construction Management/ Oversight	**6%**		**$ 130,394**
						Project Management	**5%**		**$ 108,662**
		TOTAL ESTIMATED COST							**$ 3,194,664**
		COST PER TON							**$ 205**

TABLE 5B

Base Implementation, Removal, and In-Situ Stabilization Costs for Alternative 7: Dredging entire soft sediment column, stabilize 3-5 feet of native sediment in targeted areas, and capping with treatment layer, isolation layer, and armor layer.

Gowanus Canal Feasibility Study

Brooklyn, New York

BASE IMPLEMENTATION COSTS

PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL	

ISS: RTA#2 MAIN CANAL

PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL	
1	**Pre-Design Testing/Site Investigation/Design Costs**	**Remedial Design and Pre-Design Sampling & Testing**	**1**	**LS**	**$644,969.50**	**$537,474.58**	**$80,621.19**	**$26,873.73**	**$ 644,969**	
		Pre-Design Treatability Sampling	1	LS	$ 100,000.00	$100,000.00	$15,000.00	$5,000.00		
		Pilot Test	1	LS	$ 400,000.00	$400,000.00	$60,000.00	$20,000.00		
		Coordination With Agencies/Stakeholders/Permitting (1% of Remediation Costs)	1	LS	$ 37,474.58	$37,474.58	$5,621.19	$1,873.73		
2	**Includes all labor, equipment, & odc costs to complete pre-remedial site work**	**Pre-Remediation Site Work**	**1**	**LS**	**$39,947.46**	**$33,289.55**	**$4,993.43**	**$1,664.48**	**$ 39,947**	
		Temporary Access Road Constructi	2,933	SY	$ 11.35	$33,289.55	$4,993.43	$1,664.48		PER MEANS 01 55 23.50.0100
3	**Includes all labor, equipment, & odc costs for project long facility costs**	**Facility Costs**	**4.4**	**MO**	**$20,220.00**	**$73,779.42**	**$11,066.91**	**$3,688.97**	**$ 88,535**	
		Office Facilities	4.4	MO	$ 5,200.00	$22,768.72	$3,415.31	$1,138.44		ALLOWANCE: (2) Trailers
		Jobsite Sanitation	4.4	MO	$ 750.00	$3,283.95	$492.59	$164.20		PER MEANS 01 56 26.50.0020
		Site Security	4.4	MO	$ 5,400.00	$23,644.44	$3,546.67	$1,182.22		PER MEANS 31 22 16.10.0010
		Site Utilities	4.4	MO	$ 4,500.00	$19,703.70	$2,955.56	$985.19		ALLOWANCE: Phone/Power/Misc
		Temporary Storage	4.4	MO	$ 1,000.00	$4,378.60	$656.79	$218.93		ALLOWANCE: (3) Conex Boxes

TABLE 5B

Base Implementation, Removal, and In-Situ Stabilization Costs for Alternative 7: Dredging entire soft sediment column, stabilize 3-5 feet of native sediment in targeted areas, and capping with treatment layer, isolation layer, and armor layer.

Gowanus Canal Feasibility Study

Brooklyn, New York

BASE IMPLEMENTATION COSTS									
PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL
4	**Includes all labor, equipment, & odc costs for Sediment Solidification**	**ISS: RTA#2 MAIN CANAL**	**49,259**	**TON**	**$73.47**	**$3,015,812.76**	**$452,371.91**	**$150,790.64**	**$ 3,618,975**
		Blast Furnace Slag	5,542	TON	$ 50.00	$277,083.33	$41,562.50	$13,854.17	
		Portland Cement	1,847	TON	$ 125.00	$230,902.78	$34,635.42	$11,545.14	
		Barge With Deep Soil Auger	131	DAY	$ 1,380.00	$181,274.07	$27,191.11	$9,063.70	
		Barge With Deep Soil Auger	131	DAY	$ 1,380.00	$181,274.07	$27,191.11	$9,063.70	
		Scow	131	DAY	$ 180.00	$23,644.44	$3,546.67	$1,182.22	
		Scow	131	DAY	$ 180.00	$23,644.44	$3,546.67	$1,182.22	
		Superintendent	131	DAY	$ 1,566.45	$205,766.08	$30,864.91	$10,288.30	
		Tug Operator	131	DAY	$ 1,213.83	$159,446.37	$23,916.96	$7,972.32	
		Tug Operator	131	DAY	$ 1,213.83	$159,446.37	$23,916.96	$7,972.32	
		Auger Operator	131	DAY	$ 1,362.13	$178,927.03	$26,839.05	$8,946.35	
		Equipment Operator	131	DAY	$ 1,362.13	$178,927.03	$26,839.05	$8,946.35	
		Equipment Operator	131	DAY	$ 1,362.13	$178,927.03	$26,839.05	$8,946.35	
		Scowman	131	DAY	$ 945.51	$124,200.78	$18,630.12	$6,210.04	
		Scowman	131	DAY	$ 945.51	$124,200.78	$18,630.12	$6,210.04	
		FOGM	131	DAY	$ 6,000.00	$788,148.15	$118,222.22	$39,407.41	
5	**Includes all labor, equipment, & odc costs for Dewatering & Treating Dredge Cell Water**	**ISS RTA Cell Water Treatment (Costs assume that startup and initial purchase costs are captured under the base alternative. Costs included for ISS are for system operation and reagent replacement.)**	**4.4**	**MO**	**$175,259.99**	**$639,494.62**	**$95,924.19**	**$31,974.73**	**$ 767,394**
		Power Drop	1.0	LS	$75,000.00	$75,000.00	$11,250.00	$3,750.00	
		Power/Electric	4.4	MO	$10,000.00	$43,786.01	$6,567.90	$2,189.30	
		Treatment System Operation	720	HR	$74.53	$53,660.65	$8,049.10	$2,683.03	
		Treatment Chemicals	4.4	MO	$10,000.00	$43,786.01	$6,567.90	$2,189.30	
		Replacement Carbon	211,631	LBS	$2.00	$423,261.95	$63,489.29	$21,163.10	
		ESTIMATED COST							**$ 5,159,821**
						Contingency	**30%**		**$ 1,547,946**
						Remedial Design	**6%**		**$ 309,589**
						Construction Management/ Oversight	**6%**		**$ 309,589**
						Project Management	**5%**		**$ 257,991**
		TOTAL ESTIMATED COST							**$ 7,584,937**
		COST PER TON							**$ 154**

TABLE 5B

Base Implementation, Removal, and In-Situ Stabilization Costs for Alternative 7: Dredging entire soft sediment column, stabilize 3-5 feet of native sediment in targeted areas, and capping with treatment layer, isolation layer, and armor layer.

Gowanus Canal Feasibility Study

Brooklyn, New York

BASE IMPLEMENTATION COSTS										
PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL	

ISS: RTA#2 4TH STREET AND 6TH STREET TURNING BASINS										
PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL	
1	**Pre-Design Testing/Site Investigation//Design Costs**	**Remedial Design and Pre-Design Sampling & Testing**	**1**	**LS**	**$612,187.30**	**$510,156.08**	**$76,523.41**	**$25,507.80**	**$ 612,187**	
		Pre-Design Treatability Sampling	1	LS	$ 100,000.00	$100,000.00	$15,000.00	$5,000.00		
		Pilot Test	1	LS	$ 400,000.00	$400,000.00	$60,000.00	$20,000.00		
		Coordination With Agencies/Stakeholders/Permitting (1% of Remediation Costs)	1	LS	$ 10,156.08	$10,156.08	$1,523.41	$507.80		
2	**Includes all labor, equipment, & odc costs to complete pre-remedial site work**	**Pre-Remediation Site Work**	**1**	**LS**	**$39,947.46**	**$33,289.55**	**$4,993.43**	**$1,664.48**	**$ 39,947**	
		Temporary Access Road Constructi	2,933	SY	$ 11.35	$33,289.55	$4,993.43	$1,664.48		PER MEANS 01 55 23.50.0100
3	**Includes all labor, equipment, & odc costs for project long facility costs**	**Facility Costs**	**1.2**	**MO**	**$20,220.00**	**$19,415.64**	**$2,912.35**	**$970.78**	**$ 23,299**	
		Office Facilities	1.2	MO	$ 5,200.00	$5,991.77	$898.77	$299.59		ALLOWANCE: (2) Trailers
		Jobsite Sanitation	1.2	MO	$ 750.00	$864.20	$129.63	$43.21		PER MEANS 01 56 26.50.0020
		Site Security	1.2	MO	$ 5,400.00	$6,222.22	$933.33	$311.11		PER MEANS 31 22 16.10.0010
		Site Utilities	1.2	MO	$ 4,500.00	$5,185.19	$777.78	$259.26		ALLOWANCE: Phone/Power/Misc
		Temporary Storage	1.2	MO	$ 1,000.00	$1,152.26	$172.84	$57.61		ALLOWANCE: (3) Conex Boxes

TABLE 5B

Base Implementation, Removal, and In-Situ Stabilization Costs for Alternative 7: Dredging entire soft sediment column, stabilize 3-5 feet of native sediment in targeted areas, and capping with treatment layer, isolation layer, and armor layer.

Gowanus Canal Feasibility Study

Brooklyn, New York

BASE IMPLEMENTATION COSTS									
PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL
4	**Includes all labor, equipment, & odc costs for Sediment Solidification**	**ISS: RTA#2 4TH STREET AND 6TH STREET TURNING BASINS**	**12,963**	**TON**	**$73.47**	**$793,634.94**	**$119,045.24**	**$39,681.75**	**$ 952,362**
		Blast Furnace Slag	1,458	TON	$ 50.00	$72,916.67	$10,937.50	$3,645.83	
		Portland Cement	486	TON	$ 125.00	$60,763.89	$9,114.58	$3,038.19	
		Barge With Deep Soil Auger	35	DAY	$ 1,380.00	$47,703.70	$7,155.56	$2,385.19	
		Barge With Deep Soil Auger	35	DAY	$ 1,380.00	$47,703.70	$7,155.56	$2,385.19	
		Scow	35	DAY	$ 180.00	$6,222.22	$933.33	$311.11	
		Scow	35	DAY	$ 180.00	$6,222.22	$933.33	$311.11	
		Superintendent	35	DAY	$ 1,566.45	$54,148.97	$8,122.35	$2,707.45	
		Tug Operator	35	DAY	$ 1,213.83	$41,959.57	$6,293.94	$2,097.98	
		Tug Operator	35	DAY	$ 1,213.83	$41,959.57	$6,293.94	$2,097.98	
		Auger Operator	35	DAY	$ 1,362.13	$47,086.06	$7,062.91	$2,354.30	
		Equipment Operator	35	DAY	$ 1,362.13	$47,086.06	$7,062.91	$2,354.30	
		Equipment Operator	35	DAY	$ 1,362.13	$47,086.06	$7,062.91	$2,354.30	
		Scowman	35	DAY	$ 945.51	$32,684.42	$4,902.66	$1,634.22	
		Scowman	35	DAY	$ 945.51	$32,684.42	$4,902.66	$1,634.22	
		FOGM	35	DAY	$ 6,000.00	$207,407.41	$31,111.11	$10,370.37	
5	**Includes all labor, equipment, & odc costs for Dewatering & Treating Dredge Cell Water**	**ISS RTA Cell Water Treatment (Costs assume that startup and initial purchase costs are captured under the base alternative. Costs included for ISS are for system operation and reagent replacement.)**	**1.2**	**MO**	**$273,990.11**	**$263,090.64**	**$39,463.60**	**$13,154.53**	**$ 315,709**
		Power Drop	1.0	LS	$75,000.00	$75,000.00	$11,250.00	$3,750.00	
		Power/Electric	1.2	MO	$10,000.00	$11,522.63	$1,728.40	$576.13	
		Treatment System Operation	720	HR	$74.53	$53,660.65	$8,049.10	$2,683.03	
		Treatment Chemicals	1.2	MO	$10,000.00	$11,522.63	$1,728.40	$576.13	
		Replacement Carbon	55,692	LBS	$2.00	$111,384.72	$16,707.71	$5,569.24	
		ESTIMATED COST							**$ 1,943,504**
						Contingency	**30%**		**$ 583,051**
						Remedial Design	**6%**		**$ 116,610**
						Construction Management/ Oversight	**6%**		**$ 116,610**
						Project Management	**5%**		**$ 97,175**
		TOTAL ESTIMATED COST							**$ 2,856,951**
		COST PER TON							**$ 220**

TABLE 5B

Base Implementation, Removal, and In-Situ Stabilization Costs for Alternative 7: Dredging entire soft sediment column, stabilize 3-5 feet of native sediment in targeted areas, and capping with treatment layer, isolation layer, and armor layer.

Gowanus Canal Feasibility Study

Brooklyn, New York

BASE IMPLEMENTATION COSTS

PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL	

ISS: RTA#2 7TH STREET TURNING BASIN

PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL	
1	**Pre-Design Testing/Site Investigation//Design Costs**	**Remedial Design and Pre-Design Sampling & Testing**	**1**	**LS**	**$607,504.13**	**$506,253.44**	**$75,938.02**	**$25,312.67**	**$ 607,504**	
		Pre-Design Treatability Sampling	1	LS	$ 100,000.00	$100,000.00	$15,000.00	$5,000.00		
		Pilot Test	1	LS	$ 400,000.00	$400,000.00	$60,000.00	$20,000.00		
		Coordination With Agencies/Stakeholders/Permitting (1% of Remediation Costs)	1	LS	$ 6,253.44	$6,253.44	$938.02	$312.67		
2	**Includes all labor, equipment, & odc costs to complete pre-remedial site work**	**Pre-Remediation Site Work**	**1**	**LS**	**$39,947.46**	**$33,289.55**	**$4,993.43**	**$1,664.48**	**$ 39,947**	
		Temporary Access Road Constructi	2,933	SY	$ 11.35	$33,289.55	$4,993.43	$1,664.48		PER MEANS 01 55 23.50.0100
3	**Includes all labor, equipment, & odc costs for project long facility costs**	**Facility Costs**	**0.7**	**MO**	**$20,220.00**	**$11,649.38**	**$1,747.41**	**$582.47**	**$ 13,979**	
		Office Facilities	0.7	MO	$ 5,200.00	$3,595.06	$539.26	$179.75		ALLOWANCE: (2) Trailers
		Jobsite Sanitation	0.7	MO	$ 750.00	$518.52	$77.78	$25.93		PER MEANS 01 56 26.50.0020
		Site Security	0.7	MO	$ 5,400.00	$3,733.33	$560.00	$186.67		PER MEANS 31 22 16.10.0010
		Site Utilities	0.7	MO	$ 4,500.00	$3,111.11	$466.67	$155.56		ALLOWANCE: Phone/Power/Misc
		Temporary Storage	0.7	MO	$ 1,000.00	$691.36	$103.70	$34.57		ALLOWANCE: (3) Conex Boxes

TABLE 5B

Base Implementation, Removal, and In-Situ Stabilization Costs for Alternative 7: Dredging entire soft sediment column, stabilize 3-5 feet of native sediment in targeted areas, and capping with treatment layer, isolation layer, and armor layer.

Gowanus Canal Feasibility Study

Brooklyn, New York

BASE IMPLEMENTATION COSTS									
PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL
4	**Includes all labor, equipment, & odc costs for Sediment Solidification**	**ISS: RTA#2 7TH STREET TURNING BASIN**	**7,778**	**TON**	**$73.47**	**$476,180.96**	**$71,427.14**	**$23,809.05**	**$ 571,417**
		Blast Furnace Slag	875	TON	$ 50.00	$43,750.00	$6,562.50	$2,187.50	
		Portland Cement	292	TON	$ 125.00	$36,458.33	$5,468.75	$1,822.92	
		Barge With Deep Soil Auger	21	DAY	$ 1,380.00	$28,622.22	$4,293.33	$1,431.11	
		Barge With Deep Soil Auger	21	DAY	$ 1,380.00	$28,622.22	$4,293.33	$1,431.11	
		Scow	21	DAY	$ 180.00	$3,733.33	$560.00	$186.67	
		Scow	21	DAY	$ 180.00	$3,733.33	$560.00	$186.67	
		Superintendent	21	DAY	$ 1,566.45	$32,489.38	$4,873.41	$1,624.47	
		Tug Operator	21	DAY	$ 1,213.83	$25,175.74	$3,776.36	$1,258.79	
		Tug Operator	21	DAY	$ 1,213.83	$25,175.74	$3,776.36	$1,258.79	
		Auger Operator	21	DAY	$ 1,362.13	$28,251.64	$4,237.75	$1,412.58	
		Equipment Operator	21	DAY	$ 1,362.13	$28,251.64	$4,237.75	$1,412.58	
		Equipment Operator	21	DAY	$ 1,362.13	$28,251.64	$4,237.75	$1,412.58	
		Scowman	21	DAY	$ 945.51	$19,610.65	$2,941.60	$980.53	
		Scowman	21	DAY	$ 945.51	$19,610.65	$2,941.60	$980.53	
		FOGM	21	DAY	$ 6,000.00	$124,444.44	$18,666.67	$6,222.22	
5	**Includes all labor, equipment, & odc costs for Dewatering & Treating Dredge Cell Water**	**ISS RTA Cell Water Treatment (Costs assume that startup and initial purchase costs are captured under the base alternative. Costs included for ISS are for system operation and reagent replacement.)**	**0.69**	**MO**	**$363,317.37**	**$209,318.65**	**$31,397.80**	**$10,465.93**	**$ 251,182**
		Power Drop	1.0	LS	$75,000.00	$75,000.00	$11,250.00	$3,750.00	
		Power/Electric	0.7	MO	$10,000.00	$6,913.58	$1,037.04	$345.68	
		Treatment System Operation	720	HR	$74.53	$53,660.65	$8,049.10	$2,683.03	
		Treatment Chemicals	0.7	MO	$10,000.00	$6,913.58	$1,037.04	$345.68	
		Replacement Carbon	33,415	LBS	$2.00	$66,830.83	$10,024.63	$3,341.54	
		ESTIMATED COST							**$ 1,484,030**
						Contingency	**30%**		**$ 445,209**
						Remedial Design	**6%**		**$ 89,042**
						Construction Management/ Oversight	**6%**		**$ 89,042**
						Project Management	**5%**		**$ 74,202**
		TOTAL ESTIMATED COST							**$ 2,181,525**
		COST PER TON							**$ 280**

TABLE 6a

Treatment and Disposal Costs by RTA

Gowanus Canal Feasibility Study

Brooklyn, New York

DISPOSALTREATMENT OPTION A: THERMAL DESORPTION RTA#1									
PAY ITEM No.	**PAY ITEM DESCRIPTION**	**LINE ITEM DESCRIPTION**	**QUANTITY**	**UNIT**	**UNIT PRICE**	**CONTRACTOR COST**	**CONTRACTOR FEE**	**CONTRACTOR PM/OH**	**TOTAL**
1	**Includes all labor, equipment, & odc costs for Sediment Solidification**	**Sediment Solidification (assumes 7.5% by weight Portland cement)**	**114,800**	**TON**	**$47.25**	**$4,520,250.00**	**$678,037.50**	**$226,012.50**	**$ 5,424,300**
		Portland Cement	8,610	TON	$125.00	$1,076,250.00	$161,437.50	$53,812.50	
		Soil Mixing	114,800	TON	$30.00	$3,444,000.00	$516,600.00	$172,200.00	
2	**Includes all labor, equipment, & odc costs for Transporting to Thermal facility**	**Transport (assumes approximately 60 miles via truck)**	**123,410**	**TON**	**$30.00**	**$3,085,250.00**	**$462,787.50**	**$154,262.50**	**$ 3,702,300**
		Soil Transport	123,410	TON	$25.00	$3,085,250.00	$462,787.50	$154,262.50	
3	**Includes all labor, equipment, & odc costs for Thermal Desorption & Beneficial Use**	**Thermal Desorption/Beneficial Use**	**82,000**	**CY**	**$102.00**	**$6,970,000.00**	**$1,045,500.00**	**$348,500.00**	**$ 8,364,000**
		Thermal Desorption Quote	82,000	CY	$85.00	$6,970,000.00	$1,045,500.00	$348,500.00	
4	**Includes all labor, equipment, & odc costs for Transporting to Thermal facility**	**Transport Post Treatment (assumes approximately 60 miles via truck)**	**123,410**	**TON**	**$30.00**	**$3,085,250.00**	**$462,787.50**	**$154,262.50**	**$ 3,702,300**
		Soil Transport	123,410	TON	$25.00	$3,085,250.00	$462,787.50	$154,262.50	
		ESTIMATED COST							**$ 21,192,900**
						Contingency	**30%**		**$ 6,357,870**
						Construction Management/Oversight	**6%**		**$ 1,271,574**
						Project Management	**5%**		**$ 1,059,645**
		TOTAL RTA#1 THERMAL DESORPTION COST							**$ 29,881,989**

TABLE 6a

Treatment and Disposal Costs by RTA

Gowanus Canal Feasibility Study

Brooklyn, New York

DISPOSALTREATMENT OPTION A: THERMAL DESORPTION RTA#2									
PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL
1	Includes all labor, equipment, & odc costs for Sediment Solidification	Sediment Solidification (assumes 7.5% by weight Portland cement)	315,000	TON	$47.25	$12,403,125.00	$1,860,468.75	$620,156.25	$ 14,883,750
		Portland Cement	23,625	TON	$125.00	$2,953,125.00	$442,968.75	$147,656.25	
		Soil Mixing	315,000	TON	$30.00	$9,450,000.00	$1,417,500.00	$472,500.00	
2	Includes all labor, equipment, & odc costs for Transporting to Thermal facility	Transport (assumes approximately 60 miles via truck)	338,625	TON	$30.00	$8,465,625.00	$1,269,843.75	$423,281.25	$ 10,158,750
		Soil Transport	338,625	TON	$25.00	$8,465,625.00	$1,269,843.75	$423,281.25	
3	Includes all labor, equipment, & odc costs for Thermal Desorption & Beneficial Use	Thermal Desorption/Beneficial Use	225,000	CY	$102.00	$19,125,000.00	$2,868,750.00	$956,250.00	$ 22,950,000
		Thermal Desorption Quote	225,000	CY	$85.00	$19,125,000.00	$2,868,750.00	$956,250.00	
4	Includes all labor, equipment, & odc costs for Transporting to Thermal facility	Transport Post Treatment (assumes approximately 60 miles via truck)	338,625	TON	$30.00	$8,465,625.00	$1,269,843.75	$423,281.25	$ 10,158,750
		Soil Transport	338,625	TON	$25.00	$8,465,625.00	$1,269,843.75	$423,281.25	
		ESTIMATED COST							$ 58,151,250
						Contingency	30%		$ 17,445,375
						Construction Management/Oversight	6%		$ 3,489,075
						Project Management	5%		$ 2,907,563
		TOTAL RTA#2 THERMAL DESORPTION COST							$ 81,993,263

TABLE 6a
Treatment and Disposal Costs by RTA
Gowanus Canal Feasibility Study
Brooklyn, New York

PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL
DISPOSALTREATMENT OPTION A: THERMAL DESORPTION RTA#3									
1	**Includes all labor, equipment, & odc costs for Sediment Solidification**	**Sediment Solidification (assumes 7.5% by weight Portland cement)**	**393,400**	**TON**	**$47.25**	**$15,490,125.00**	**$2,323,518.75**	**$774,506.25**	**$ 18,588,150**
		Portland Cement	29,505	TON	$125.00	$3,688,125.00	$553,218.75	$184,406.25	
		Soil Mixing	393,400	TON	$30.00	$11,802,000.00	$1,770,300.00	$590,100.00	
2	**Includes all labor, equipment, & odc costs for Transporting to Thermal facility**	**Transport (assumes approximately 60 miles via truck)**	**422,905**	**TON**	**$30.00**	**$10,572,625.00**	**$1,585,893.75**	**$528,631.25**	**$ 12,687,150**
		Soil Transport	422,905	TON	$25.00	$10,572,625.00	$1,585,893.75	$528,631.25	
3	**Includes all labor, equipment, & odc costs for Thermal Desorption & Beneficial Use**	**Thermal Desorption/Beneficial Use**	**281,000**	**CY**	**$102.00**	**$23,885,000.00**	**$3,582,750.00**	**$1,194,250.00**	**$ 28,662,000**
		Thermal Desorption Quote	281,000	CY	$85.00	$23,885,000.00	$3,582,750.00	$1,194,250.00	
4	**Includes all labor, equipment, & odc costs for Transporting to Thermal facility**	**Transport Post Treatment (assumes approximately 60 miles via truck)**	**422,905**	**TON**	**$30.00**	**$10,572,625.00**	**$1,585,893.75**	**$528,631.25**	**$ 12,687,150**
		Soil Transport	422,905	TON	$25.00	$10,572,625.00	$1,585,893.75	$528,631.25	
		ESTIMATED COST							**$ 72,624,450**
						Contingency	**30%**		**$ 21,787,335**
						Construction Management/Oversight	**6%**		**$ 4,357,467**
						Project Management	**5%**		**$ 3,631,223**
		TOTAL RTA#3 THERMAL DESORPTION COST							**$ 102,400,475**

TABLE 6a
Treatment and Disposal Costs by RTA
Gowanus Canal Feasibility Study
Brooklyn, New York

DISPOSALTREATMENT OPTION B: OFFSITE/LANDFILL DISPOSAL RTA#1									
PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL
1	Includes all labor, equipment, & odc costs for Sediment Solidification	Sediment Solidification (assumes 7.5% by weight Portland cement)	114,800	TON	$47.25	$4,520,250.00	$678,037.50	$226,012.50	$ 5,424,300
		Portland Cement	8,610	TON	$125.00	$1,076,250.00	$161,437.50	$53,812.50	
		Soil Mixing	114,800	TON	$30.00	$3,444,000.00	$516,600.00	$172,200.00	
2	Includes all labor, equipment, & odc costs for Transporting to Thermal facility	Transport & Disposal (assumes transport distance of approximately 110 miles via truck and $81 tipping fee)	123,410	TON	$138.00	$14,192,150.00	$2,128,822.50	$709,607.50	$ 17,030,580
		Soil Transport & Disposal	123,410	TON	$115.00	$14,192,150.00	$2,128,822.50	$709,607.50	
		ESTIMATED COST							$ 22,454,880
						Contingency	30%		$ 6,736,464
						Construction Management/Oversight	6%		$ 1,347,293
						Project Management	5%		$ 1,122,744
		TOTAL RTA#1 OFFSITE DISPOSAL COST							$ 31,661,381

DISPOSALTREATMENT OPTION B: OFFSITE/LANDFILL DISPOSAL RTA#2									
PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL
1	Includes all labor, equipment, & odc costs for Sediment Solidification	Sediment Solidification (assumes 7.5% by weight Portland cement)	315,000	TON	$47.25	$12,403,125.00	$1,860,468.75	$620,156.25	$ 14,883,750
		Portland Cement	23,625	TON	$125.00	$2,953,125.00	$442,968.75	$147,656.25	
		Soil Mixing	315,000	TON	$30.00	$9,450,000.00	$1,417,500.00	$472,500.00	
2	Includes all labor, equipment, & odc costs for Transporting to Thermal facility	Transport & Disposal (assumes transport distance of approximately 110 miles via truck and $81 tipping fee)	338,625	TON	$138.00	$38,941,875.00	$5,841,281.25	$1,947,093.75	$ 46,730,250
		Soil Transport & Disposal	338,625	TON	$115.00	$38,941,875.00	$5,841,281.25	$1,947,093.75	
		ESTIMATED COST							$ 61,614,000
						Contingency	30%		$ 18,484,200
						Construction Management/Oversight	6%		$ 3,696,840
						Project Management	5%		$ 3,080,700
		TOTAL RTA#2 OFFSITE DISPOSAL COST							$ 86,875,740

TABLE 6a
Treatment and Disposal Costs by RTA
Gowanus Canal Feasibility Study
Brooklyn, New York

DISPOSALTREATMENT OPTION B: OFFSITE/LANDFILL DISPOSAL RTA#3									
PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL
1	Includes all labor, equipment, & odc costs for Sediment Solidification	Sediment Solidification (assumes 7.5% by weight Portland cement)	393,400	TON	$47.25	$15,490,125.00	$2,323,518.75	$774,506.25	$ 18,588,150
		Portland Cement	29,505	TON	$125.00	$3,688,125.00	$553,218.75	$184,406.25	
		Soil Mixing	393,400	TON	$30.00	$11,802,000.00	$1,770,300.00	$590,100.00	
2	Includes all labor, equipment, & odc costs for Transporting to Thermal facility	Transport & Disposal (assumes transport distance of approximately 110 miles via truck and $81 tipping fee)	422,905	TON	$138.00	$48,634,075.00	$7,295,111.25	$2,431,703.75	$ 58,360,890
		Soil Transport & Disposal	422,905	TON	$115.00	$48,634,075.00	$7,295,111.25	$2,431,703.75	
		ESTIMATED COST							$ 76,949,040
						Contingency	30%		$ 23,084,712
						Construction Management/Oversight	6%		$ 4,616,942
						Project Management	5%		$ 3,847,452
		TOTAL RTA#3 OFFSITE DISPOSAL COST							$ 108,498,146

DISPOSALTREATMENT OPTION C: COGEN RTA#1									
PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL
1	Includes all labor, equipment, & odc costs for Sediment Solidification	Sediment Solidification (assumes 7.5% by weight Portland cement)	114,800	TON	$47.25	$4,520,250.00	$678,037.50	$226,012.50	$ 5,424,300
		Portland Cement	8,610	TON	$125.00	$1,076,250.00	$161,437.50	$53,812.50	
		Soil Mixing	114,800	TON	$30.00	$3,444,000.00	$516,600.00	$172,200.00	
2	Includes all labor, equipment, & odc costs for Transporting Dredged Material to Co-Gen Facility	Transport and treatment at Co-Generation Facility (assumes transport of 350 miles via truck and $40 per ton tipping fee)	123,410	TON	$138.00	$14,192,150.00	$2,128,822.50	$709,607.50	$ 17,030,580
		Soil Transport & Treatment	123,410	TON	$115.00	$14,192,150.00	$2,128,822.50	$709,607.50	
3	Includes all labor, equipment, & odc costs for Transporting Dredged Material to Final Use Location	Transport to Final Use Location (assumes transport distance of approximately 60 miles via truck)	123,410	TON	$30.00	$3,085,250.00	$462,787.50	$154,262.50	$ 3,702,300
		Soil Transport	123,410	TON	$25.00	$3,085,250.00	$462,787.50	$154,262.50	
		ESTIMATED COST							$ 26,157,180
						Contingency	30%		$ 7,847,154
						Construction Management/Oversight	6%		$ 1,569,431
						Project Management	5%		$ 1,307,859
		TOTAL RTA#1 COGEN COST							$ 36,881,624

TABLE 6a

Treatment and Disposal Costs by RTA

Gowanus Canal Feasibility Study

Brooklyn, New York

DISPOSALTREATMENT OPTION C: COGEN RTA#2									
PAY ITEM No.	**PAY ITEM DESCRIPTION**	**LINE ITEM DESCRIPTION**	**QUANTITY**	**UNIT**	**UNIT PRICE**	**CONTRACTOR COST**	**CONTRACTOR FEE**	**CONTRACTOR PM/OH**	**TOTAL**
1	**Includes all labor, equipment, & odc costs for Sediment Solidification**	**Sediment Solidification (assumes 7.5% by weight Portland cement)**	**315,000**	**TON**	**$47.25**	**$12,403,125.00**	**$1,860,468.75**	**$620,156.25**	**$ 14,883,750**
		Portland Cement	23,625	TON	$125.00	$2,953,125.00	$442,968.75	$147,656.25	
		Soil Mixing	315,000	TON	$30.00	$9,450,000.00	$1,417,500.00	$472,500.00	
2	**Includes all labor, equipment, & odc costs for Transporting Dredged Material to Co-Gen Facility**	**Transport and treatment at Co-Generation Facility (assumes transport of 350 miles via truck and $40 per ton tipping fee)**	**338,625**	**TON**	**$138.00**	**$38,941,875.00**	**$5,841,281.25**	**$1,947,093.75**	**$ 46,730,250**
		Soil Transport & Treatment	338,625	TON	$115.00	$38,941,875.00	$5,841,281.25	$1,947,093.75	
3	**Includes all labor, equipment, & odc costs for Transporting Dredged Material to Final Use Location**	**Transport to Final Use Location (assumes transport distance of approximately 60 miles via truck)**	**338,625**	**TON**	**$30.00**	**$8,465,625.00**	**$1,269,843.75**	**$423,281.25**	**$ 10,158,750**
		Soil Transport	338,625	TON	$25.00	$8,465,625.00	$1,269,843.75	$423,281.25	
		ESTIMATED COST							**$ 71,772,750**
						Contingency	**30%**		**$ 21,531,825**
						Construction Management/Oversight	**6%**		**$ 4,306,365**
						Project Management	**5%**		**$ 3,588,638**
		TOTAL RTA#2 COGEN COST							**$ 101,199,578**

TABLE 6a
Treatment and Disposal Costs by RTA
Gowanus Canal Feasibility Study
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DISPOSALTREATMENT OPTION C: COGEN RTA#3									
PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL
1	Includes all labor, equipment, & odc costs for Sediment Solidification	Sediment Solidification (assumes 7.5% by weight Portland cement)	393,400	TON	$47.25	$15,490,125.00	$2,323,518.75	$774,506.25	$ 18,588,150
		Portland Cement	29,505	TON	$125.00	$3,688,125.00	$553,218.75	$184,406.25	
		Soil Mixing	393,400	TON	$30.00	$11,802,000.00	$1,770,300.00	$590,100.00	
2	Includes all labor, equipment, & odc costs for Transporting Dredged Material to Co-Gen Facility	Transport and treatment at Co-Generation Facility (assumes transport of 350 miles via truck and $40 per ton tipping fee)	422,905	TON	$138.00	$48,634,075.00	$7,295,111.25	$2,431,703.75	$ 58,360,890
		Soil Transport & Treatment	422,905	TON	$115.00	$48,634,075.00	$7,295,111.25	$2,431,703.75	
3	Includes all labor, equipment, & odc costs for Transporting Dredged Material to Final Use Location	Transport to Final Use Location (assumes transport distance of approximately 60 miles via truck)	422,905	TON	$30.00	$10,572,625.00	$1,585,893.75	$528,631.25	$ 12,687,150
		Soil Transport	422,905	TON	$25.00	$10,572,625.00	$1,585,893.75	$528,631.25	
		ESTIMATED COST							$ 89,636,190
						Contingency	30%		$ 26,890,857
						Construction Management/Oversight	6%		$ 5,378,171
						Project Management	5%		$ 4,481,810
		TOTAL RTA#3 COGEN COST							$ 126,387,028

PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL
DISPOSALTREATMENT OPTION D: RTA#1 OFFSITE STABILIZATION/BENEFICIAL USE									
1	Includes all labor, equipment, & odc costs for Transporting Dredged Material to Offsite Stabilization Site	Transport to Offsite Stabilization Site	114,800	TON	$30.00	$2,870,000.00	$430,500.00	$143,500.00	$ 3,444,000
		Soil Transport	114,800	TON	$25.00	$2,870,000.00	$430,500.00	$143,500.00	
2	Includes all labor, equipment, & odc costs for Sediment Solidification	Sediment Solidification For Beneficial Use (assumes 15% by weight reagent; reagents are 75% blast furnace slag and 25% Portland cement).	114,800	TON	$53.78	$5,144,475.00	$771,671.25	$257,223.75	$ 6,173,370
		Portland Cement	4,305	TON	$125.00	$538,125.00	$80,718.75	$26,906.25	
		Blast Furnace Slag	12,915	TON	$50.00	$645,750.00	$96,862.50	$32,287.50	
		Soil Mixing	132,020	TON	$30.00	$3,960,600.00	$594,090.00	$198,030.00	
3	Includes all labor, equipment, & odc costs for Transporting Soil (110 Miles)	Stabilized Soil Transport	132,020	TON	$90.00	$9,901,500.00	$1,485,225.00	$495,075.00	$ 11,881,800
		Soil Transport (To End User)	132,020	TON	$75.00	$9,901,500.00	$1,485,225.00	$495,075.00	
		ESTIMATED COST							$ 21,499,170
						Contingency	30%		$ 6,449,751
						Construction Management/Oversight	6%		$ 1,289,950
						Project Management	5%		$ 1,074,959
		TOTAL RTA#1 OFFSITE STABILIZATION COST							$ 30,313,830

TABLE 6a

Treatment and Disposal Costs by RTA

Gowanus Canal Feasibility Study

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DISPOSALTREATMENT OPTION D: RTA#3 OFFSITE STABILIZATION/BENEFICIAL USE									
PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL
1	Includes all labor, equipment, & odc costs for Transporting Dredged Material to Offsite Stabilization Site	Transport to Offsite Stabilization Site	393,400	TON	$30.00	$9,835,000.00	$1,475,250.00	$491,750.00	$ 11,802,000
		Soil Transport	393,400	TON	$25.00	$9,835,000.00	$1,475,250.00	$491,750.00	
2	Includes all labor, equipment, & odc costs for Sediment Solidification	Sediment Solidification For Beneficial Use (assumes 15% by weight reagent; reagents are 75% blast furnace slag and 25% Portland cement).	393,400	TON	$53.78	$17,629,237.50	$2,644,385.63	$881,461.88	$ 21,155,085
		Portland Cement	14,753	TON	$125.00	$1,844,062.50	$276,609.38	$92,203.13	
		Blast Furnace Slag	44,258	TON	$50.00	$2,212,875.00	$331,931.25	$110,643.75	
		Soil Mixing	452,410	TON	$30.00	$13,572,300.00	$2,035,845.00	$678,615.00	
3	Includes all labor, equipment, & odc costs for Transporting Soil (110 Miles)	Stabilized Soil Transport	452,410	TON	$90.00	$33,930,750.00	$5,089,612.50	$1,696,537.50	$ 40,716,900
		Soil Transport (To End User)	452,410	TON	$75.00	$33,930,750.00	$5,089,612.50	$1,696,537.50	
		ESTIMATED COST							$ 73,673,985
						Contingency	30%		$ 22,102,196
						Construction Management/Oversight	6%		$ 4,420,439
						Project Management	5%		$ 3,683,699
		TOTAL RTA#3 OFFSITE STABILIZATION COST							$ 103,880,319

TABLE 6a
Treatment and Disposal Costs by RTA
Gowanus Canal Feasibility Study
Brooklyn, New York

DISPOSALTREATMENT OPTION E: RTA#1 ONSITE STABILIZATION/BENEFICIAL USE									
PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL
1	Includes all labor, equipment, & odc costs for Transporting Dredged Material to Onsite Stabilization Site	Transport to Onsite Stabilization Site	114,800	TON	$30.00	$2,870,000.00	$430,500.00	$143,500.00	$ 3,444,000
		Soil Transport	114,800	TON	$25.00	$2,870,000.00	$430,500.00	$143,500.00	
2	Includes all labor, equipment, & odc costs for Sediment Solidification	Sediment Solidification For Beneficial Use (assumes 30% by weight reagent; reagents are 75% blast furnace slag and 25% Portland cement).	114,800	TON	$71.55	$6,844,950.00	$1,026,742.50	$342,247.50	$ 8,213,940
		Portland Cement	8,610	TON	$125.00	$1,076,250.00	$161,437.50	$53,812.50	
		Blast Furnace Slag	25,830	TON	$50.00	$1,291,500.00	$193,725.00	$64,575.00	
		Soil Mixing	149,240	TON	$30.00	$4,477,200.00	$671,580.00	$223,860.00	
3	Includes all labor, equipment, & odc costs for Transporting Stabilized Soil To Beneficial use Location	Transport For Beneficial Use	149,240	TON	$30.00	$3,731,000.00	$559,650.00	$186,550.00	$ 4,477,200
		Soil Transport	149,240	TON	$25.00	$3,731,000.00	$559,650.00	$186,550.00	
		ESTIMATED COST							$ 16,135,140
						Contingency	30%		$ 4,840,542
						Construction Management/Oversight	6%		$ 968,108
						Project Management	5%		$ 806,757
		TOTAL RTA#1 ONSITE STABILIZATION/BENEFICIAL USE ESTIMATED COST							$ 22,750,547

TABLE 6a
Treatment and Disposal Costs by RTA
Gowanus Canal Feasibility Study
Brooklyn, New York

DISPOSALTREATMENT OPTION E: RTA#3 ONSITE STABILIZATION/BENEFICIAL USE

PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL
1	Includes all labor, equipment, & odc costs for Transporting Dredged Material to Onsite Stabilization Site	Transport to Onsite Stabilization Site	393,400	TON	$30.00	$9,835,000.00	$1,475,250.00	$491,750.00	$ 11,802,000
		Soil Transport	393,400	TON	$25.00	$9,835,000.00	$1,475,250.00	$491,750.00	
2	Includes all labor, equipment, & odc costs for Sediment Solidification	Sediment Solidification For Beneficial Use (assumes 30% by weight reagent; reagents are 75% blast furnace slag and 25% Portland cement).	393,400	TON	$71.55	$23,456,475.00	$3,518,471.25	$1,172,823.75	$ 28,147,770
		Portland Cement	29,505	TON	$125.00	$3,688,125.00	$553,218.75	$184,406.25	
		Blast Furnace Slag	88,515	TON	$50.00	$4,425,750.00	$663,862.50	$221,287.50	
		Soil Mixing	511,420	TON	$30.00	$15,342,600.00	$2,301,390.00	$767,130.00	
3	Includes all labor, equipment, & odc costs for Transporting Stabilized Soil To Beneficial use Location	Transport For Beneficial Use	511,420	TON	$30.00	$12,785,500.00	$1,917,825.00	$639,275.00	$ 15,342,600
		Soil Transport	511,420	TON	$25.00	$12,785,500.00	$1,917,825.00	$639,275.00	
		ESTIMATED COST							$ 55,292,370
						Contingency	30%		$ 16,587,711
						Construction Management/Oversight	6%		$ 3,317,542
						Project Management	5%		$ 2,764,619
		TOTAL RTA#3 ONSITE STABILIZATION/BENEFICIAL USE ESTIMATED COST							$ 77,962,242

DISPOSALTREATMENT OPTION F: RTA#3 OFFSITE STABILIZATION/CDF DISPOSAL

PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL
1	Includes all labor, equipment, & odc costs for Transporting Dredged Material to Offsite Stabilization Site	Transport to Offsite Stabilization Site	393,400	TON	$30.00	$9,835,000.00	$1,475,250.00	$491,750.00	$ 11,802,000
		Soil Transport	393,400	TON	$25.00	$9,835,000.00	$1,475,250.00	$491,750.00	
2	Includes all labor, equipment, & odc costs for CDF Construction	CDF Construction	1	LS	$11,552,550.00	$9,627,125.00	$1,444,068.75	$481,356.25	$ 11,552,550
		Sheet Piling Installation	148,500	SF	$ 39.53	$5,870,205.00	$880,530.75	$293,510.25	
		Bentonite Augmented Soil	2,200	CY	$ 50.00	$110,000.00	$16,500.00	$5,500.00	
		Dewatering Pump	404	DAY	$ 750.00	$303,000.00	$45,450.00	$15,150.00	
		Pump Fuel	404	DAY	$ 200.00	$80,800.00	$12,120.00	$4,040.00	
		Existing Soil Stabilization	105,000	TON	$ 30.00	$3,150,000.00	$472,500.00	$157,500.00	
		Dewatering Pump Operator	404	DAY	$ 280.00	$113,120.00	$16,968.00	$5,656.00	
3	Includes all labor, equipment, & odc costs for Sediment Solidification	Sediment Solidification For CDF Placement (assumes 15% by weight reagent; reagents are 75% blast furnace slag and 25% Portland cement).	393,400	TON	$53.78	$17,629,237.50	$2,644,385.63	$881,461.88	$ 21,155,085
		Blast Furnace Slag	44,258	TON	$ 50.00	$2,212,875.00	$331,931.25	$110,643.75	
		Portland Cement	14,753	TON	$ 125.00	$1,844,062.50	$276,609.38	$92,203.13	
		Soil Mixing	452,410	TON	$ 30.00	$13,572,300.00	$2,035,845.00	$678,615.00	

TABLE 6a

Treatment and Disposal Costs by RTA

Gowanus Canal Feasibility Study

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4	**Includes all labor, equipment, & odc costs for Transporting Dredged Material to CDF**	**Transport To CDF (assumed to be approximately 30 nautical miles via barge)**	**452,410**	**TON**	**$12.00**	**$4,524,100.00**	**$678,615.00**	**$226,205.00**	**$ 5,428,920**		
		Soil Transport	452,410	TON	$ 10.00	$4,524,100.00	$678,615.00	$226,205.00			
5	**Includes all labor, equipment, & odc costs for Sediment Placement in the CDF**	**Disposal Option F: Sediment Placement in CDF**	**323,150**	**CY**	**$7.06**	**$1,900,066.66**	**$285,010.00**	**$95,003.33**	**$ 2,280,080**		
		D8 Dozer	162	DAY	$ 440.00	$71,093.00	$10,663.95	$3,554.65			
		FOGM	162	DAY	$ 264.00	$42,655.80	$6,398.37	$2,132.79			
		D8 Dozer	162	DAY	$ 440.00	$71,093.00	$10,663.95	$3,554.65			
		FOGM	162	DAY	$ 264.00	$42,655.80	$6,398.37	$2,132.79			
		Cat 825C Soil Compactor	162	DAY	$ 520.00	$84,019.00	$12,602.85	$4,200.95			
		FOGM	162	DAY	$ 312.00	$50,411.40	$7,561.71	$2,520.57			
		Cat 825C Soil Compactor	162	DAY	$ 520.00	$84,019.00	$12,602.85	$4,200.95			
		FOGM	162	DAY	$ 312.00	$50,411.40	$7,561.71	$2,520.57			
		Cat 963 Track Loader	162	DAY	$ 360.00	$58,167.00	$8,725.05	$2,908.35			
		FOGM	162	DAY	$ 216.00	$34,900.20	$5,235.03	$1,745.01			
		Laborer	1,939	HR	$ 78.79	$152,771.34	$22,915.70	$7,638.57			
		Laborer	1,939	HR	$ 78.79	$152,771.34	$22,915.70	$7,638.57			
		Laborer	1,939	HR	$ 78.79	$152,771.34	$22,915.70	$7,638.57			
		Laborer	1,939	HR	$ 78.79	$152,771.34	$22,915.70	$7,638.57			
		Operator	1,939	HR	$ 113.51	$220,086.55	$33,012.98	$11,004.33			
		Operator	1,939	HR	$ 113.51	$220,086.55	$33,012.98	$11,004.33			
		Operator	1,939	HR	$ 113.51	$220,086.55	$33,012.98	$11,004.33			
		Asphalt Surfacing: 6"	5,000	SY	$ 7.86	$39,296.07	$5,894.41	$1,964.80			
		ESTIMATED COST							**$ 52,218,635**		
						Contingency	**30%**		**$ 15,665,590**		
						Construction Management/Oversight	**6%**		**$ 3,133,118**		
						Project Management	**5%**		**$ 2,610,932**		
		TOTAL DISPOSAL OPTION ESTIMATED COST							**$ 73,628,275**		

TABLE 6a
Treatment and Disposal Costs by RTA
Gowanus Canal Feasibility Study
Brooklyn, New York

PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL
DISPOSALTREATMENT OPTION G: RTA#3 ONSITE STABILIZATION/CDF DISPOSAL									
1	**Includes all labor, equipment, & odc costs for Transporting Dredged Material to Onsite Stabilization Site**	**Transport to Onsite Stabilization Site**	**393,400**	**TON**	**$18.00**	**$5,901,000.00**	**$885,150.00**	**$295,050.00**	**$ 7,081,200**
		Soil Transport	393,400	TON	$15.00	$5,901,000.00	$885,150.00	$295,050.00	
2	**Includes all labor, equipment, & odc costs for CDF Construction**	**CDF Construction**	**1**	**LS**	**$11,552,550.00**	**$9,627,125.00**	**$1,444,068.75**	**$481,356.25**	**$ 11,552,550**
		Sheet Piling Installation	148,500	SF	$ 39.53	$5,870,205.00	$880,530.75	$293,510.25	
		Bentonite Augmented Soil	2,200	CY	$ 50.00	$110,000.00	$16,500.00	$5,500.00	
		Dewatering Pump	404	DAY	$ 750.00	$303,000.00	$45,450.00	$15,150.00	
		Pump Fuel	404	DAY	$ 200.00	$80,800.00	$12,120.00	$4,040.00	
		Existing Soil Stabilization	105,000	TON	$ 30.00	$3,150,000.00	$472,500.00	$157,500.00	
		Dewatering Pump Operator	404	DAY	$ 280.00	$113,120.00	$16,968.00	$5,656.00	
3	**Includes all labor, equipment, & odc costs for Sediment Solidification**	**Sediment Solidification For CDF Placement (assumes 15% by weight reagent; reagents are 75% blast furnace slag and 25% Portland cement).**	**393,400**	**TON**	**$53.78**	**$17,629,237.50**	**$2,644,385.63**	**$881,461.88**	**$ 21,155,085**
		Blast Furnace Slag	44,258	TON	$ 50.00	$2,212,875.00	$331,931.25	$110,643.75	
		Portland Cement	14,753	TON	$ 125.00	$1,844,062.50	$276,609.38	$92,203.13	
		Soil Mixing	452,410	TON	$ 30.00	$13,572,300.00	$2,035,845.00	$678,615.00	
4	**Includes all labor, equipment, & odc costs for Transporting Dredged Material to CDF**	**Transport To CDF (assumed to be approximately 2 nautical miles via barge)**	**452,410**	**TON**	**$12.00**	**$4,524,100.00**	**$678,615.00**	**$226,205.00**	**$ 5,428,920**
		Soil Transport	452,410	TON	$ 10.00	$4,524,100.00	$678,615.00	$226,205.00	

TABLE 6a

Treatment and Disposal Costs by RTA

Gowanus Canal Feasibility Study

Brooklyn, New York

5	**Includes all labor, equipment, & odc costs for Sediment Placement in the CDF**	**Disposal Option G: Sediment Placement in CDF**	**323,150**	**CY**	**$7.06**	**$1,900,066.66**	**$285,010.00**	**$95,003.33**	**$ 2,280,080**		
		D8 Dozer	162	DAY	$ 440.00	$71,093.00	$10,663.95	$3,554.65			
		FOGM	162	DAY	$ 264.00	$42,655.80	$6,398.37	$2,132.79			
		D8 Dozer	162	DAY	$ 440.00	$71,093.00	$10,663.95	$3,554.65			
		FOGM	162	DAY	$ 264.00	$42,655.80	$6,398.37	$2,132.79			
		Cat 825C Soil Compactor	162	DAY	$ 520.00	$84,019.00	$12,602.85	$4,200.95			
		FOGM	162	DAY	$ 312.00	$50,411.40	$7,561.71	$2,520.57			
		Cat 825C Soil Compactor	162	DAY	$ 520.00	$84,019.00	$12,602.85	$4,200.95			
		FOGM	162	DAY	$ 312.00	$50,411.40	$7,561.71	$2,520.57			
		Cat 963 Track Loader	162	DAY	$ 360.00	$58,167.00	$8,725.05	$2,908.35			
		FOGM	162	DAY	$ 216.00	$34,900.20	$5,235.03	$1,745.01			
		Laborer	1,939	HR	$ 78.79	$152,771.34	$22,915.70	$7,638.57			
		Laborer	1,939	HR	$ 78.79	$152,771.34	$22,915.70	$7,638.57			
		Laborer	1,939	HR	$ 78.79	$152,771.34	$22,915.70	$7,638.57			
		Laborer	1,939	HR	$ 78.79	$152,771.34	$22,915.70	$7,638.57			
		Operator	1,939	HR	$ 113.51	$220,086.55	$33,012.98	$11,004.33			
		Operator	1,939	HR	$ 113.51	$220,086.55	$33,012.98	$11,004.33			
		Operator	1,939	HR	$ 113.51	$220,086.55	$33,012.98	$11,004.33			
		Asphalt Surfacing: 6"	5,000	SY	$ 7.86	$39,296.07	$5,894.41	$1,964.80			
		ESTIMATED COST							**$ 47,497,835**		
						Contingency	**30%**		**$ 14,249,350**		
						Construction Management/Oversight	**6%**		**$ 2,849,870**		
						Project Management	**5%**		**$ 2,374,892**		
		TOTAL DISPOSAL OPTION ESTIMATED COST							**$ 66,971,947**		

TABLE 6B

Base Implementation Costs for Onsite Stabilization (Disposal Options E and G)

Gowanus Canal Feasibility Study

Brooklyn, New York

STABILIZATION FACILITY COSTS										
PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL	
1	Pre-Design Testing/Site Investigation//Design Costs	Remedial Design and Pre-Design Sampling & Testing	1	LS	$215,737.29	$179,781.07	$26,967.16	$8,989.05	$ 215,737	
		Full-Scale Remedial Design (4% of Remediation Costs)	1	LS	$143,824.86	$143,824.86	$21,573.73	$7,191.24		
		Coordination With Agencies/Stakeholders/Permitting (1% of Remediation Costs)	1	LS	$35,956.21	$35,956.21	$5,393.43	$1,797.81		
2	Includes all labor, equipment, & odc costs to complete pre-remedial site work	Pre-Remediation Site Work	9,500	LF	$30.80	$243,826.21	$36,573.93	$12,191.31	$ 292,591	
		Temporary Access Road Construction	10,000	SY	$11.35	$113,500.00	$17,025.00	$5,675.00		PER MEANS 01 55 23.50.0100
		Rough Grading	9,683	SY	$1.00	$9,683.48	$1,452.52	$484.17		
		Stone Base	2,163	CY	$30.00	$64,885.78	$9,732.87	$3,244.29		
		Silt Fence	3,000	LF	$5.00	$15,000.00	$2,250.00	$750.00		
		Filter Fabric	9,683	SY	$2.00	$19,366.95	$2,905.04	$968.35		
		Chain-Link Fence (Temporary)	3,000	LF	$7.13	$21,390.00	$3,208.50	$1,069.50		PER MEANS 01 56 26.50.0100
3	Includes all labor, equipment, & odc costs for project long facility costs	Facility Costs	72	MO	$43,020.00	$2,581,200.00	$387,180.00	$129,060.00	$ 3,097,440	
		Office Facilities	72	MO	$5,200.00	$374,400.00	$56,160.00	$18,720.00		ALLOWANCE: (2) Trailers
		Jobsite Sanitation	72	MO	$750.00	$54,000.00	$8,100.00	$2,700.00		PER MEANS 01 56 26.50.0020
		Site Security	72	MO	$5,400.00	$388,800.00	$58,320.00	$19,440.00		PER MEANS 31 22 16.10.0010
		Site Utilities	72	MO	$4,500.00	$324,000.00	$48,600.00	$16,200.00		ALLOWANCE: Phone/Power/Misc
		Temporary Storage Area (2 Acres)	72	MO	$20,000.00	$1,440,000.00	$216,000.00	$72,000.00		ALLOWANCE: (3) Conex Boxes
4	Includes all labor, equipment, & odc costs for establishing a docking area	Docking Area Establishment	1	LS	$127,590.00	$106,325.00	$15,948.75	$5,316.25	$ 127,590	
		Debris Removal	40	HR	$230.00	$9,200.00	$1,380.00	$460.00		
		Sheet Piling Installation	1,600	SF	$60.00	$96,000.00	$14,400.00	$4,800.00		PER MEANS 31 41 16.10.1800
		Tie Back Installation	1	TON	$2,250.00	$1,125.00	$168.75	$56.25		PER MEANS 31 41 16.10.3000
5	Includes all labor, equipment, & odc costs for Mobilizing/Demobilizing Stabilization Equipment	Stabilization Equipment: Mobe/Demobe	1	LS	$78,000.00	$65,000.00	$9,750.00	$3,250.00	$ 78,000	
		Grizzly Screen	1	LS	$15,000.00	$15,000.00	$2,250.00	$750.00		ALLOWANCE: Mobe/Demobe/Set-Up/Tear-Down
		Pugmill	1	LS	$15,000.00	$15,000.00	$2,250.00	$750.00		ALLOWANCE: Mobe/Demobe/Set-Up/Tear-Down
		Radial Conveyor	1	LS	$15,000.00	$15,000.00	$2,250.00	$750.00		ALLOWANCE: Mobe/Demobe/Set-Up/Tear-Down
		Storage Bins	1	LS	$5,000.00	$5,000.00	$750.00	$250.00		ALLOWANCE: Mobe/Demobe/Set-Up/Tear-Down
		Pneumatic Pigs	1	LS	$15,000.00	$15,000.00	$2,250.00	$750.00		ALLOWANCE: Mobe/Demobe/Set-Up/Tear-Down
		ESTIMATED COST							$ 3,811,359	
						Contingency	30%		$ 1,143,408	
						Construction Management/Oversight	6%		$ 228,682	
						Project Management	5%		$ 190,568	
		TOTAL STABILIZATION FACILITY COSTS							$ 5,374,016	

TABLE 7

Long Term Operations and Maintenance Costs for Sediment Cap

Gowanus Canal Feasibility Study

Brooklyn, New York

Site: Gowanus Canal **Description:** Operations and Maintenance Detailed Costing

Location: Brooklyn, NY

CAPITAL COSTS	DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Cap Replacement						
	Clay Import	1,356	CY	$200.00	$271,245	
	Sand Import	1,356	CY	$23.00	$31,193	
	Armor Import	4,069	CY	$31.50	$128,163	
	Material Placement-Equipment	25	DAY	$2,580.00	$65,607	
	Material Placement-Labor	25	DAY	$3,060.00	$77,813	
	SUBTOTAL CAP REPLACEMENT				$574,022	
Survey						
	Bathymetric Survey	3	DAY	3000	$9,000	
	SUBTOTAL SURVEY				$9,000	
	TOTAL CAPITAL COST				**$583,022**	

O&M	DESCRIPTION	YEAR	QTY	UNIT	COST	TOTAL	NOTES
	Sampling						
	Surface Sediment Sampling		25	ea	$500	$12,500	
	Subsurface Sediment Sampling		0	ea	$500	$0	
	Biota Sampling		25	ea	$1,500	$37,500	
	Subtotal Annual O&M					**$50,000**	
	Reporting (1 annual report)		1	LS	$15,000	$15,000	
	Contingency		20%			$13,000	
	Subtotal Annual O&M					$78,000	
	Project Management		15%			$11,700	
	TOTAL PERIODIC O&M COST					**$89,700**	

PRESENT VALUE ANALYSIS (30-year) Discount Rate = 7.0%

End Year	COST TYPE	Capital Cost	O&M Cost	TOTAL COST/YEAR	DISCOUNT FACTOR	PRESENT VALUE
0	CAPITAL COST	$583,022	$0	$583,022	1.000	$ 583,022
1	PERIODIC COST - O&M	$0	$0	$0	0.935	$ -
2	PERIODIC COST - O&M	$0	$0	$0	0.873	$ -
3	PERIODIC COST - O&M	$0	$0	$0	0.816	$ -
4	PERIODIC COST - O&M	$0	$0	$0	0.763	$ -
5	PERIODIC COST - O&M	$583,022	$89,700	$672,722	0.713	$ 479,642
6	PERIODIC COST - O&M	$0		$0	0.666	$ -
7	PERIODIC COST - O&M	$0		$0	0.623	$ -
8	PERIODIC COST - O&M	$0		$0	0.582	$ -
9	PERIODIC COST - O&M	$0		$0	0.544	$ -
10	PERIODIC COST - O&M	$583,022	$89,700	$672,722	0.508	$ 341,978
11	PERIODIC COST - O&M	$0		$0	0.475	$ -
12	PERIODIC COST - O&M	$0		$0	0.444	$ -
13	PERIODIC COST - O&M	$0		$0	0.415	$ -
14	PERIODIC COST - O&M	$0		$0	0.388	$ -
15	PERIODIC COST - O&M	$583,022	$89,700	$672,722	0.362	$ 243,826
16	PERIODIC COST - O&M	$0		$0	0.339	$ -
17	PERIODIC COST - O&M	$0		$0	0.317	$ -
18	PERIODIC COST - O&M	$0		$0	0.296	$ -
19	PERIODIC COST - O&M	$0		$0	0.277	$ -
20	PERIODIC COST - O&M	$583,022	$89,700	$672,722	0.258	$ 173,844
21	PERIODIC COST - O&M	$0		$0	0.242	$ -
22	PERIODIC COST - O&M	$0		$0	0.226	$ -
23	PERIODIC COST - O&M	$0		$0	0.211	$ -
24	PERIODIC COST - O&M	$0		$0	0.197	$ -
25	PERIODIC COST - O&M	$583,022	$89,700	$672,722	0.184	$ 123,949
26	PERIODIC COST - O&M	$0		$0	0.172	$ -
27	PERIODIC COST - O&M	$0		$0	0.161	$ -
28	PERIODIC COST - O&M	$0		$0	0.150	$ -
29	PERIODIC COST - O&M	$0		$0	0.141	$ -
30	PERIODIC COST - O&M	$583,022	$89,700	$672,722	0.131	$ 88,374
					TOTAL PRESENT VALUE OF ALTERNATIVE	**$ 2,034,600**

TABLE 8

Long Term Operations and Maintenance Costs for Onsite Confined Disposal Facility (CDF) - Disposal Options F and G

Gowanus Canal Feasibility Study

Brooklyn, New York

Site: Gowanus Canal
Location: Brooklyn, NY
Description: Operations and Maintenance Detailed Costing

CAPITAL COSTS	DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
CDF Maintenance						
	Integrity Surveys	5	DAY	$2,100.00	$10,500	
	Mowing	0	EA	$1,000.00	$0	
	Utilities	0	MO	$1,000.00	$0	
	SUBTOTAL CDF MAINTENANCE				$10,500	
	TOTAL CAPITAL COST				**$10,500**	

O&M	DESCRIPTION	YEAR	QTY	UNIT	COST	TOTAL	NOTES
	Sampling						
				ea	$0	$0	
	Subtotal Annual O&M					**$0**	
	Reporting (1 annual report)		1	LS	$5,000	$5,000	
	Contingency		20%			$1,000	
	Subtotal Annual O&M					$6,000	
	Project Management		15%			$900	
	TOTAL PERIODIC O&M COST					**$6,900**	

PRESENT VALUE ANALYSIS (30-year) Discount Rate = 7.0%

End Year	COST TYPE	Capital Cost	O&M Cost	TOTAL COST/YEAR	DISCOUNT FACTOR	PRESENT VALUE
0	CAPITAL COST	$10,500	$0	$10,500	1.000	$ 10,500
1	PERIODIC COST - O&M	$10,500	$0	$10,500	0.935	$ 9,813
2	PERIODIC COST - O&M	$10,500	$0	$10,500	0.873	$ 9,171
3	PERIODIC COST - O&M	$10,500	$0	$10,500	0.816	$ 8,571
4	PERIODIC COST - O&M	$10,500	$0	$10,500	0.763	$ 8,010
5	PERIODIC COST - O&M	$10,500	$6,900	$17,400	0.713	$ 12,406
6	PERIODIC COST - O&M	$10,500	$0	$10,500	0.666	$ 6,997
7	PERIODIC COST - O&M	$10,500	$0	$10,500	0.623	$ 6,539
8	PERIODIC COST - O&M	$10,500	$0	$10,500	0.582	$ 6,111
9	PERIODIC COST - O&M	$10,500	$0	$10,500	0.544	$ 5,711
10	PERIODIC COST - O&M	$10,500	$6,900	$17,400	0.508	$ 8,845
11	PERIODIC COST - O&M	$10,500	$0	$10,500	0.475	$ 4,988
12	PERIODIC COST - O&M	$10,500	$0	$10,500	0.444	$ 4,662
13	PERIODIC COST - O&M	$10,500	$0	$10,500	0.415	$ 4,357
14	PERIODIC COST - O&M	$10,500	$0	$10,500	0.388	$ 4,072
15	PERIODIC COST - O&M	$10,500	$6,900	$17,400	0.362	$ 6,307
16	PERIODIC COST - O&M	$10,500	$0	$10,500	0.339	$ 3,557
17	PERIODIC COST - O&M	$10,500	$0	$10,500	0.317	$ 3,324
18	PERIODIC COST - O&M	$10,500	$0	$10,500	0.296	$ 3,107
19	PERIODIC COST - O&M	$10,500	$0	$10,500	0.277	$ 2,903
20	PERIODIC COST - O&M	$10,500	$6,900	$17,400	0.258	$ 4,496
21	PERIODIC COST - O&M	$10,500	$0	$10,500	0.242	$ 2,536
22	PERIODIC COST - O&M	$10,500	$0	$10,500	0.226	$ 2,370
23	PERIODIC COST - O&M	$10,500	$0	$10,500	0.211	$ 2,215
24	PERIODIC COST - O&M	$10,500	$0	$10,500	0.197	$ 2,070
25	PERIODIC COST - O&M	$10,500	$6,900	$17,400	0.184	$ 3,206
26	PERIODIC COST - O&M	$10,500	$0	$10,500	0.172	$ 1,808
27	PERIODIC COST - O&M	$10,500	$0	$10,500	0.161	$ 1,690
28	PERIODIC COST - O&M	$10,500	$0	$10,500	0.150	$ 1,579
29	PERIODIC COST - O&M	$10,500	$0	$10,500	0.141	$ 1,476
30	PERIODIC COST - O&M	$10,500	$6,900	$17,400	0.131	$ 2,286
					TOTAL PRESENT VALUE OF ALTERNATIVE	**$ 155,700**

TABLE 9

Long Term Operations and Maintenance Costs for Onsite Stabilization and Beneficial Use Disposal Option (Option E)

Gowanus Canal Feasibility Study

Brooklyn, New York

Site:	Gowanus Canal		**Description:**	Operations and Maintenance Detailed Costing			
Location:	Brooklyn, NY						

CAPITAL COSTS	DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Staging Facility Maintenance						
	Temporary Access Road Construction	2,500	SY	$11.35	$28,375	
	Rough Grading	2,421	SY	$1.00	$2,421	
	Stone Base	541	CY	$30.00	$16,221	
	Silt Fence	750	LF	$5.00	$3,750	
	Filter Fabric	2,421	SY	$2.00	$4,842	
	SUBTOTAL FACILITY MAINTENANCE				$55,609	
Property Rental						
	Temporary Storage Area (2 Acres)	12	MO	20000	$240,000	
	SUBTOTAL PROPERTY RENTAL				$240,000	
	TOTAL CAPITAL COST				**$295,609**	

O&M	DESCRIPTION	YEAR	QTY	UNIT	COST	TOTAL	NOTES
	Sampling						
	Geoprobe Sampling		1	LS	$7,150	$7,150	
	Subtotal Annual O&M					**$7,150**	
	Reporting (1 annual report)		1	LS	$15,000	$15,000	
	Contingency		20%			$4,430	
	Subtotal Annual O&M					$26,580	
	Project Management		15%			$3,987	
	TOTAL PERIODIC O&M COST					**$30,567**	

PRESENT VALUE ANALYSIS (30-year) Discount Rate = 7.0%

End Year	COST TYPE	Capital Cost	O&M Cost	TOTAL COST/YEAR	DISCOUNT FACTOR	PRESENT VALUE
0	CAPITAL COST	$0.00	$0.00	$0.00	1.000	$ -
1	CAPITAL COST/PERIODIC COST - O&M	$295,609	$30,567	$326,176	0.935	$ 304,837
2	CAPITAL COST/PERIODIC COST - O&M	$295,609	$30,567	$326,176	0.873	$ 284,895
3	CAPITAL COST/PERIODIC COST - O&M	$295,609	$30,567	$326,176	0.816	$ 266,257
4	CAPITAL COST/PERIODIC COST - O&M	$295,609	$30,567	$326,176	0.763	$ 248,838
5	CAPITAL COST/PERIODIC COST - O&M	$295,609	$30,567	$326,176	0.713	$ 232,559
6	CAPITAL COST/PERIODIC COST - O&M	$295,609	$30,567	$326,176	0.666	$ 217,345
10	CAPITAL COST/PERIODIC COST - O&M	$295,609	$30,567	$326,176	0.508	$ 165,811
15	CAPITAL COST/PERIODIC COST - O&M	$295,609	$30,567	$326,176	0.362	$ 118,221
20	CAPITAL COST/PERIODIC COST - O&M	$295,609	$30,567	$326,176	0.258	$ 84,290
25	CAPITAL COST/PERIODIC COST - O&M	$295,609	$30,567	$326,176	0.184	$ 60,098
30	CAPITAL COST/PERIODIC COST - O&M	$295,609	$30,567	$326,176	0.131	$ 42,849
					TOTAL PRESENT VALUE OF ALTERNATIVE	**$ 2,026,000**

Feasibility Study December 2011 Errata

This errata sheet contains corrections to the Feasibility Study (FS) report for the Gowanus Canal, Brooklyn, New York (December 2011).

1. Table 2-2, Summary of Preliminary Remediation Goals for Surface Water – surface water concentrations are reported in nanograms per liter (ng/L)
2. Appendix C.1, Table 6, Calculation of Human Health Preliminary Remediation Goals for Surface Water – all surface water concentrations are reported in micrograms per liter (µg/L)

Confined Disposal Facility Construction and Operation ARARs

If a Confined Disposal Facility (CDF) were to be constructed, it would need to meet the substantive requirements of the action-specific Applicable or Relevant and Appropriate Requirements (ARARs) listed below. The design of the CDF would need to consider if these substantive requirements are triggered and identify how compliance will be achieved.

ARARs
Section 401 of the Clean Water Act Certification
6 NYCRR Part 608 Use and Protection of Waters
6 NYCRR Part 701 Classifications-Surface Waters and Groundwaters

Section 404(b) of the Clean Water Act
40 CFR Part 230

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
Article 3 Title 3
Article 15 Title 5

New York State ECL Article 11, Title 5 - NY ECL § 11-0503

New York State ECL Article 17, Title 5

New York State ECL, Article 19, Title 3
6 NYCRR Parts 200–257

NYSDEC - New York Guidelines for Soil Erosion and Sediment Control

To Be Considered
NYSDEC- Technical & Operational Guidance Series (TOGS)
5.1.9 In-Water and Riparian Management of Sediment and Dredged Material (November, 2004)

NYSDEC Technical and Administrative Guidance Memorandum (TAGM) 4031 Fugitive Dust Suppression and Particulate Monitoring Program at Inactive Hazardous Waste Sites
NYSDEC Division of Air Resources: Air Guide 1 – Guidelines for the Control of Toxic Ambient Air Contaminants

NYC Law 77
Title 24 Section 24-163.3

NYCDEP Notice of Promulgation of Chapter 14 of Title 15 of the Rules of the City of New York

New York City Noise Code (Local Law 113 of 2005)

New York City Administrative Codes: Title 13, Article 15 Prevention of Emission of Dust from Construction Related Activities, Title 24: Environmental Protection and Utilities

In addition to the above, based on the selected location, the CDF would need to comply with the substantive requirements of location-specific ARARs. The list of location-specific ARARs to be considered is presented in the Feasibility Study.