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New York/Caribbean Superfund Branch
U.S. Environmental Protection Agency, Region II
290 Broadway, 17th Floor
New York, NY 10007-1866

Re: City of New York's Comments to Support EPA's Feasibility Study at the Gowanus Canal

Dear Mr. Tsiamis:

The City of New York ("City") hereby submits the following comments to the United States Environmental Protection Agency ("EPA") to assist EPA's efforts to develop a Feasibility Study ("FS") for the Gowanus Canal Superfund Site. The City requests that these comments be included in the administrative record for the site.

Introduction

Since the release of the draft Remedial Investigation (RI) in January 2011, the City has provided EPA the following written documents: (i) a May 25, 2011 letter to EPA on the overall Draft Remedial Investigation ("May Letter"); (ii) an October 6, 2011 presentation to EPA presenting analysis of RI data with respect to combined sewer overflow (CSO) contaminant levels for contaminants of concern (COCs) identified in sediment or surface water ("October EPA Presentation"); (iii) a November 3 presentation to Contaminated Sediment Technical Advisory Group (CSTAG) ("CSTAG Presentation"); (iv) and a November 28, 2011 memorandum from Angela Licata to Dr. Marc S. Greenberg of the CSTAG entitled *Gowanus Canal Superfund Site: Estimation of PAH Concentrations on Solids from CSO Water Column Data* ("CSTAG Memo"). Item iv. is attached to this letter, in order to provide a complete record, as that letter was submitted directly to CSTAG.

The purpose of this letter is to present additional details of the analyses which were completed in support of the EPA presentation and the CSTAG presentation. The following sections present data and analyses on 1) RI data analysis in support of the Feasibility Study; 2) Assessment of the Conceptual Site Model (CSM) for the Gowanus Canal based on available site data; 3) Impact of organic carbon content in solids from CSOs on the canal; 4)

Recommendations for additional sampling and analysis; and 5) Planned Upgrades and projected benefits related to ongoing, planned, or potential Clean Water Act-related projects.

1 RI Data Analysis in Support of the Feasibility Study

The City analyzed the data presented in the RI Report to provide information for use in the Feasibility Study (FS) and to assist EPA in determining whether remedial action is required for CSOs in order to be protective of human health and the environment, as is required under CERCLA. The data used in this analysis are the data reported in the RI Report for CSOs for both sediment and surface water. The process that was used in this analysis included:

- Identification of contaminants of concern (COCs) based on the results of the human health and ecological risk assessments,
- Development of risk-based cleanup values, also called preliminary remediation goals (PRGs),
- Comparison of City CSO data to regional background concentrations, and
- Comparison of City CSO data to PRGs to determine which, if any, of the COCs identified were measured in City CSOs at concentrations exceeding these values.

1.1 Identification of Contaminants of Concern (COC)

COCs were identified based on the results of the human health and ecological risk assessments.

1.1.1 Human Health Risk Assessment (HHRA) Results:

The NCP identifies the acceptable risk range for human health as 10^{-6} to 10^{-4} for carcinogens and an acceptable hazard index (HI) of 1.0 for non-carcinogens. These risk targets were exceeded for the Lifetime Recreational User based on exposures to sediment and surface water in the canal. These risk targets were also exceeded for the Lifetime Angler based on ingestion of fish and crabs from the canal. The results of the HHRA are presented in Appendix 1.

The following COCs were identified in sediment based on risks to the lifetime recreational user: arsenic;benz(a)anthracene;benzo(a)pyrene;benzo(b)fluoranthene;benzo(k)fluoranthene;dibenz(a, h)anthracene; and indeno(1,2,3-c,d)pyrene. These are shown in Table 1-1.

The following COCs were identified in surface water based on risks to the lifetime recreational user: chromium $^{+6}$and tetrachloroethylene. These are shown in Table 1-2.

The following COCs were identified in fish/crabs based on risks to the lifetime recreational angler: PCBs;arsenic;mercury;benzo(a)pyrene;dibenz(a,h)anthracene; andindeno(1,2,3-c,d)pyrene. These risk results are shown in Appendix 1.

1.1.2 Ecological Risk Results:

The results of the Ecological Risk Assessment identified the following COCs in sediment: barium; cadmium; lead; mercury; nickel; silver; total PAHs; and Total PCBs. The only COC identified for ecological receptors in surface water was lead.

1.2 Derivation of Risk-Based Cleanup Values

1.2.1 Human Health-Based PRGs:

Tables 1-1 and 1-2 show the risk-based cleanup values that have been derived for COCs identified in sediment and surface water based on recreational use of the Canal. CSO sediments do not exceed the PRGs proposed for any of the COCs identified in sediment or surface water. Furthermore the cumulative cancer risks calculated for the COCs in CSOs, utilizing maximum measured contaminant concentrations is 9.9 x 10-6, which is well below the acceptable risk target of 10^{-4} set forth in the NCP. Additionally, the cumulative risks for background samples for all COCs in sediment measured at background locations is 6.2×10^{-6}. Thus, the CSO and background risks are essentially equal. The conclusion from this assessment is that CSO solids do not represent a source of contaminants at concentrations that exceed risk targets or that exceed the concentrations measured in background samples. The same set of conclusions can be drawn for the surface water data presented in Table 1-2 for CSOs in the RI. The cumulative risks for COCs measured in water at CSOs are equivalent to background and are well below EPA's risk targets.

1.2.2 Ecological PRGs:

Table 1-3 presents the PRGs which were derived for ecological receptors for sediment and surface water based on the results presented in the RI Report. The analysis conducted in the derivation of PRGs for ecological receptors is presented in Appendix 1.

1.3 Comparison to Background

Sediment and surface water data presented in the RI Report for CSOs were compared with the samples collected from the reference/background site in order to determine whether COC concentrations measured in the CSOs are representative of regional background conditions.

EPA's statistical software package, ProUCL version 4.1, was used to compare the CSOs with the background. Quantitative comparisons of the CSO and background data were conducted by comparing the CSO results by hypothesis testing and/or by comparison to a background threshold value. Hypothesis testing was limited for some COCs due to the limited number of detected samples in the two datasets. Qualitative comparison using box and whisker and normal quantile plots were also used to compare the data. Background threshold values were derived for the reference site using guidelines from EPA in the ProUCL 4.1 documentation.

Comparison of the concentration in CSOs vs. background was conducted only for COCs identified based on ecological and human health risks. Results of the comparison for sediments and surface water are summarized in Tables 1-4a and 1-4b, respectively. There were no PAHs in CSOs which were demonstrated to exceed the background sediment values. Due to data limitations, conclusive results could not be reached for dibenz(a,h)anthracene. CSO data were analyzed only for Aroclors in the RI Report. CSO results for TPCB by Aroclor were within the range of reference area results for TPCB by congeners. At face value, this would indicate that CSO and reference area solids have essentially the same PCB levels. However, data for PCBs include frequent non-detects and inconsistencies within the reference area samples. Comparison of the sediment results showed that CSOs exceeded background for barium, copper, and lead.

Comparison of CSO surface water data with background was affected by data quality issues which are discussed in detail in the November 28 letter to CSTAG (Attachment C). One of the main issues is that the reporting limits for background and CSOs in surface water were not consistent. For some CSO samples, the reporting limit was greater than the corresponding reporting limit of the background samples by an order of magnitude. Also, in some cases the detected results of the CSOs were lower than the reporting limits of the background samples. These data quality issues create difficulties when comparing CSO data to background for surface water. Surface water comparisons showed that the CSO concentrations were greater than the background for whole water lead, and tetrachloroethylene.

2 Assessment of the CSM for the Gowanus Canal based on available site data

As stated in prior comment submissions, the EPA has yet to develop an adequate conceptual site model to characterize the Canal. This stems primarily from the fact that EPA has not developed solids and contaminant mass balances. While much work remains to be done, the City performed several analyses to advance the current CSM. These analyses included an assessment of ground water impact on the Canal, an estimation of solids loads from CSOs, and an estimation of solids accumulation in the Canal, each discussed below.

2.1 Groundwater Modeling:

There are several potential sources of contamination to the Canal and an essential task in developing the CSM is to evaluate the relative importance of the different sources. One of the major potential sources is contaminants borne on groundwater discharges to the Canal. To estimate the amount of contaminants that are delivered to the Canal (i.e., the mass loaded to the Canal) by groundwater, it is first necessary to estimate the amount of groundwater that discharges to the Canal. Once the groundwater discharge is estimated, then a contaminant load can be estimated from the observed groundwater concentrations and from the estimate of dissolution of dense non-aqueous phase liquids (DNAPL) that exist within the groundwater flow path to the Canal. This estimation of groundwater contaminant load can then be used to compare to the contaminant loads represented by other sources. For the analysis of the potential impact of groundwater on chemical loads to the Canal, groundwater modeling was conducted in two steps. The first step was to determine groundwater discharge using the MODFLOW groundwater flow model. The second step was to model contaminant fate and transport through the aquifer using the contaminant fate and transport/NAPL dissolution model SEAM3D, which utilizes results from the MODFLOW simulation, contaminant concentrations found in the groundwater near the Canal, and coal tar DNAPL characteristics.

The MODFLOW model approach and results are as follows:

- Based on site information and USGS publications, using stratigraphy found in soil borings and sediment cores, as well as regional stratigraphy from USGS documents, hydraulic properties that are similar to those used in USGS models for the area and recharge values that are similar to those used by the USGS (note these were adjusted downward from the USGS values to achieve calibration);
- The model developed by the City agrees well with USGS groundwater levels from long-term monitoring wells within the model domain that are not influenced by tides and flow data;
- The calibrated discharge to Gowanas Canal is about 2.1 ft^3/sec., which compares well with a USGS pre-development estimate of 2.5 ft^3/sec (note that the USGS model did not simulate current conditions, but estimated that there is general reduction in recharge, hence a reduction in discharge due to development).
- The model indicates about 75 percent of the groundwater flow to the Canal is through the bottom sediment and 25 percent of flow is through the banks.

The analyses of contaminant fate and transport and loading are as follows:

- DNAPL chemistry and composition were defined based on DNAPL investigations from National Grid, as well as examining contaminant distribution in samples collected from strata identified as containing DNAPL beneath the Canal. National Grid's observations recorded in core logs indicate DNAPL is present beneath almost the entire Canal;

- The model SEAM3D simulated dissolution of DNAPL as a kinetic process dependent on the effective solubility. The effective solubility was estimated based on Raout's Law which considers the molar fraction of each compound in the DNAPL. SEAM3D combines the dissolution kinetics with the 3-dimensional flow from MODFLOW. SEAM3D also considers the retardation effects of contaminants being sorbed to organic carbon in the sediment and subsurface material.
- Four analytes(benzo(a)pyrene, phenanthrene, naphthalene, and total xylenes) representing heavy to light organic compounds found in the DNAPL were simulated.
- The simplistic representation of the model is of constituents dissolved in groundwater and does not account for organic carbon saturation (although the model was run simulating reduced available organic carbon), the effect of co-solvent compounds on the dissolution and partitioning of the various chemicals, and the existence of DNAPL discharges to the Canal. These factors are important to the transport of contaminants and will increase the mass loaded to the Canal beyond the amounts loaded as constituents dissolved in groundwater.
- Parallel calculations were made by simply estimating the mass that could be delivered by the water arriving at the Canal being saturated to the effective solubility of the compounds identified in the DNAPL, and at the concentration of the compounds in the groundwater adjacent to the Canal (including for metals which were not simulated in the model and not part of the DNAPL). These results were compared to the estimates of loading of the four analytes predicted by the model. The model-predicted loadings were less than the effective solubility-estimated contaminant loads. In comparison to the groundwater concentration based loads, only BaP from the model-predicted loads was greater than the groundwater concentration based load. Table 2-1a presents the comparison and Table 2-1b presents the groundwater concentration based loads for metals.
- The groundwater-transported contaminant loads estimated by the model and the calculations were compared to the loads represented by the CSOs. This comparison shows that smallest loads estimate for groundwater are significantly greater than the loads estimated for the CSOs (see Tables2-1a and 2-1b). If the effects of co-solvency and direct discharge of DNAPL to the Canal are considered, then the groundwater-transported loads are even larger, further diminishing the importance of any CSO-related contaminant loads.

Comparison of potential loads from groundwater and CSOs to the Gowanus Canal indicates that groundwater contributions are several times higher than loads from CSOs for PAHs. In particular, for benzo(a)pyrene, groundwater loads to the Canal are estimated to be at least four times greater than corresponding CSO contribution. Estimates of potential groundwater loads for heavy metals are also higher than loads from CSOs, except for copper and lead.

2.2 Solids Load from CSOs:

The solids load from the CSOs to the Gowanus Canal was estimated using the modeled annual discharge from the CSOs and the TSS concentrations from the EPA RI report. DEP had modeled the annual discharge from the CSOs to the Canal for current conditions and for conditions post implementation of the force main project. The annual discharge for the two conditions was estimated to be 376 (million gallons (MG)/yr) and 250 (MG/yr) respectively (NYCDEP, 2008). Water samples from CSOs collected by EPA were analyzed for total suspended solids (TSS) concentration. The TSS concentrations during the three wet weather events ranged from 18 mg/L to 989 mg/L. The average and median concentrations of TSS were 136 mg/L and 61 mg/L respectively. TSS results provided by EPA are shown in Table 2-2. Higher concentrations of TSS were observed during Wet Weather Event 2. However, evaluation of the rainfall intensity showed that Wet Weather Event 2 had the lowest rainfall intensity of all the rainfall events, suggesting that these high values may not be typical of most major rainfall events and the larger volume of CSO discharges that occur during these events. If these two values are excluded from the mean wet weather TSS calculation, the average TSS values reduces to 70 mg/L, which is more consistent with the City's expectation of lower TSS levels (65-70 mg/L[1]) during wet weather events. The wide variation in the results and the sensitivity of the mean value to just two values is considered symptomatic of poor TSS data in general. The City believes that the discrete sampling method employed by EPA fails to characterize the TSS levels in the CSO discharge during a wet weather event. The TSS value of 70 mg/L and the modeled discharge rate of 376 MG/yr were used by the City to estimate the solids load from the CSOs. For current conditions, the estimated solids load is approximately 100 MT/yr. For future conditions, where the City anticipates a 45% reduction in the CSO discharge volume, the solids load from the CSOs is estimated to be 60 MT/yr.

2.3 Estimation of Solids Accumulation in the Canal:

To increase the understanding of the conceptual site model for the Canal it is important to understand the sources of solids to the Canal. Sources of freshwater to the Canal are the CSOs, groundwater flow, overland flow, and storm water outfalls. Of these sources, groundwater is not a significant solids source to the Canal. CSO and stormwater discharges are limited to wet weather.

To estimate the solids accumulation in the Canal, bathymetry surveys conducted in 2003 and 2010 were evaluated. These surveys were conducted using single beam bathymetry transects.

[1]TSS values in sanitary sewage average about 115 mg/L (NYCDEP, 2002) while in stormwater, TSS values average about 60 mg/L (Hazen and Sawyer, P.C., 1993). Analyses conducted for the *Gowanus Canal WBWS Facility Plan Report, August 2008* indicate that CSOs are roughly 90 percent stormwater and 10 percent sanitary sewage, yielding a typical TSS concentration for CSOs at about 65-70 mg/L.

The survey conducted in 2003 consists of lateral transects approximately 150 ft apart and only one longitudinal transect. The 2010 survey consists of lateral and longitudinal transects with higher density of soundings compared to 2003. However, there is little overlap between the lateral transects surveyed in 2003 and those surveyed in 2010. This lack of overlap increases the uncertainty associated with estimating the change in elevation between the surveys
Results of this comparison are shown in Figure 2-1. Comparison of the surveys shows that the Canal is mostly depositional with few localized erosional areas. Since 2003 the head end of the Canal has experienced the most deposition with an average accumulation of 1.2 ft. Table 2-3lists the net volume and mass of solids that have accumulated in the Canal. Analysis of the bathymetry data shows that the Canal accumulated approximately 1,000 metric tons (MT) of solids annually from 2003 to 2010. To understand the contribution of CSOs to this accumulation, a conservative assumption was made that all the solids contributed to the Canal by CSOs settled in the Canal. An estimate of the mass of solids delivered by the CSOs on an annual basis was compared with the mass of solids accumulated. Figure 2-2 shows the percentage contribution of CSOs to the Canal. Under this conservative assumption, the CSOs account for only 10 percent of the solids that have accumulated since 2003. For future conditions (45 percent reduction in CSO discharge) the contribution of solids to the Canal will reduce to 5 percent making CSOs an insignificant source of solids.

The City is aware of the general uncertainty associated with the bathymetry survey measurements, along with the uncertainty due to interpolation of the data, misalignment of transects, and sensitivity of the comparison to vertical datum corrections. Thus, in order to develop a robust solids balance that can be used to understand sediment dynamics, it is important to account for these uncertainties. Additional multi-beam surveys as well as targeted sampling are required to better define the relative contributions of CSO and estuary solids to develop an accurate CSM. This includes collection of beryllium-7 bearing sediment sampling to identify recent depositional areas and the properties of recently deposited sediments, as well as deployment of sediment traps during dry and wet weather events to characterize mean water column suspended matter properties, especially at the head end of the Canal where significant deposition has been observed.

3 Impact of Organic Carbon Content in solids from CSOs on the Canal

EPA has expressed concern that the high Organic Carbon concentration in the CSO solids will hinder the recovery of the Canal post-cleanup by acting as a "magnet" to organic contaminants. However, ecological exposure is not simply a function of absolute sediment concentration. Rather the amount of the compound in sediment that is bioavailable is dependent on factors specific to the sediment, many of which can be represented by noting the amount of organic carbon on the sediments. Generally speaking, for a given absolute sediment concentration, the sediment with the highest amount of organic carbon has the lowest amount of bioavailable contaminant. This is often represented as the organic carbon-normalized concentration. DEP performed some theoretical calculations for sediments in the Canal, creating a blend of CSO and reference area solids and allowing the solids to come to equilibrium with a constant load of benzo(a)pyrene.

Figures 3-1a and 3-1b depict the results of this calculation. The organic carbon content of the solids created by the blend (intended to represent settling solids in the Canal) increased as the fraction of CSO solids in the mixture increased. While the addition of organic carbon did cause some increase in the absolute concentration of B(a)P on the solids, the organic carbon normalized concentration decreased under all additions of CSO solids. On this basis, the addition of CSO solids to the sediments in the Canal would serve to reduce bioavailable concentrations of contaminants in essentially all cases. For the likely scenarios where CSO solids represent 0 to 10 percent of the settling solids in the Canal, absolute concentrations might increase by a maximum of 37 percent but the bioavailable concentrations would decrease by 16 percent, with the greatest benefit of the organic carbon addition occurring at the maximum absolute concentration.

To further investigate EPA's concern, data collected by EPA for total organic carbon (TOC) concentration in sediment for the CSOs, Canal, and background was evaluated. The average TOC concentration in the sampled CSOs ranges from 1% to 22% with an average and median concentration of 6% and 3% respectively. Figure 3-2 shows the distribution of TOC concentration in the sampled CSOs, Canal, and Background. Data collected by EPA shows that the TOC concentration in all the sampled CSOs, except OH-007, is not significantly different from background levels. However, given the nature of the solids that are discharged from the CSOs based on other studies, it is likely the TOC concentration in the CSO discharges is higher than what was sampled by EPA. This concern again points the need to obtain better data to properly assess the impact of the CSO discharge.

4 Additional Sampling and Analysis

The City believes that EPA's data fails to characterize the CSOs accurately and consequently the impact of the CSOs on the Canal. The current available data for the site are limited and fraught with quality concerns, and hence cannot be used to develop a robust conceptual site model. It is therefore the City's opinion that additional data collection and analysis is required to develop an understanding of the Canal. These data collection and analysis should include:

a) Re-characterization of CSOs
    - Aqueous sampling with analysis of particulate and dissolved phase concentrations with lower detection for analyzing the contaminants.
    - Composite sampling to integrate the concentration variations over the period of discharge during a rainfall event.

b) Targeted Sampling to develop an accurate Conceptual Site Model.
   - Deployment of sediment traps during dry and wet weather events to characterize mean water column suspended matter properties, especially at the head end of the canal where most deposition has been observed.
   - Beryllium-7 bearing sediment sampling to identify recently depositional areas and the properties of recently deposited sediments.

c) Sampling to advance the groundwater model.
   - Identification of groundwater discharge pathways.
   - Sampling of pore water and assessment of NAPL stability.

d) Forensic analysis to identify relative contributions by external/internal loads to the canal (CSOs, Upper NY Bay, SWO, groundwater, sediment resuspension).

e) Water quality monitoring to establish tidal cycle current velocities, water column stratification (salinity), TSS levels.

f) Simple contaminant fate and transport and water quality modeling (e.g. Recovery Model).

g) Development of sediment transport models to understand the transport of solids in the canal.

5 Planned and/or Potential Upgrades and Projected Benefits under the NYSDEC CSO Consent Order

The following section describes the benefits of planned or potential upgrades (and related programs) which we have discussed with EPA over the past several months.

5.1 Characterization of the Gowanus Canal Watershed and Waterbody:

DEP has compiled available information and specifications regarding the collection-system infrastructure serving the Canal watershed, and has performed field surveys and modeling analyses to confirm and verify this information. The relevant portions of this information are too extensive to include here, but are documented in the WB/WS (NYCDEP 2008). Chapter 3 of that report focuses on the existing collection-system infrastructure, and Chapters 4 and 5 present an overview of infrastructure inspection and improvement programs in which DEP has engaged over the last quarter century. DEP continues to refine the watershed information, including converting the relevant data into geographical information system (GIS) format, using high-resolution satellite images to characterize surface imperviousness, and implementing high-resolution digital elevation mapping (DEM) data. In addition, DEP continues to expand and update information, such as measurements of in-sewer sediment levels and time-varying water levels. DEP has also compiled substantial information pertaining to characterization of the Gowanus Canal waterbody. Chapter 4 of the WB/WS summarizes various DEP studies characterizing the waterbody's water quality, biota, benthos, and toxicity. Notably, DEP has sampled waterbodytotal suspended solids (TSS) concentrations as part of its regular Harbor Survey Program, special Tributary Survey Programs, and project-specific field investigations. DEP has also increased the understanding of water quality in the Canal through the development and application of water-quality modeling of the CanalWB/WS.

5.2 Planned Facility Upgrades in the Gowanus Canal Watershed:

As part of its efforts to develop an effective and efficient plan to reduce wet-weather-induced pollution and improve water quality in the Canal, DEP has conducted a series of investigations analyzing alternatives for CSO control and other measures. These investigations considered the feasibility, effectiveness, costs, and public acceptance of a wide array of CSO-control alternatives. Chapters 5 and 7 of the WB/WS (NYCDEP 2008) summarizes historical investigations as well as control alternatives considered during the development of the WB/WS Facility Plan. As described in the WB/WS, DEP first screened alternatives that were infeasible or publicly unacceptable, and then performed modeling analyses to determine the CSO reduction and water-quality impacts for a wide range of control alternatives. For each alternative, DEP also performed costing analyses, and used the results to create "knee-of-the-curve" relationships of cost-effectiveness. The results showed that adding CSO controls beyond a certain point provided no further increase in attainment of water-quality standards or uses, and recommended the following as the effective and efficient plan: modernization of the Gowanus Canal Flushing Tunnel to improve circulation in the Canal; reconstruction of the Gowanus Wastewater Pumping Station to reduce capacity limitations and redirect flow away from the overburdened Bond-Lorraine Sewer, thereby reducing CSO discharges to the Canal; environmental dredging of the upper 750-ft section of the Canal to eliminate exposed sediment mounds and the associated odors and increase secondary contact recreational activity access; and continued implementation of existing programmatic controls including the 14 best management practices as required in the City's SPDES permits, floatables controls per the City's Floatables Plan, and Sustainable Stormwater Management practices.

The WB/WS did not specifically account for additional sustainable stormwater management controls, which were still being developed at the time. These additional controls would add to the benefits of the WB/WS Facility Plan elements.

5.3 Ongoing Additional CSO Controls for the Gowanus Canal Watershed:

Beyond the upgrades associated with the WB/WS, DEP is pursuing a number of specific actions that are anticipated to reduce CSO discharges and/or improve water quality in the Canal. These actions include:

Implementation of High Level Sewer Separation (HLSS): HLSS directs runoff collected in catch basins to a separate stormwater pipe leading directly to the waterbody rather than to the combined-sewer system. This action removes flow from the combined sewer system and reduces the likelihood and magnitude of CSOs. The City has already implemented a programmatic approach whereby HLSS is proceeding in selected areas, including an area of roughly 100 acres in the Gowanus Canal watershed. This project area is shown in Figure 5-1. DEP performed preliminary modeling analyses that indicate this project would reduce CSOs to the Canal by about 5 percent, at a cost of about $20 million.

Sewer Maintenance: In 2004, sewer cleaning removed approximately 110,000 cubic yards of silt, debris and grease from the Bond-Lorraine Sewer and, in 2011, sewer cleaning has removed 724 cubic yards of similar material from the 4th Avenue sewer. Removal of material restores the hydraulic capacity of the sewer and helps to minimize CSOs that would otherwise increase over time. In total, these cleaning operations have cost approximately $685,000.

Interceptor Maintenance: Ongoing inspections of the Red Hook and Owls Head collection-system interceptors are 90 and 16 percent complete, respectively. These inspections help optimize cleaning requirements to maintain capacity and minimize CSOs. In 2010 and 2011, DEP spent $148,000 for interceptor maintenance, which will be completed by the end of 2012.

5.4 Green Infrastructure Program:

In September 2010, New York City released the NYC Green Infrastructure Plan (GIP) which presents an alternative approach to improving water quality that integrates "green infrastructure," such as swales and green roofs, with investments to optimize the existing system and to build targeted, cost-effective "grey" or traditional infrastructure. On a city-wide basis, the GIP will reduce CSO volume by an additional 1.5 billion gallons per year beyond the cost-effective Grey Strategy that is made part of the approved WB/WS Plans. In the Gowanus Canal watershed area, the GIP will:

- Capture rainfall from 10% of impervious surfaces in CSO areas through green infrastructure and other source controls.
- Provide substantial, quantifiable sustainability benefits – cooling the city, reducing energy use, increasing property values, and cleaning the air – that an all-Grey Strategy does not provide.

Examples of GIP alternatives that could be pursued in the Gowanus Canal watershed include tree pits, swales, green roofs, blue roofs, cisterns, and other controls. It is anticipated that GIP alternatives implemented in the Gowanus Canal watershed will reduce CSO discharges by approximately 11 percent from the level achieved by the elements of the WB/WS. Sub-catchment opportunities analysis for CSOs RH-034 and OH-007 is shown in Figure 5-2.

5.5 Potential Additional CSO Controls Considered for the Gowanus Canal Watershed:

Potential additional controls that will be further evaluated as part of the Gowanus Canal LTCP, due 2015, include modifications at the 2nd Avenue Pumping Station, an auxiliary wet-weather pumping facility at the Gowanus Pumping Station, and cleaning and structural modifications at the OH-007 sediment trap. Each of these alternatives is described in more detail below.

5.5.1 2nd Ave Pumping Station: DEP currently has a small 1.0 MGD capacity subsurface pump station located near the intersection of 2nd Avenue and 5th Streets in Brooklyn. This pump station transfers dry weather sewage and wet weather flow into a force main that conveys the flow to the 4th Avenue interceptor and then to the Owls Head WWTP. This pump station was last renovated about 20-years ago in the early 1990's.

The 2nd Avenue Pump Station alternative would involve abandoning the subsurface 1.0 MGD pump station and constructing a larger 5 MGD above grade facility. The dry weather flow capacity of the station would remain at 1.0 MGD but the additional capacity would be used to pump wet weather flow from outfall OH-007 to the 4th Avenue interceptor. The construction of a larger pump station would require the replacement of the existing 6-inch force main with a larger 12-inch force main.

A large pump station at this location, shown in Figure 5-3, would result in an estimated CSO reduction from outfall OH-007 of 14 MG/yr. The additional wet weather flows conveyed to the 4th Avenue interceptor could overflow prior to reaching the Owls Head WWTP depending on the storm event. Approximately 1.5 MG/yr is projected to overflow from outfall OH-006 into Gowanus Bay during a typical rainfall year with an additional 12.1 MG/yr to overflow at outfalls that are in the lower NY Harbor and outside the limits of Gowanus Canal. The overall capital cost for this alternative is estimated at $30.9M.

5.5.2 Gowanus Canal Wet-Weather Auxiliary Pumping Station: Upon completion of the current Gowanus Facilities Upgrade, the Gowanus Pump Station will pump into a force main that transports dry and wet weather flows to the Columbia Street interceptor and then to the Red Hook Wastewater Treatment Plant (WWTP). This new wastewater force main, combined with pump station improvements would increase the design flow of the system from 22 mgd to 30 mgd. An additional pump station could be constructed to transfer wet weather combined sewage from outfall RH-034 into the Bond-Lorraine sewer and further reduce CSOs to the Canal. Potential location for this wet weather pumping station is shown in Figure 5-4. Once in this sewer, the combined sewage would either be transported all the way to the Red Hook WWTP or would overflow at other CSO outfalls in Gowanus Canal or the Upper Bay.The Gowanus Wet Weather Pump Station alternative would involve two phases. During the first phase, temporary pumps currently being used during the construction of the Gowanus Facilities Upgrade would be used. This phase could not be activated until after the Gowanus Pump Station construction upgrades are completed in 2013 and a connection is made to the Bond-Lorraine sewer. In parallel, property adjacent to the existing pump station on the corner of Bond Street and Nevins Street would need to be acquired to site a permanent wet weather pump station. Since this acquisition would be for the purposes of siting a new DEP facility, it would require a land use review ("ULURP") pursuant to City law and likely an EIS. The overall capital cost for this alternative is estimated to be $38.5M.

The CSO reduction benefit of this alternative would be a CSO reduction of 58 MG/yr from outfall RH-034. As the wet weather pump station would discharge into the Bond-Lorraine sewer some 36 MG/yr would overflow from downstream outfalls including RH-035. This would result in a net reduction of 22 MG/yr to Gowanus Canal. To eliminate this overflow from RH-035 and provide a net overall CSO reduction of 58 MG/yr, the project could be enhanced to include modifications to constrictions in the Bond-Lorraine sewer located near 5th Street and Hoyt Street. In 2004, a cost estimate was made for this improvement to the Bond-Lorraine sewer. The present estimate for the work strictly associated with constructing this improvement to the Bond-Lorraine sewer is $11.8M – which would be in addition to $38.5M cost for the Gowanus Wet Weather pump station.

5.5.3 Outfall OH-007 Sediment Trap Cleaning and Structural Evaluation: Under the WB/WS, CSO discharges from OH-007 represent about 28 percent of the total to Gowanus Canal in a typical year. A chamber – measuring 35 ft wide by 70 ft long and featuring a baffle/weir combination intended to prevent the discharge of floatables and settleable solids – is installed in the sewer line just upstream of the outfall. Over time, floatables and settleable solids can build up in the chamber and can reduce the effectiveness of the trap device. Periodic inspections of material buildup within the trap, particularly in the area of the weir/baffle combination, as well as post construction monitoring of floatables in the Canal will help to ensure that the trap remains functional and that cleaning of the trap be performed at optimum frequencies.

Due to structural-deficiency issues requiring construction of bulkheads and confined-space issues, inspection/cleaning of the trap chamber is beyond the scope of DEP's sewer-cleaning contracts and must be handled through a capital contract requiring development of bid documents and contractor procurement. This is currently under evaluation.

Conclusion

The City believes that the analyses presented in this document will help to advance the understanding of the Canal and the data related to CSOs. We welcome the opportunity to answer any questions you may have on this document and to further discuss the feasibility study with you.

Sincerely yours,

Angela Licata
Deputy Commissioner
New York City Department
of Environmental Protection

cc: B. Carr, EPA
D. Greene, NYC
E. Mahoney, NYC

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Tables

Table 1-1 Human Health Risk-Based PRGs in Sediment

COC	EPC Canal Sediments (mg/kg)	Calculated HI for All Pathways	Calculated Cancer Risk	PRG for 10^{-6} Risk (mg/kg)	PRG for 10^{-5} risk (mg/kg)	PRG for 10^{-4} risk (mg/kg)	Maximum CSO Sediment Concentration (mg/kg)	Maximum Background Concentration (mg/kg)	Risks from CSO max value	Risks from Background max value
Recreational User Lifetime Exposure										
Arsenic	18	NA	1.3E-06	13.8	138.5	1,385.0	7.9	19.0	5.7E-07	1.4E-06
Benz(a)anthracene	127	NA	4.6E-05	2.8	27.6	276	1.3	1.2	4.7E-07	4.3E-07
Benzo(a)pyrene	107	NA	3.9E-04	0.3	2.7	27	1.3	0.9	4.7E-06	3.3E-06
Benzo(b)fluoranthene	113	NA	4.1E-05	2.8	27.6	276	4.5	1.4	1.6E-06	5.1E-07
Benzo(k)fluoranthene	65	NA	2.3E-06	28.1	280.9	2,809	1.5	0.8	5.3E-08	2.8E-08
Dibenz(a,h)anthracene	6	NA	2.2E-05	0.3	2.8	28	0.5	nr	1.8E-06	1.8E-06
Indeno(1,2,3-c,d)pyrene	49	NA	1.9E-05	2.6	25.7	257	1.8	1.0	7.0E-07	3.9E-07
Cumulative Risks					7.0E-05				9.9E-06	7.8E-06

Table 1-2 Human Health Risk-Based PRGs in Surface Water

	EPC Canal Surface Water (ug/l)	Calculated HI for All Pathways	Calculated Cancer Risk	PRG for 10-6 Risk (mg/kg)	PRG for 10-5 risk (mg/kg)	10-4 risk	Maximum CSO Surface Water Concentration (ug/l)	Maximum Background Concentration (mg/kg)	Risks from CSO max value	Risks from Background max value
Recreational User Lifetime Exposure										
Chromium VI	8.5	NA	2.5E-06	3.4	34.0	756.0	7.9	19.0	2.3E-06	5.6E-06
Tetrachloroethylene	24	NA	3.6E-06	6.8	67.8	678	20.0	1.2	3.0E-06	1.8E-07
Cumulative Risks					7.0E-05				5.3E-06	5.8E-06

Table 1-3. Comparison of CSO Sediment Concentrations to Ecological Risk-Based Cleanup Values and Background Sediment Concentrations

Chemical of Concern	Maximum measured CSO sediment concentration (mg/kg) (1)	Average measured CSO sediment concentration (mg/kg) (1)	Ecological risk-based cleanup value average concentration (mg/kg) (2)	Maximum background sediment concentration (mg/kg) (3)	Background statistical comparison (4)	Greater of back-ground and PRG (mg/kg)	CSO Exceeds Back-ground and risk-based cleanup value?
Barium	368 (RH-037)	149	141	133	Hyp: CSO= Bkgd	141	Y
Cadmium	6.8 (RH-031)	2.0	2.6	6.3	Hyp: CSO= Bkgd	6.3	N
Copper	4,540 (OH-007)	921	188.6	242	CSO > Bkgd	242	Y
Lead	619 (RH-037)	248	340	244	CSO> Bkgd	340	N
Mercury	1.0	0.4	1.24	3.7	CSO< Bkgd	3.7	N
Nickel	42.9	29	41.75	50	Hyp: CSO= Bkgd	50	N
Silver	2.8	1.6	4.1	9.5	CSO < Bkgd	9.5	N
Total PAHs	18.2	8.3	85.3	14.4	NT	85.3	N
Total PCBs	ND	ND	0.69	NR	NT	NT	N

(1) Taken from Table I-47A or RI Report
(2) Risk-based cleanup value based on ecological receptors
(3) Taken from Table 4-4b of RI Report
(4) Results from background analysis
ND—all results were non-detect from Table I-44A in RI Report:
NA-Not applicable: not a COC for human health;
NR-Not Reported in Table 4-4b of RI Report;
NT-Not tested

Table 1-4a. Comparison of CSOs and Background for Sediment Data

Chemical Name	Reference (Background) Data			CSO Data			Testing	Result	Conclusion
	Number of Detected Results	Number of Non-Detect Results	Outlier	Number of Detected Results	Number of Non-Detect Results	Outlier			
Arsenic	10			3		Cannot be Confirmed	Point by point comparison with the BTV. BTV set to the 95% UPL derived from a normal distribution.	Of the 7 CSO results, 4 results were rejected by the lab. Comparison shows that the 3 available CSO samples (OH-007, RH-031, and RH-037) have concentration lower than the BTV. Likely CSO< Background.	Additional CSO data is needed confirm that CSO ≤ Background.
Barium	9	1	1	7			Point-by-point comparison with BTV. BTV set as the non-parametric 95% UPL.	Point-by-point testing indicated that 3 samples (OH-007, RH-031, and RH-037) exceeded the BTV.	Likely CSO > Background
Cadmium	9	1		7			Point-by-point comparison with BTV and two sample hypothesis testing. BTV set as the non-parametric 95% UPL.	None of the CSO samples exceed the BTV. Hypothesis test indicated that CSOs ≤ Background.	CSOs ≤ Background
Lead	10		1	7		1	Point-by-point comparison with BTV. BTV selected as the second highest value, since the maximum value was an outlier and 95% UPL from Kaplan-Meier was not calculated.	Data plots indicate that CSOs may be higher than background. 5 CSO samples (excluding the outlier) exceeded the BTV. CSO RH-033 does not exceed the BTV.	CSOs > Background
Mercury	10		1	7		1	Point-by-point comparison with BTV. BTV set to the 95% UPL (normal distribution).	None of the CSO samples exceeded the BTV. Testing indicated that CSOs ≤ Background.	CSOs ≤ Background
Nickel	10			7			Point-by-point comparison with BTV (95% UPL assuming normal distribution) and two sample hypothesis testing (Wilcoxon Ranked Sum Test).	Data plots, hypothesis test, and comparison indicated that CSOs ≤ Background.	CSOs ≤ Background
Silver	3	7	Cannot be Confirmed	7			Point-by-point comparison with BTV. BTV set to the maximum detected value since there are only three detected results. Comparison was also conducted by setting the BTV to the second highest value.	All CSO concentrations are less than the maximum observed value. Only one CSO result (OH-007) slightly exceeds the second highest detected value. Results indicated that CSOs ≤ Background.	CSOs ≤ Background
Benzo(a)anthracene	9	1		7		1	Point-by-point comparison with BTV. BTV set as the non-parametric 95% UPL.	Only the outlier (RH-031) in CSO dataset exceeds the BTV. Comparison and data plots indicated that CSOs ≤ Background.	CSOs ≤ Background

Chemical Name	Reference (Background) Data			CSO Data			Testing	Result	Conclusion
	Number of Detected Results	Number of Non-Detect Results	Outlier	Number of Detected Results	Number of Non-Detect Results	Outlier			
Benzo(a)pyrene	8	2		4	3		Point-by-point comparison with BTV. BTV set as the non-parametric 95% UPL.	One CSO sample (RH-031) exceeds the BTV. Comparison indicates that it is likely that CSOs ≤ Background.	Likely that CSOs ≤ Background
Benzo(b)fluoranthene	10		1	7		1	Point-by-point comparison with BTV. BTV set to the 95% UPL (normal distribution).	Two CSO samples (RH-031 and OH-007) exceeded the BTV; one of the results is an outlier. Due to limited sample size, the second highest value cannot be confirmed as an outlier.	Need to confirm presence of outliers.
Benzo(k)fluoranthene	9	1		5	2		Point-by-point comparison with BTV. BTV set as the non-parametric 95% UPL.	Two CSO samples (RH-031 and OH-007) exceeded the BTV. It is not clear whether these two samples are outliers. It is likely that CSOs ≤ Background.	Likely CSOs≤ background
Dibenz(a,h)anthracene		10		6	1		Insufficient data for background vs. canal comparison due to detection limits.	All the background data is non-detect. Two samples (RH-031 and OH-007) are higher than the maximum detection limit of the background. Comparison cannot be conducted.	Comparison cannot be conducted.
Indeno(1,2,3-c,d)pyrene	8	2	1	7		1	Point-by-point comparison with BTV. BTV set to the non-parametric 95% UPL.	Three CSO samples are greater than the BTV. CSOs that exceed the BTV are OH-007, RH-037, and RH-031 (identified as an outlier). Comparison is inconclusive.	Comparison inconclusive.
Total PAH	10			7			Point-by-point comparison with BTV and hypothesis testing. BTV set as the 95% UPL derived from normal distribution.	Only two CSO samples (OH007 and RH-031) exceed the BTV. Hypothesis testing (Wilcoxon Mann Whitney) indicates that CSOs ≤ Background.	CSOs ≤ Background
Total PCBs (Sum of Aroclors)		10	Cannot be Confirmed	2	5	Cannot be Confirmed	All the reference sample concentrations were below the reporting limit for TPCB - Aroclors. Of the three reference samples analyzed for congeners, the TPCB value ranged from 0.44 ppm to 1.7ppm.	Two CSOs (RH-037 - 1.2ppm and RH-033-0.17ppm) were detected for Aroclor 1260. For all other Aroclors the CSO results were below the reporting limit. CSO results for TPCB (Aroclor) fall within the range of reference results for TPCB (congeners). It is likely that CSO = Background. However, additional data is needed to confirm this.	Additional data is needed to reach a conclusion
Total PCBs (Sum of Congeners)	3		Cannot be Confirmed	Not Analyzed for Congeners					

Table 1-4b. Comparison of CSOs and Background for Surface Water Data

Chemical Name	Reference			CSO			Testing	Result	Conclusion
	Detect	ND	Outlier	Detect	ND	Outlier			
Arsenic Dissolved	10			18		1	Two Sample Hypotheses Testing using Wilcoxon Mann Whitney test.	Hypothesis testing results show that CSO ≤ Background.	CSO ≤ Background
Arsenic Total	10			18		1	Two Sample Hypotheses Testing using Wilcoxon Mann Whitney test.	Hypothesis testing results show that CSO ≤ Background.	CSO ≤ Background
Chromium Dissolved	8	2	1	17			BTV set to the second maximum detected value. Single Sample Hypothesis Testing with BTV using Wilcoxon Signed Rank test.	Hypothesis testing results show that CSO ≤ Background.	CSO ≤ Background
Chromium Total	10			17		1	Two Sample Hypotheses Testing using Wilcoxon Mann Whitney test.	Hypothesis testing results show that CSO ≤ Background.	CSO ≤ Background
Mercury Dissolved	0	10		1	18		None, but reference RL compared with CSO results.	Detected value in the CSOs is an order of magnitude lower than the Reporting limit (RL) for all the reference samples. Comparison cannot be conducted.	Comparison cannot be conducted.
Mercury Total	2	8		2	16		None	Two detected values (RH-33 and OH-007) sampled during wet weather event (WWE) 1 and 3 respectively are higher than the detected reference samples but lower than the RL of the non-detected reference samples.	Comparison cannot be conducted.
Benzo(a)pyrene	2	8		6	13		Point by point comparison of CSO (all wet weather samples) with the BTV. BTV is set to the second largest value (since the max value may be an outlier).	Point by point comparison shows that 4 of the 6 detected samples are higher than the second largest value. Comparison with the maximum value shows no CSO exceedances.	Inconclusive
Dibenz(a,h)anthracene	1	9		8	11		None. However, the detected results were compared to the detected reference result.	Of the 8 detected CSO results, only two were greater than the detected background value.	Inconclusive
Indeno(1,2,3-c,d)pyrene	9	1	1	4	15	1	Point by point comparison of CSO (all wet weather samples) with the BTV. BTV is set to the second largest value.	Two of the detected CSO values including the outlier exceed the BTV. Of the 15 non-detected values, 3 samples have RL greater than the BTV.	Inconclusive due higher detection limits in the CSOs

Chemical Name	Reference			CSO			Testing	Result	Conclusion
	Detect	ND	Outlier	Detect	ND	Outlier			
Tetrachloroethylene	3	7		14	4	1	BTV set to the second maximum detected value because the maximum value may be an outlier. Single Sample Hypothesis testing with BTV using Wilcoxon Signed Rank test.	Hypothesis testing results show that CSO > Background.	CSO> Background
PCB - Sum of Aroclors		10		1	17		None	Aroclor 1260 was detected in sample OH-006 during Wet Weather Event 3. Detected result (0.57 ppb) is lower than the reporting limit of all the non-detect values. Results indicate that CSOs are similar to background.	Comparison cannot be conducted.

Table 2-1a. Estimates of PAH loads to the Canal from Ground Water.

Analyte	Mean GW Concentration (ug/L)	Potential Annual Loads from GW (Kg/yr) *	Annual Loads for Parameters Modeled using GW Models (Kg/yr) **	Mean CSO Aqueous Concentration (ug/L)	Current CSO Loads (kg/yr)	Future CSO Loads (kg/yr) -After 45% Reduction in CSO Discharge
Acenaphthene	946	1,750		0.67	0.96	0.53
Acenaphthylene	1,020	1,900		0.2	0.28	0.16
Anthracene	156	300		0.2	0.29	0.16
Benzo(a)anthracene	5.1	10		0.25	0.36	0.20
Benzo(a)pyrene	1.2	2	1.5	0.25	0.36	0.20
Benzo(b)fluoranthene	0.7	1		0.35	0.5	0.27
Benzo(g,h,i)perylene	0.4	1		0.39	0.55	0.30
Benzo(k)fluoranthene	0.2	0.4		0.23	0.33	0.18
Chrysene	3	6		0.26	0.37	0.20
Dibenz(a,h)anthracene	9	17		0.24	0.34	0.19
Fluoranthene	34	65		0.34	0.48	0.26
Fluorene	429	800		0.29	0.41	0.23
Indeno(1,2,3-d)pyrene	0.44	1		0.35	0.5	0.28
Naphthalene	26,925	50,500	7,500	4	5.7	3.13
Phenanthrene	412	770	110	0.48	0.69	0.38
Pyrene	53	100		0.38	0.55	0.30

* Based on effective solubility of NAPL in water.
** Based on results of SEAM3D groundwater contaminant fate and transport model.

Table 2-1b. Upper Bound Estimates of Metals Load from Groundwater to Sediment Bottom

Analyte	Mean GW Concentration, (ug/l)	Potential Annual Loads from GW (kg/yr)	Mean CSO Aqueous Concentration (ug/L)	Current CSO Loads (kg/yr)	Future CSO Loads (kg/yr) -After 45% Reduction in CSO Discharge
Arsenic	9.1	17.6	3	2.9	2.4
Barium	308	598	59	56	46
Cadmium	0.7	1.4	1	0.8	0.7
Chromium, Total	4.9	9.5	4	4	3.3
Copper	21.7	42	58	55	46
Lead	9.6	19	67	63	52
Mercury	0.097	0.2	0.1	0.10	0.08
Nickel	10.2	20	6	6	5
Silver	0.73	1.4	0.7	0.7	0.6

Table 2-2. Total Suspended Solids (TSS) in CSO Effluent

CSO	TSS (mg/L) Dry Weather	TSS (mg/L) Wet Weather Event 1	TSS (mg/L) Wet Weather Event 2	TSS (mg/L) Wet Weather Event 3
OH-005	171	46		19
OH-006	78			132
OH-007	61			40
RH-031	161		377	56
RH-033	71	24		66
RH-034	123	38	70	
RH-035	220		989	126
RH-036	100	45		18
RH-037	38	102		91
RH-038	467	186		35
Average	**149**		**137**	
Median	**112**		**61**	

Table 2-3. Solids Accumulation in the Canal from June 2003 to January 2010.

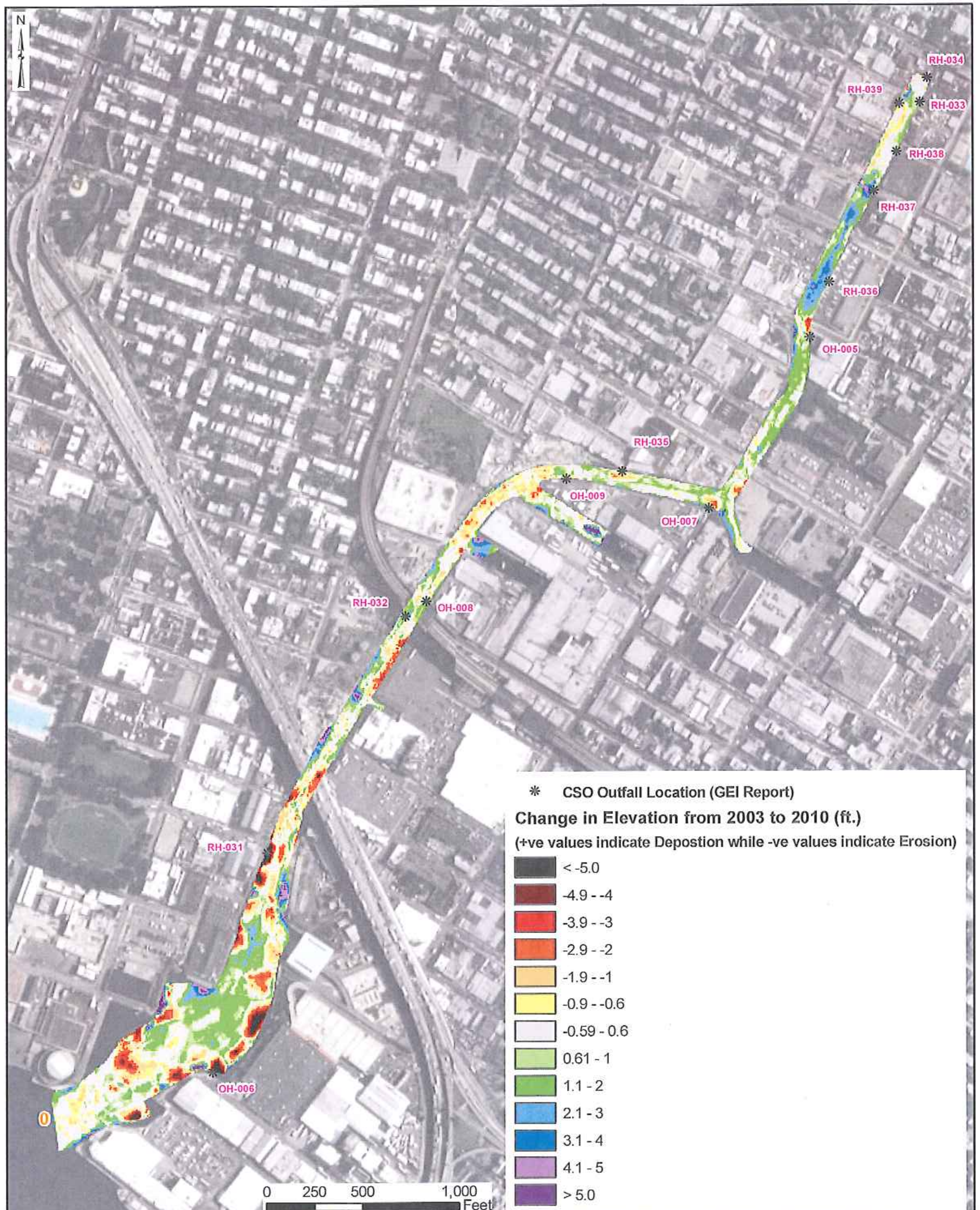
	Depositional Areas[1]	**Erosional Areas**[1]	**Net (Deposition - Erosion)**
Volume (cy)	31,400	20,300	11,100
Rate (cy/yr)	4,800	3,100	1,700
Mass (kg/yr)[2]	2,900,000	1,900,000	1,000,000

Notes:

1. Depositional and erosional areas are defined as areas showing a net change in bathymetry of more than 6 inches between the 2003 and 2010 surveys, with depositional areas having shallower bathymetry in 2010 and erosional having deeper bathymetry in 2010.
2. Mass is calculated by assuming solid density of 0.8 g/cc.

NA Not applicable

Figures

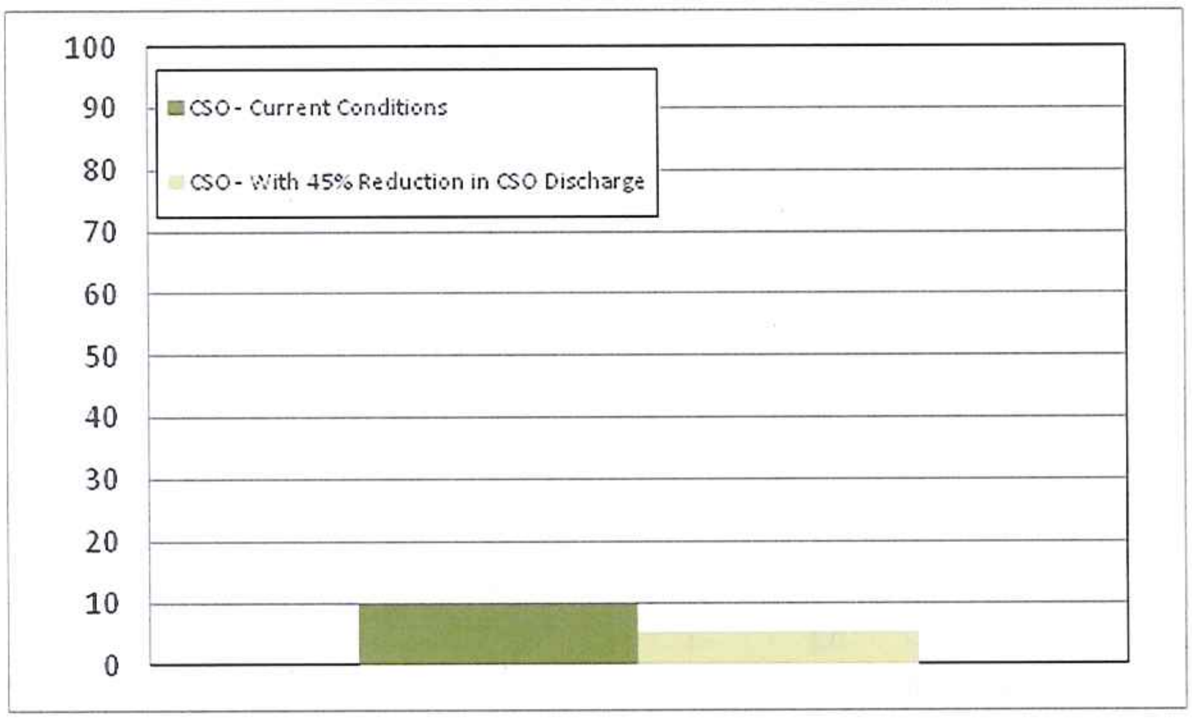


NYC Environmental Protection | DDC

Comparison of 2003 and 2010 Bathymetry Surveys

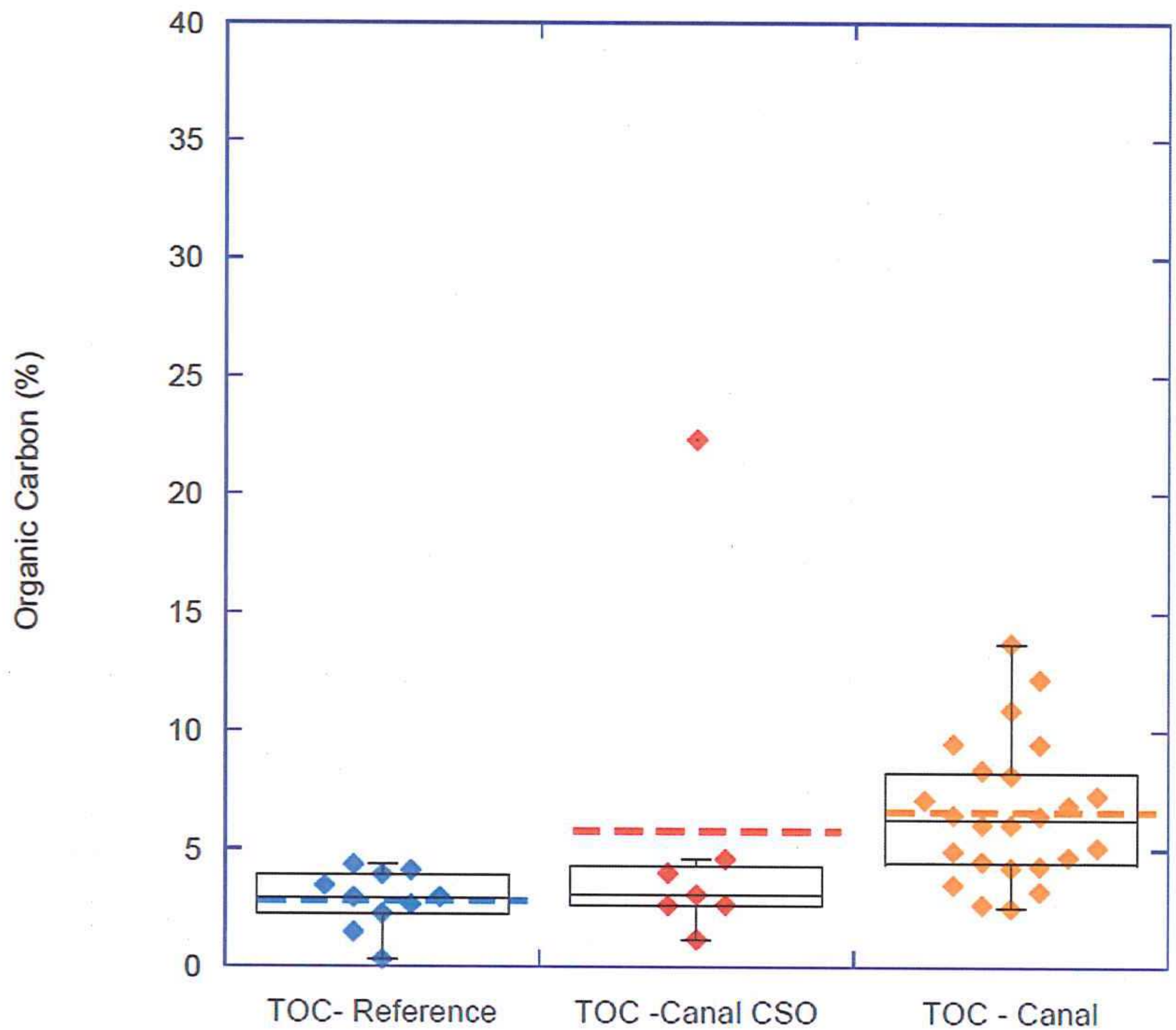
Figure 2-1

December 2011



Calculation assumes that all CSO solids settle in the Canal

NYC Environmental Protection; DDC New York City Department of Design + Construction; LB	Percentage Contribution of CSO Solids to the Net Solids Accumulation from 2010 to 2003	Figure 2-2 November 2011

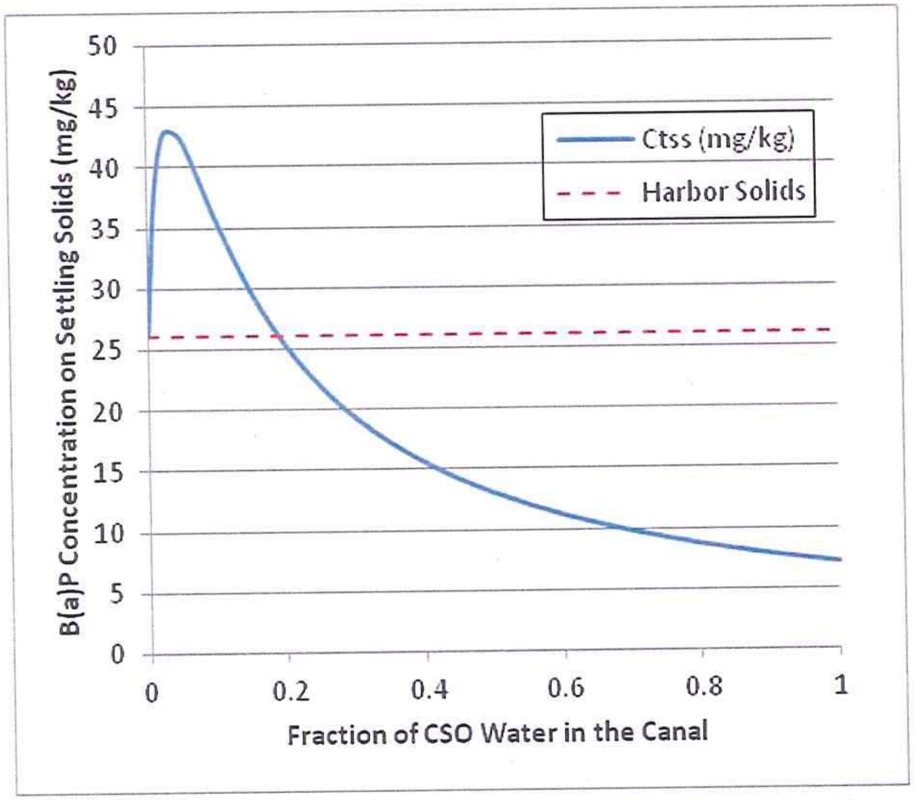


Total Organic Carbon Concentration in Reference Site, CSOs and Canal.

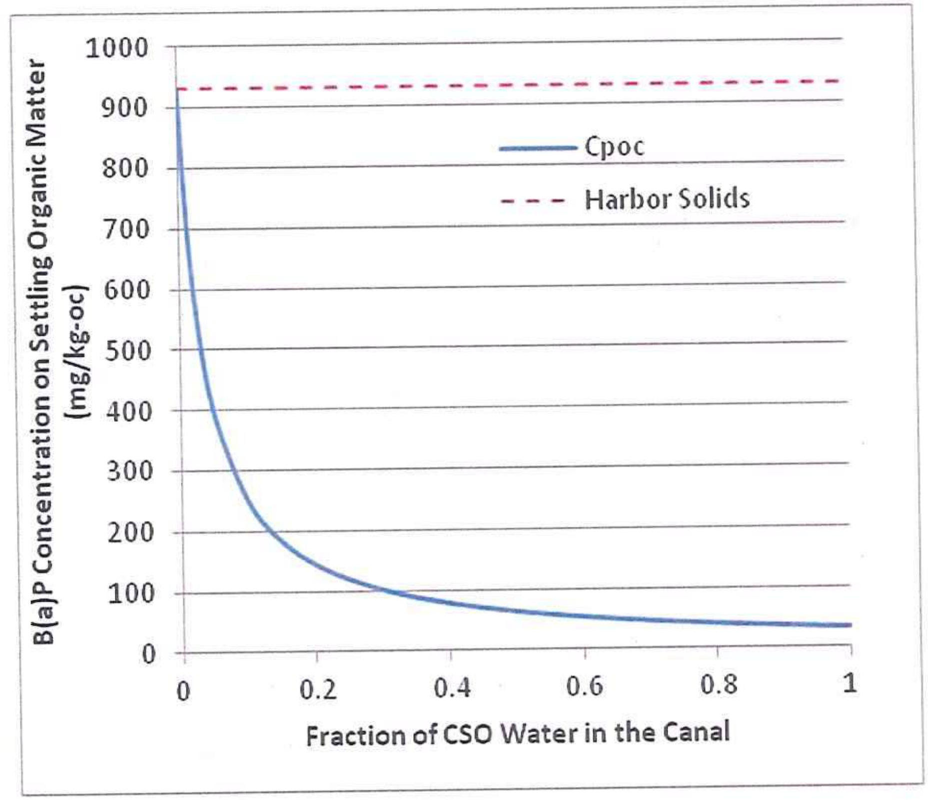
Figure 3-2

November 2011

Simple Concentration



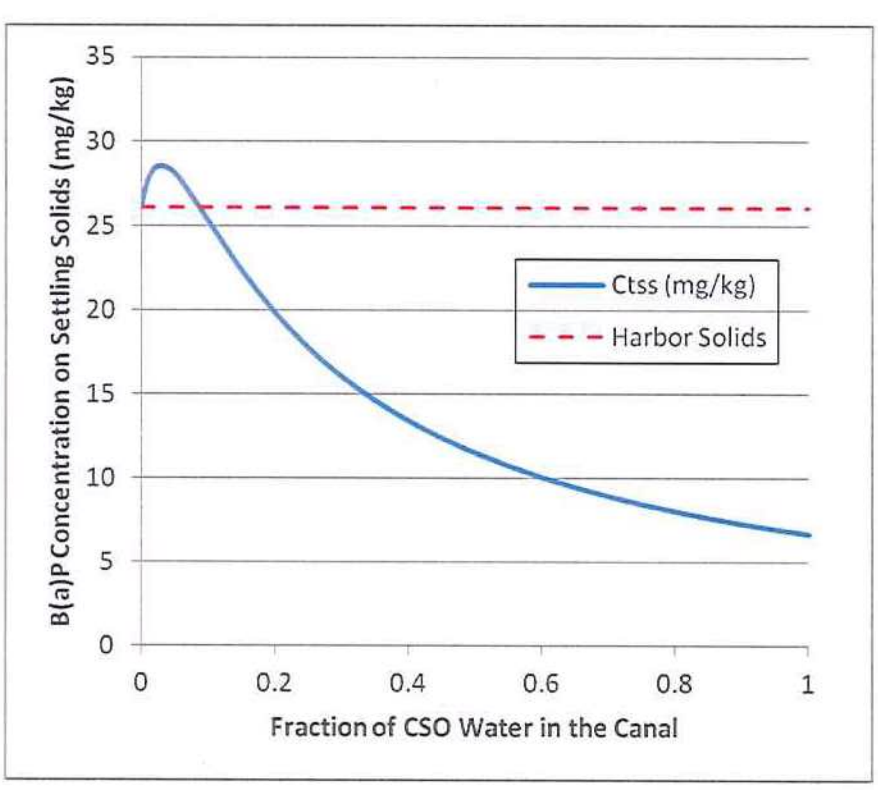
Organic-Carbon Normalized "Bioavailable" Concentration



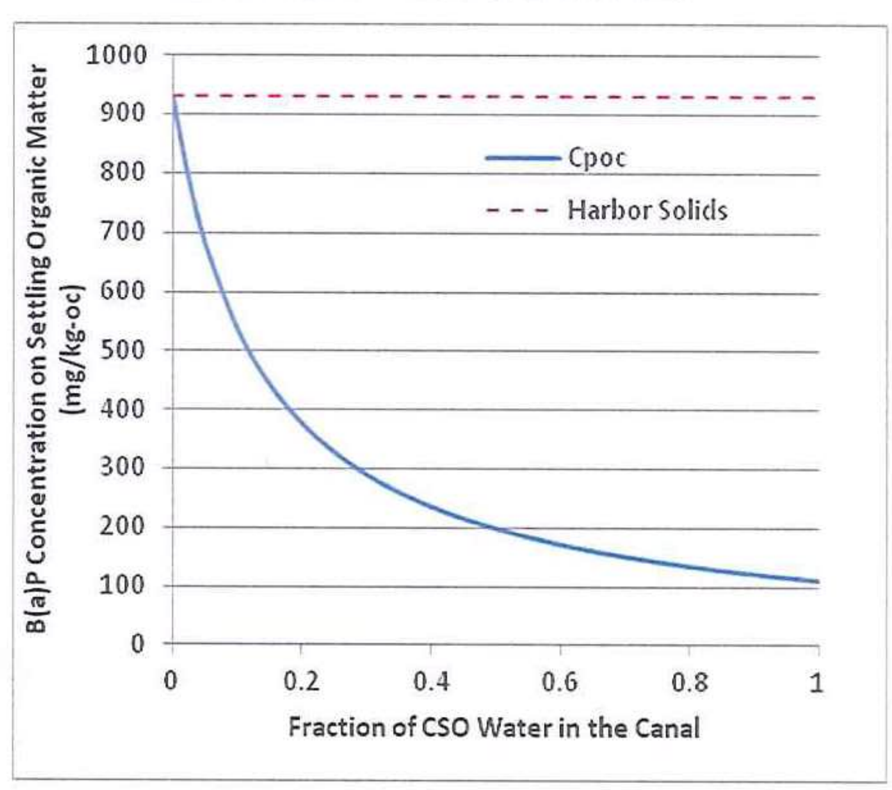
TOC Concentrations based on mean baseline and <u>maximum CSO</u> results (22%) as measured by EPA

NYC Environmental Protection; NEW YORK CITY DEPARTMENT OF DESIGN + CONSTRUCTION	Effect of Organic Carbon on Contaminant Concentration in Solids – Maximum TOC Concentration in CSO Solids	Figure 3-1b November 2011

Simple Concentration



Organic-Carbon Normalized "Bioavailable" Concentration



TOC Concentrations based on mean values for baseline (3%) and CSO (6%) as measured by EPA

NYC Environmental Protection / DDC New York City Department of Design + Construction	Effect of Organic Carbon on Contaminant Concentration in Solids – Average TOC Concentration in CSO Solids	Figure 3-1a November 2011

High Level Sewer Separation Project Area

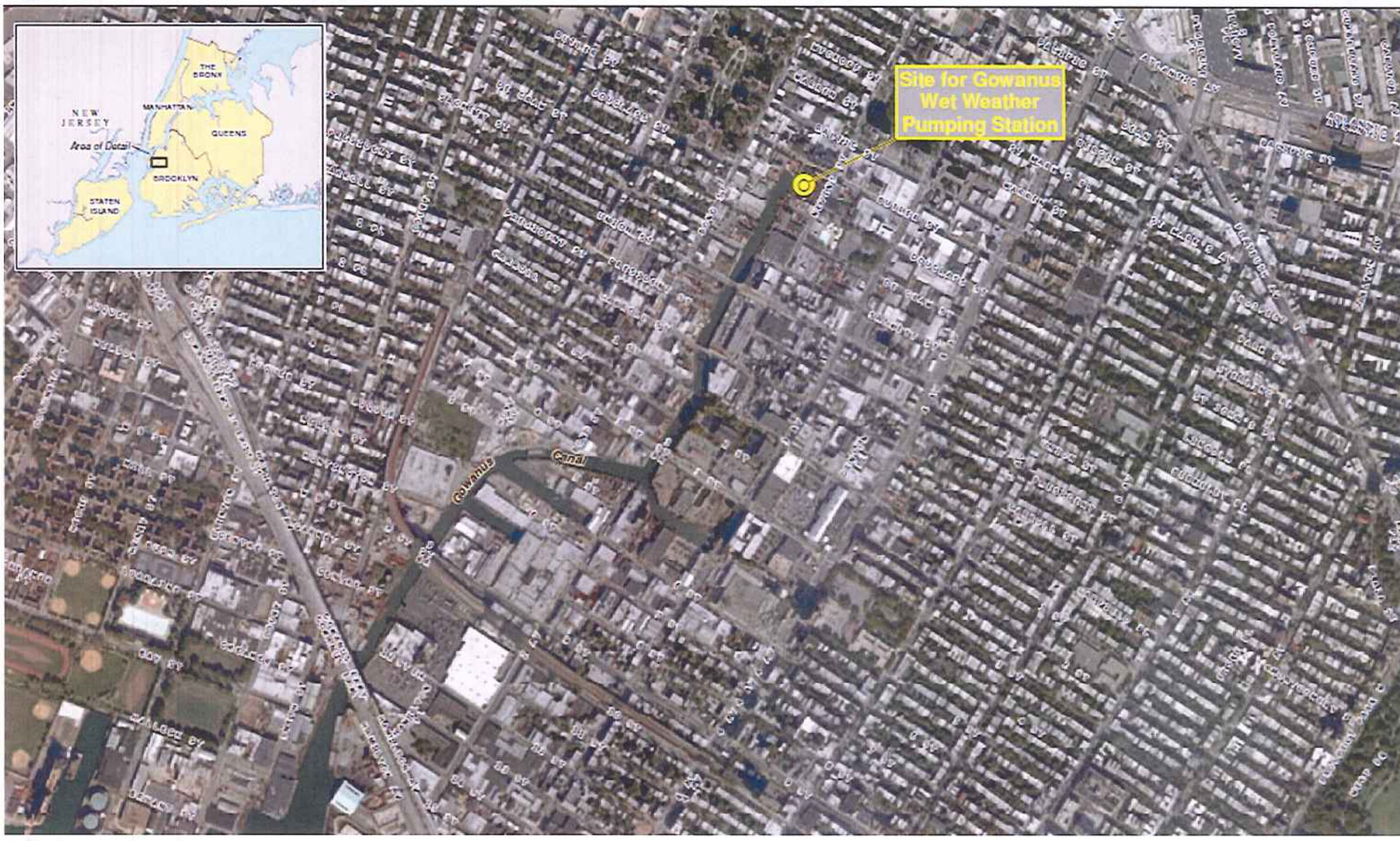
Figure 5-1

December 2011

Sub-Catchment Opportunities Analysis for Green Infrastructure Program : RH-034 and OH-007

Figure 5-2

December 2011



NYC Environmental Protection · DDC New York City Department of Design + Construction	Potential Location for Gowanus Wet Weather Pumping Station	Figure 5-4
		December 2011

NYC Environmental Protection | DDC New York City Department of Design + Construction

Potential Location for Expanded 2nd Avenue Pumping Station

Figure 5-3

December 2011

Appendix 1
Derivation of Risk-Based PRGs for Contaminants of Concern at Gowanus Canal Superfund Site

1 Summary of Ecological Risk Assessment Results, Appendix K

The USEPA conclusions are summarized in the following sections, and discussed relative to considerations that were not made in the RI report. Risk-based cleanup values (PRGs) have been developed based on the ecological risk assessment, as modified, based on the City's review of that report.

Summary of USEPA Findings of Significant Ecological Risk

The USEPA ecological risk assessment (Appendix K) concluded that there is potential site-related risk to higher trophic levels due to exposures of Black Duck, water column organisms, benthic invertebrates, and Green Heron. Specifically, USEPA concluded that:

- "There is a potential risk to aquatic herbivores (represented by black duck) from exposure to PAHs [polycyclic aromatic hydrocarbons]. PAHs were detected onsite (in sediments)at concentrations above those detected in offsite locations and represent a site-related riskto aquatic herbivores."
- "Sediment bioassays indicate a site-related potential for adverse effects to benthic communities from the presence of chemicals in sediment throughout the length of the canal, with the greatest potential for adverse effects occurring in the central portion of the canal."
- "In surface water collected during the wet period, only lead was detected at a concentration exceeding its ecological screening benchmark and at a concentration above that detected in offsite surface water, indicating it represents a site-related risk to aquatic life."
- "There is a potential risk to avian omnivores (represented by heron) from exposure to mercury ...and...mercury was the only metal that was frequently detected at elevated concentrations in fish and crab tissues, and that was also detected onsite (in sediments) a tconcentrations above those detected in offsite locations, and thus represents a site-related risk to avian omnivores."

Each of these conclusions is discussed in further detail below.

1.1 PRGs Based on Risk to Black Duck

USEPA concluded (Appendix K) that "There is a potential risk to aquatic herbivores (represented by black duck) from exposure to PAHs. PAHs were detected onsite (in sediments)at concentrations above those detected in offsite locations and represent a site-related risk to aquatic herbivores." This conclusion is based on exposure to Black Ducks through ingestion of rooted aquatic vegetation; however, this pathway does not appear to exist in the Gowanus Canal based on:

- The explicit USEPA statement (Appendix K) that "...there are no significant colonies of rooted aquatic vegetation within the Gowanus Canal..." and that "...these observations are consistent with NYSDEC [New York State Department of Environmental Conservation] tidal maps that designate the entire water body as a littoral zone...that does not include coastal fresh marsh, intertidal marsh, or other types of vegetative wetland..."
- A recent site visit that demonstrated steep urbanized slopes or vertical bulkheads lining the banks of the Gowanus Canal.

Therefore, this document does not provide calculations of a PRG based on exposures to BlackDuck from ingestion of rooted aquatic vegetation because this is an explicitly unlikely exposure pathway in Gowanus Canal.

1.2 PRGs Based on Risk in Surface Water

USEPA concluded (Appendix K) that "In surface water collected during the wet period, only lead was detected at a concentration exceeding its ecological screening benchmark and at a concentration above that detected in offsite surface water, indicating it represents a site-related risk to aquatic life."

Therefore the suggested PRG for lead in surface water is the National Recommended Water Quality Criterion Continuous Concentration (CCC) which is the highest concentration in water to which a community of organisms can be exposed indefinitely without unacceptable effects. For lead this concentration in salt water is 8.1 micrograms per liter (μg/L) dissolved lead (http://water.epa.gov/scitech/swguidance/standards/current/index.cfm).

1.3 PRGs Based on Sediment Toxicity Testing

This subsection calculates PRGs for those chemicals that USEPA considers "...to represent a potential site-related risk to the benthic community." These chemicals include: PAHs (as total PAHs for the calculation of PRGs), PCBs (as total PCB), barium, cadmium, copper, lead, mercury, nickel, and silver. These calculations assume that:

- The most valid toxicity tests at the Site are those conducted with the polychaete, *Nereisvirens*, indicated various uncertainties associated with amphipod toxicity testing thatinvalidates the use of these tests in estimating risk in our opinion;
- Site samples are toxic only if toxicity in a sample was considered toxic using USEPA'sreference envelope approach;

- The average concentrations of these total PAHs, total PCBs, barium, cadmium, copper,lead, mercury, nickel, and silver represent the exposure point concentrations.

1.4 Use of Nereisvirens Toxicity Tests

Although USEPA used two test organisms, *Nereisvirens* and *Leptochirusplumulosus*to estimate sediment toxicity, this PRG calculation used only the *N. viren s*toxicity tests because the *L.plumulosus*tests encountered several operational problems that shed significant uncertainty on the conclusions drawn from these test. Specifically, Appendix K:

- States that the *L. plumulosus* toxicity test was run three times because the first two runs did not meet acceptability criteria for survival of test organisms.
- Suggests that there may have been a problem with the health of the test organisms.
- Is unclear on whether these final tests were re-run on the same test sediments as used in the first two failed tests, on new samples, or on an archived subsample.
- Does not address the question of the potential for a change in sediment conditions (*e.g.,*COPC concentrations, Total Organic Carbon fraction, etc.) during the time required to do the first two unacceptable runs.
- Does not address the uncertainties associated with exceeding holding times between the first and second failed tests and the final third test.
- Does not address how the sediments were held (*e.g.*, frozen? at 4 degrees C?) during the periods between failed tests.

1.5 Use of USEPA's Reference Envelope Approach

In Appendix K, USEPA used a reference envelope approach to decide whether a sample from the Gowanus canal was toxic. In this approach, "...the lowest endpoint result for the reference samples was selected as the envelope value for comparison to the canal, following the elimination of any reference sample outliers." Using the *N. virens* toxicity test results for the survival endpoint (which maximizes the number of potentially toxic stations) USEPA:

- Specified the lowest average survival from among reference samples (stations 328, 329,330 and 333 from New York Harbor) as the reference envelope value;
- Found that there are 8 toxicity test stations (non-toxic group of stations 303, 307A, 307B,309, 318, 319, 321, and 324) that had endpoint responses above (that is, greater survival) the reference envelope value; and
- Considered that stations 310, 313, 314, and 315 (toxic group) were toxic based on this comparison (that is, these stations had average survival below the reference envelope value for survival).

The average concentrations of chemicals from among the eight non-toxic (relative to the reference envelope) stations were considered to represent an exposure concentration that is not toxic (and therefore not a risk) to benthic organisms.

1.6 Risk Based Ecological PRGs

The results of the Ecological risk Assessment indicate that there are contaminants in sediment and surface water which contribute to risks which are unacceptable to ecological receptors at the Site. These are identified as Chemicals of Concern (COCs). Table A1-1 presents risk-based cleanup values for COCs in sediment and surface water which require remedial action in order to be protective of ecological receptors at the Site.

Table A1-1 Ecological Risk-Based Cleanup Values in Sediment
Mean Concentrations in Sediment at Non-Toxic Stations Compared to NOAA Effect Levels
Gowanus Canal, Brooklyn, New York

Chemical of Concern	Proposed Sediment PRG - Mean Concentration Among the Non-Toxic Stations (ppm)	ER-L	ER-M
Barium	140.7	NA	NA
Cadmium	2.6	1.2	9.6
Copper	188.6	34	270
Lead	339.6	46.7	218
Mercury	1.24	0.15	0.71
Nickel	41.75	20.9	51.6
Silver	4.1	1	3.7
Total PAH	85.3	4	44.8
Total PCBs (n=2)	0.695	0.023	0.18

1.7 Uncertainties Associated with Ecological PRGs

These PRGs are sufficient to describe those sediments from the Gowanus Canal that did not exhibit toxicity relative to a reference area. As such, they are defensible as site-specific PRGs.

There are uncertainties associated with these PRGs. For example, several of the PRGs exceed their respective ER-M. Specifically, the suggested PRGs for cadmium, copper, and nickel fall between their respective ER-L and ER-M. These concentrations are among those generally associated with effects in less than 50% of sediment samples examined by NOAA in their derivation of the effect range concentrations.

The suggested PRGs for lead, mercury, silver, total PAH, and total PCBs exceed their respective ER-Ms. These concentrations are among those generally associated with effects in greater than 50% of sediment samples examined by NOAA in their derivation of the effect range concentrations.

There is uncertainty in attempting to correlate the concentration of any individual chemical with the observed toxicity. For example, scatter plots (Attachment B) of the concentration of these chemicals at toxicity test stations (for the toxic and non-toxic samples together) against percent survival in the toxicity tests indicates little relationship between these chemicals and the observed toxicity. It is difficult to ascribe toxicity to any specific chemical because there is no apparent dose response; however, the sum of the potential effects associated with exposure to these chemicals as a group may explain the observed toxicity (relative to a reference area) due to some additive or synergistic effect.

1.8 Mercury PRG Based on the Green Heron

USEPA concluded that "There is a potential risk to avian omnivores (represented by heron) from exposure to mercury ...and...mercury was the only metal that was frequently detected at elevated concentrations in fish and crab tissues, and that was also detected onsite (in sediments) at concentrations above those detected in offsite locations, and thus represents a site-related risk to avian omnivores."

The concentrations of mercury in blue crabs and small prey fish (the food items used in calculating exposure to Green Heron) do not appear to be elevated relative to other areas of NY Harbor. Table A1-2 compares the wet weight tissue concentrations of mercury measured in biota in Gowanus Canal to wet weight mercury concentrations measured for the same species and tissue types at other New York Harbor locations (Upper Bay, East River, The Kills for Tom Cod and Upper Bay, East River, The Kills, and Jamaica Bay for Blue Crab). These locations include Upper Bay, the area of New York Harbor proximate to Gowanus Canal. The comparisons demonstrate that the concentrations of mercury in the tissue of fish and blue crabs used in the risk assessment for Green Heron are typical of the New York Harbor area in general and Upper Bay in particular. Therefore, these concentrations are likely due to a regional exposure to mercury (*e.g.*, atmospheric deposition) rather than exposure to the sediments of Gowanus Canal. Therefore, we do not recommend calculating a PRG for Gowanus Canal sediments based on exposure to mercury through the food chain.

Table A1-2. Comparison of Mercury Concentrations in Biota from Gowanus Canal and Biota from Other Areas of New York Harbor

Species	**Location**	**Source**	**Tissue**	**Mean**
Blue Crab	Gowanus Canal	Gowanus RI Appendix I Table I-74A	Muscle	0.153 (SD 0.028)
Blue Crab	NY/NJ Harbor (all areas)	USEPA, 1997 Table 3-22	Muscle	0.166 (SD) 0.199
Blue Crab	NY/NJ Harbor (Upper Bay)	USEPA, 1997 Table 3-22	Muscle	0.112 (SD 0.68)
	Gowanus Canal	Gowanus RI Appendix I Table I-74A	Hepatopancreas	<0.1
Blue Crab	NY/NJ Harbor (all areas)	USEPA, 1997 Table 3-22	Hepatopancreas	0.093 (SD 0.077)
Blue Crab	NY/NJ Harbor (Upper Bay)	USEPA, 1997 Table 3-22	Hepatopancreas	0.074 (SD 0.035)
Combined Mummichog and Tom Cod	Gowanus Canal	Gowanus RI Appendix I Table I-70	Whole Body	0.0866 (SD 0.011)
Tom Cod	NY/NJ Harbor (all areas)	USEPA, 1997 Table 3-22	Whole Body	0.154 (SD 0.128)
Tom Cod	NY/NJ Harbor (Upper Bay)	USEPA, 1997 Table 3-22	Whole Body	0.59 (SD 0.59)

2 Summary of Human Health Risk Assessment Results Appendix K

The results of the human health risk assessment are presented in Appendix K of the RI Report. The following conclusions are taken from Section 9: Human health Risk Assessment Summary. Risks to human receptors exceeded USEPA's acceptable risk range of 10-6 to 10-4 for carcinogens or the target Hazard Index(HI) of 1.0 for non-carcinogens for the following receptors:

- **Recreational receptors (adult, adolescent, and child)**
  - Cumulative cancer risks (RME) for recreational receptor (1×10^{-3})

- **Residential receptors (adult and child)**
  - Cumulative cancer risks (RME) for lifetime (child/adult) resident (3×10^{-4}) exceeds USEPA's acceptable level

- **Anglers (adult, adolescent, and child)**

  - Total Fish HIs (RME) (all fish types) for adults (17), adolescents (13), and children(27) exceed acceptable risk levels, primarily because of PCBs.

  - Total Crab HIs (RME) for adults (37), adolescents (3), and children (5) exceed acceptable risk levels, primarily because of PCBs. Additionally, mercury and arsenic contributed to the HIs, at HIs above 0.1 but below 1.0.
  - Average PCB concentrations in canal samples are about twice the average PCB concentrations in reference samples; however, concentrations of PCBs in reference samples would also result in HIs and ELCRs above acceptable risk levels.

A primary contributor to fish consumption risk is PCBs in tissues of fish caught from the canal. This conclusion is supported by NYDOH's decision to issue fish consumption advisories for the Upper Bay of the New York Harbor (north of the Verrazano Narrows Bridge), including the Gowanus Canal (NYSDOH, 2010) in part on the basis of PCB concentrations present in fish. Reference area average PCB fish concentrations are about one half the average concentrations identified in canal fish. However, these would also result in risks above acceptable risk levels.

2.1 Revisions to EPA's Human Health Risk Assessment

2.1.1Assessment of Dermal Risks to PAHs in Surface Water. EPA's Dermal Guidance (*Risk Assessment Guidance for Superfund, Volume E,* citation) (RAGS E) states that PAHs cannot be assessed for dermal exposures in water due to the uncertainty associated with the permeability coefficients for this class of chemicals in water. Therefore the risk results presented for PAHs due to dermal exposures in canal surface water are incorrect and should be deleted. The City has revised the risk assessment to be consistent with EPA guidance on this matter.

2.1.2 Changes to exposure assumptions for recreational user. EPA's risk assessment made very conservative and highly unlikely assumptions regarding exposures to sediment and surface water for residents, including children. The City applied exposure assumptions that are more consistent with the current and anticipated future uses of the canal by recreational users. These assumptions are presented in the Appendix tables.

2.1.3 Assessment of risks to total chromium. EPA's risk assessment assumed that all chromium was chromium +6, which is highly unstable in soil and sediment and is more likely to be present in the reduced +3 state. The City revised the risk assessment to apply the toxicity values for Cr+3 in assessing risks to sediment and fish. The assumption that chromium was all in the +6 state was not revised for the assessment of risks from exposures to surface water.

2.1.4 Calculation errors. Several errors were found in the calculations presented in the RI report. These were corrected. The revised risk assessment tables are included in this appendix and include RAGS tables 4, 5, 6, and 10.

TABLE 4.1.RME - Recreation - SEDIMENT

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE

Gowanus Canal Remedial Investigation, Brooklyn, New York

Scenario Timeframe:	Current/Future
Medium:	Sediment
Exposure Medium:	Surface Sediment

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Recreational	Adult	Exposed and near shore sediment in Gowanus Canal	EPC	Exposure Point Concentration	chemical-specific	mg/kg	EPA 2011, Table H-3.1	Average Daily Dose (ADD) = EPC x IR x EF x ED x CF / BW x AT
				IR	Sediment Ingestion Rate	50	mg/d	EPA 2011 (1/2 RME soil IR)	
				EF	Exposure Frequency	26	d/yr	EPA 2011 (1 d/wk for 1/2 yr)	
				ED	Exposure Duration	18	yr	EPA 1991	
				CF	Conversion Factor	0.000001	kg/mg	-	
				BW	Body Weight	70	kg	EPA 1991	
				AT_C	Averaging Time (Cancer)	25,550	d	EPA 1989	
				AT_{NC}	Averaging Time (Noncancer)	6,570	d	EPA 1989	
		Adolescent (12-18 years)	Exposed and near shore sediment in Gowanus Canal	EPC	Exposure Point Concentration	chemical-specific	mg/kg	EPA 2011, Table H-3.1	
				IR	Sediment Ingestion Rate	50	mg/d	EPA 2011 (1/2 RME soil IR)	
				EF	Exposure Frequency	26	d/yr	EPA 2011 (1 d/wk for 1/2 yr)	
				ED	Exposure Duration	6	yr	EPA 2011 (professional judgment)	
				CF	Conversion Factor	0.000001	kg/mg	-	
				BW	Body Weight	57	kg	EPA 1997 (mean; combined male/female)	
				AT_C	Averaging Time (Cancer)	25,550	d	EPA 1989	
				AT_{NC}	Averaging Time (Noncancer)	2,190	d	EPA 1989	
		Child (0-6 years)	Exposed and near shore sediment in Gowanus Canal	EPC	Exposure Point Concentration	chemical-specific	mg/kg	EPA 2011, Table H-3.1	
				IR	Sediment Ingestion Rate	100	mg/d	EPA 2011 (1/2 RME soil IR)	
				EF	Exposure Frequency	26	d/yr	EPA 2011 (1 d/wk for 1/2 yr)	
				ED	Exposure Duration	6	yr	EPA 1991	
				CF	Conversion Factor	0.000001	kg/mg	-	
				BW	Body Weight	15	kg	EPA 1991	
				AT_C	Averaging Time (Cancer)	25,550	d	EPA 1989	
				AT_{NC}	Averaging Time (Noncancer)	2,190	d	EPA 1989	

TABLE 4.1.RME - Recreation - SEDIMENT

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE

Gowanus Canal Remedial Investigation, Brooklyn, New York

Scenario Timeframe:	Current/Future
Medium:	Sediment
Exposure Medium:	Surface Sediment

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Dermal	Recreational	Adult	Exposed and near shore sediment in Gowanus Canal	EPC	Exposure Point Concentration	chemical-specific	mg/kg	EPA 2011, Table H-3.1	Dermal Absorbed Dose (DAD) (mg/kg-day) =
				AF	Sediment-to-Skin Adherence Factor	0.3	mg/cm^2-event	EPA 2004 (Ex. 3-3; average; reed gatherers)	$\frac{DA_{event} \times EF \times ED \times EV \times SA}{BW \times AT}$
				ABS_d	Absorption Fraction	chemical-specific	unitless	EPA 2004	
				CF	Conversion Factor	0.000001	kg/mg	-	where: DA_{event} (mg/cm^2-event)= EPC x AF x ABS_d x CF
				EF	Exposure Frequency	26	d/yr	EPA 2011 (1 d/wk for 1/2 yr)	
				ED	Exposure Duration	18	yr	EPA 1991	
				EV	Event Frequency	1	events/day	EPA, 2004 (Exhibit 3-5)	
				SA	Skin Surface Area Available for Contact	6,074	cm^2	EPA 2004 (head, hands, forearms, lower legs, feet)	
				BW	Body Weight	70	kg	EPA 1991	
				AT_C	Averaging Time (Cancer)	25,550	d/yr	EPA 1989	
				AT_{NC}	Averaging Time (Noncancer)	6,570	d	EPA 1989	
		Adolescent (12-18 years)	Exposed and near shore sediment in Gowanus Canal	EPC	Exposure Point Concentration	chemical-specific	mg/kg	EPA 2011, Table H-3.1	
				AF	Sediment-to-Skin Adherence Factor	0.2	mg/cm^2-event	EPA 2004 (average; children in wet soil)	
				ABS_d	Absorption Fraction	chemical-specific	unitless	EPA 2004	
				CF	Conversion Factor	0.000001	kg/mg	-	
				EF	Exposure Frequency	26	d/yr	EPA 2011 (1 d/wk for 1/2 yr)	
				ED	Exposure Duration	6	yr	EPA 2011 (professional judgment)	
				EV	Event Frequency	1	events/day	EPA, 2004 (Exhibit 3-5)	
				SA	Skin Surface Area Available for Contact	5,446	cm^2	EPA 2004 (head, hands, arms, legs, feet)	
				BW	Body Weight	57	kg	EPA 1997 (mean; combined male/female)	
				AT_C	Averaging Time (Cancer)	25,550	d/yr	EPA 1989	
				AT_{NC}	Averaging Time (Noncancer)	2,190	d	EPA 1989	
		Child (1-6 years)	Exposed and near shore sediment in Gowanus Canal	EPC	Exposure Point Concentration	chemical-specific	mg/kg	EPA 2011, Table H-3.1	
				AF	Sediment-to-Skin Adherence Factor	0.2	mg/cm^2-event	EPA 2004 (average; children in wet soil)	
				ABS_d	Absorption Fraction	chemical-specific	unitless	EPA 2004	
				CF	Conversion Factor	0.000001	kg/mg	-	
				EF	Exposure Frequency	26	d/yr	EPA 2011 (1 d/wk for 1/2 yr)	
				ED	Exposure Duration	6	yr	EPA 1991	
				EV	Event Frequency	1	events/day	EPA, 2004 (Exhibit 3-5)	
				SA	Skin Surface Area Available for Contact	2,800	cm^2	EPA 2004 (head, hands, forearms, lower legs, feet)	
				BW	Body Weight	15	kg	EPA 1991	
				AT_C	Averaging Time (Cancer)	25,550	d/yr	EPA 1989	
				AT_{NC}	Averaging Time (Noncancer)	2,190	d	EPA 1989	

References:

EPA 1989. Risk Assessment Guidance for Superfund. Vol. 1: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.

EPA 1991. Risk Assessment Guidance for Superfund. Vol. 1: Human Health Evaluation Manual - Supplemental Guidance, Standard Default Exposure Factors. Interim Final. OSWER Directive 9285.6-03.

EPA 1997. Exposure Factors Handbook. EPA/600/P-95/Fa, Fb, and Fc.

EPA 2004. Risk Assessment Guidance for Superfund. Vol. 1: Human Health Evaluation Manual (Part E - Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005.

EPA 2011. Human Health Risk Assessment - Gowanus Canal Superfund Site.

TABLE 4.2.RME - Recreation - SURFACE WATER

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE

Gowanus Canal Remedial Investigation, Brooklyn, New York

Scenario Timeframe:	Current/Future
Medium:	Surface Water
Exposure Medium:	Surface Water

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Recreational	Adult	Gowanus Canal	EPC	Exposure Point Concentration	chemical-specific	µg/L	EPA 2011, Table H-3.2 and H-3.3	Average Daily Dose (ADD) =
				IR	Ingestion Rate	0.05	L/hr	EPA 1989	EPC x IR x ET x EF x ED x CF1
				ET	Event Time	1.0	hr/d	EPA 1989	BW x AT
				EF	Exposure Frequency	26	d/yr	EPA 2011 (1 d/wk for 1/2 yr)	
				ED	Exposure Duration	18	yr	EPA 1991	
				CF1	Conversion Factor 1	0.001	mg/µg	-	
				BW	Body Weight	70	kg	EPA 1991	
				AT_C	Averaging Time (Cancer)	25,550	d	EPA 1989	
				AT_{NC}	Averaging Time (Noncancer)	6,570	d	EPA 1989	
		Adolescent (12-18 years)	Gowanus Canal	EPC	Exposure Point Concentration	chemical-specific	µg/L	EPA 2011, Table H-3.2 and H-3.3	
				IR	Ingestion Rate	0.05	L/hr	EPA 1989	
				ET	Event Time	1.0	hr/d	EPA 1989	
				EF	Exposure Frequency	26	d/yr	EPA 2011 (1 d/wk for 1/2 yr)	
				ED	Exposure Duration	6	yr	EPA 2011 (professional judgment)	
				CF1	Conversion Factor 1	0.001	mg/µg	-	
				BW	Body Weight	57	kg	EPA 1997 (mean; combined male/female)	
				AT_C	Averaging Time (Cancer)	25,550	d	EPA 1989	
				AT_{NC}	Averaging Time (Noncancer)	2,190	d	EPA 1989	
		Child (1-6 years)	Gowanus Canal	EPC	Exposure Point Concentration	chemical-specific	µg/L	EPA 2011, Table H-3.2 and H-3.3	
				IR	Ingestion Rate	0.05	L/hr	EPA 1989	
				ET	Event Time	1.0	hr/d	EPA 1989	
				EF	Exposure Frequency	26	d/yr	EPA 2011 (1 d/wk for 1/2 yr)	
				ED	Exposure Duration	6	yr	EPA 1991	
				CF1	Conversion Factor 1	0.001	mg/µg	-	
				BW	Body Weight	15	kg	EPA 1991	
				AT_C	Averaging Time (Cancer)	25,550	d	EPA 1989	
				AT_{NC}	Averaging Time (Noncancer)	2,190	d	EPA 1989	

TABLE 4.2.RME - Recreation - SURFACE WATER
VALUES USED FOR DAILY INTAKE CALCULATIONS
REASONABLE MAXIMUM EXPOSURE
Gowanus Canal Remedial Investigation, Brooklyn, New York

Scenario Timeframe:	Current/Future
Medium:	Surface Water
Exposure Medium:	Surface Water

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Dermal Contact	Recreational	Adult	Gowanus Canal	EPC	Exposure Point Concentration	chemical-specific	µg/L	EPA 2011, Table H-3.2 and H-3.3	Average Daily Dose (ADD) =
				Kp	Dermal Permeability Coefficient in Water	chemical-specific	cm/hr	EPA 2004	$\frac{DA_{event} \times EV \times EF \times ED \times SA}{BW \times AT_{NC}}$
				t_{event}	Event Duration	1.0	hr/event	EPA 2011	
				CF1	Conversion Factor 1	0.001	mg/µg	-	where:
				CF2	Conversion Factor 2	0.001	L/cm^3	-	DA_{event} for inorganics = EPC x Kp x t_{event} x CF1 x CF2
				FA	Fraction absorbed water	chemical-specific	-	EPA 2004	
				τ	Lag time per event	chemical-specific	hr/event	EPA 2004	DA_{event} for organics with t_{event} < t* = EPC x Kp x 2 x FA x (sqrt((6 x τ x t_{event})/π)) x CF1 x CF2
				EV	Event Frequency	1	events/d	EPA 2004	
				EF	Exposure Frequency	26	d/yr	EPA 2011 (1 d/wk for 1/2 yr)	
				ED	Exposure Duration	18	yr	EPA 1991	
				SA	Body Surface Area	6,074	cm^2	EPA 2011	
				BW	Body Weight	70	kg	EPA 1991	
				AT_C	Averaging Time-Cancer	25,550	d	EPA 1989	
				AT_{NC}	Averaging Time-Noncancer	6,570	d	EPA 1989	
		Adolescent (12-18 years)	Gowanus Canal	EPC	Exposure Point Concentration	chemical-specific	µg/L	EPA 2011, Table H-3.2 and H-3.3	
				Kp	Dermal Permeability Coefficient in Water	chemical-specific	cm/hr	EPA 2004	
				t_{event}	Event Duration	1.0	hr/event	EPA 2011	
				CF1	Conversion Factor 1	0.001	mg/µg	-	
				CF2	Conversion Factor 2	0.001	L/cm^3	-	
				FA	Fraction absorbed water	chemical-specific	-	EPA 2004	
				τ	Lag time per event	chemical-specific	hr/event	EPA 2004	
				EV	Event Frequency	1	events/d	EPA 2004	
				EF	Exposure Frequency	26	d/yr	EPA 2011 (1 d/wk for 1/2 yr)	
				ED	Exposure Duration	6	yr	EPA 2011	
				SA	Body Surface Area	5,446	cm^2	EPA 2011	
				BW	Body Weight	57	kg	EPA 1997 (mean; combined male/female)	
				AT_C	Averaging Time-Cancer	25,550	d	EPA 1989	
				AT_{NC}	Averaging Time-Noncancer	2,190	d	EPA 1989	

TABLE 4.2.RME - Recreation - SURFACE WATER
VALUES USED FOR DAILY INTAKE CALCULATIONS
REASONABLE MAXIMUM EXPOSURE
Gowanus Canal Remedial Investigation, Brooklyn, New York

Scenario Timeframe:	Current/Future
Medium:	Surface Water
Exposure Medium:	Surface Water

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
		Child	Gowanus Canal	EPC	Exposure Point Concentration	chemical-specific	µg/L	EPA 2011, Table H-3.2 and H-3.3	
		(1-6 years)		Kp	Dermal Permeability Coefficient in Water	chemical-specific	cm/hr	EPA 2004	
				t_{event}	Event Duration	1.0	hr/event	EPA 2011	
				CF1	Conversion Factor 1	0.001	mg/µg	-	
				CF2	Conversion Factor 2	0.001	L/cm^3	-	
				FA	Fraction absorbed water	chemical-specific	-	EPA 2004	
				τ	Lag time per event	chemical-specific	hr/event	EPA 2004	
				EV	Event Frequency	1	events/d	EPA 2004	
				EF	Exposure Frequency	26	d/yr	EPA 2011 (1 d/wk for 1/2 yr)	
				ED	Exposure Duration	6	yr	EPA 1991	
				SA	Body Surface Area	2,800	cm^2	EPA 2011	
				BW	Body Weight	15	kg	EPA 1991	
				AT_C	Averaging Time-Cancer	25,550	d	EPA 1989	
				AT_{NC}	Averaging Time-Noncancer	2,190	d	EPA 1989	

References:

EPA 1989. Risk Assessment Guidance for Superfund. Vol. 1: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.

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EPA 2011. Human Health Risk Assessment - Gowanus Canal Superfund Site.

TABLE 4.4.RME - Angler - FISH/CRAB
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

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Angler	Adult	Striped Bass	EPC	Exposure Point Concentration	chemical-specific	mg/kg	EPA 2011, Table 3.8RME, 3.9RME, 3.10RME	Average Daily Dose (ADD) =
			White Perch	IR	Ingestion Rate	26	g/d	EPA 1997	EPC x IR x CF x SUF x FI x EF x ED
			Eel	FI	Fraction Ingested	fish-specific	-	EPA 2000	BW x AT
					Striped Bass	0.47	-	Connelly 1992	
					White Perch	0.09	-	Connelly 1992	
					Eel	0.44	-	Connelly 1992	
				CF	Conversion Factor	1E-03	kg/g		
				SUF	Site Use Factor	1	unitless	assumed	
				EF	Exposure Frequency	365	d/yr	EPA 1997	
				ED	Exposure Duration	18	yr	EPA 1991	
				BW	Body Weight	70	kg	EPA 1991	
				AT_c	Averaging Time-Cancer	25550	d/yr	EPA 1989	
				AT_{NC}	Averaging Time-Noncancer	6570	d	EPA 1989	
		Adolescent	Striped Bass	EPC	Exposure Point Concentration	chemical-specific	mg/kg	EPA 2011, Table 3.8RME, 3.9RME, 3.10RME	
			White Perch	IR	Ingestion Rate	17	g/d	Assumed 2/3 adult rate	
			Eel	FI	Fraction Ingested	fish-specific	-	EPA 2000	
					Striped Bass	0.47	-	Connelly 1992	
					White Perch	0.09	-	Connelly 1992	
					Eel	0.44	-	Connelly 1992	
				CF	Conversion Factor	1E-03	kg/g		
				SUF	Site Use Factor	1	unitless	assumed	
				EF	Exposure Frequency	365	d/yr	EPA 1997	
				ED	Exposure Duration	6	yr	EPA 1991	
				BW	Body Weight	57	kg	EPA 1997 (mean; combined male/female)	
				AT_c	Averaging Time-Cancer	25550	d/yr	EPA 1989	
				AT_{NC}	Averaging Time-Noncancer	2190	d	EPA 1989	
		Child	Striped Bass	EPC	Exposure Point Concentration	chemical-specific	mg/kg	EPA 2011, Table 3.8RME, 3.9RME, 3.10RME	
			White Perch	IR	Ingestion Rate	9	g/d	Assumed 1/3 adult rate	
			Eel	FI	Fraction Ingested	fish-specific	-	EPA 2000	
					Striped Bass	0.47	-	Connelly 1992	
					White Perch	0.09	-	Connelly 1992	
					Eel	0.44	-	Connelly 1992	
				CF	Conversion Factor	1E-03	kg/g		
				SUF	Site Use Factor	1	unitless	assumed	
				EF	Exposure Frequency	365	d/yr	EPA 1997	
				ED	Exposure Duration	6	yr	EPA 1991	
				BW	Body Weight	15	kg	EPA 1991	
				AT_c	Averaging Time-Cancer	25550	d/yr	EPA 1989	
				AT_{NC}	Averaging Time-Noncancer	2190	d	EPA 1989	

TABLE 4.4.RME - Angler - FISH/CRAB

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

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	EPC	Exposure Point Concentration	chemical-specific	mg/kg	EPA 2011, Table 3.11RME	Average Daily Dose (ADD) =
				IR	Ingestion Rate	23	g/d	EPA 1997	EPC x IR x CF x SUF x EF x ED
				CF	Conversion Factor	1E-03	kg/g		BW x AT
				SUF	Site Use Factor	1	unitless	assumed	
				EF	Exposure Frequency	365	d/yr	EPA 1997	
				ED	Exposure Duration	18	yr	EPA 1991	
				BW	Body Weight	70	kg	EPA 1991	
				AT_C	Averaging Time-Cancer	25550	d/yr	EPA 1989	
				AT_{NC}	Averaging Time-Noncancer	6570	d	EPA 1989	
		Adolescent	Blue Crab	EPC	Exposure Point Concentration	chemical-specific	mg/kg	EPA 2011, Table 3.11RME	
				IR	Ingestion Rate	15	g/d	Assumed 2/3 adult rate	
				CF	Conversion Factor	1E-03	kg/g		
				SUF	Site Use Factor	1	unitless	assumed	
				EF	Exposure Frequency	365	d/yr	EPA 1997	
				ED	Exposure Duration	6	yr	EPA 1991	
				BW	Body Weight	57	kg	EPA 1997 (mean; combined male/female)	
				AT_C	Averaging Time-Cancer	25550	d/yr	EPA 1989	
				AT_{NC}	Averaging Time-Noncancer	2190	d	EPA 1989	
		Child	Blue Crab	EPC	Exposure Point Concentration	chemical-specific	mg/kg	EPA 2011, Table 3.11RME	
				IR	Ingestion Rate	8	g/d	Assumed 1/3 adult rate	
				CF	Conversion Factor	1E-03	kg/g		
				SUF	Site Use Factor	1	unitless	assumed	
				EF	Exposure Frequency	365	d/yr	EPA 1997	
				ED	Exposure Duration	6	yr	EPA 1991	
				BW	Body Weight	15	kg	EPA 1991	
				AT_C	Averaging Time-Cancer	25550	d/yr	EPA 1989	
				AT_{NC}	Averaging Time-Noncancer	2190	d	EPA 1989	

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EPA 2011. Human Health Risk Assessment - Gowanus Canal Superfund Site.

Chemical of Potential Concern	EPCs (mg/kg, edible tissue, fresh weight)				Toxicity Values	
	Striped Bass	White Perch	American Eel	Blue Crab	RfD (mg/kg-d)	CSF $(mg/kg\text{-}d)^{-1}$
Metals						
Arsenic, inorganic (assumed to be 10% of total As)	6.80E-02		5.00E-02	1.31E-01	3E-04	1.5
Chromium			6.70E-01		1.5E+00	NA
Copper			7.40E+00	1.02E+01	4E-02	NA
Mercury	2.00E-01	1.90E-01	2.60E-01	1.24E-01	1E-04	NA
Pesticides						
Dieldrin			1.70E-02		5E-05	16
PCB/TEQ						
PCB Dioxin	4.31E-06	5.80E-06	1.41E-05	5.04E-06	NA	1.6E+05
PCB Nondioxin	4.09E-01	4.37E-01	1.22E+00	1.43E-01	NA	2
Total PCB Congeners	4.35E-01	4.62E-01	1.35E+00	1.66E-01	2E-05	
PAHs						
Benzo(a)pyrene (>16 year old)				1.18E-02	NA	7.3
Benzo(a)pyrene (2-16 year old)						22
Benzo(a)pyrene (0-2 year old)						73
Dibenz(a,h)anthracene (>16 year old)				3.94E-03	NA	7.3
Dibenz(a,h)anthracene (2-16 year old)						22
Dibenz(a,h)anthracene (0-2 year old)						73
Indeno(1,2,3-cd)pyrene (>16 year old)				9.91E-03	NA	0.73
Indeno(1,2,3-cd)pyrene (2-16 year old)						2.2
Indeno(1,2,3-cd)pyrene (0-2 year old)						7.3

Notes:

1. EPCs from Tables H-3.8 through H-3.11 from the HHRA with all values converted to units of mg/kg, fresh weight. In addition, EPCs for total arsenic have been divided by 10 to estimate the concentration of inorganic arsenic.
2. EPCs in gray do not correspond to risks that appear in the Table 10 series.
3. Chromium is assumed to have the toxicity of trivalent chromium instead of EPA's assumption of hexavalent chromium.

TABLE 10.1.RME
RISK SUMMARY
REASONABLE MAXIMUM EXPOSURE
Gowanus Canal Remedial Investigation, Brooklyn, New York

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

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Sediment	Surface Sediment	Exposed and near shore sediment in Gowanus Canal	Benz(a)anthracene	1.2E-06	NA	5.7E-06	7.0E-06		NA	NA	NA	0E+00
			Benzo(a)pyrene	1.0E-05	NA	4.8E-05	5.9E-05		NA	NA	NA	0E+00
			Benzo(b)fluoranthene	1.1E-06	NA	5.1E-06	6.2E-06		NA	NA	NA	0E+00
			Dibenz(a,h)anthracene	5.9E-07	NA	2.8E-06	3.4E-06		NA	NA	NA	0E+00
			Indeno(1,2,3-cd)pyrene	4.7E-07	NA	2.2E-06	2.7E-06		NA	NA	NA	0E+00
Chemical Total				1.4E-05	NA	6.4E-05	7.8E-05		0.0E+00	NA	0.0E+00	0.0E+00
Exposed Surface Sediment Total							7.8E-05					0.0E+00
Surface Water	Surface Water	Gowanus Canal (Dry event)	Chromium	1.2E-07	NA	1.2E-06	1.3E-06	Not identified	3.2E-04	NA	3.1E-03	3.4E-03
Chemical Total				1.24E-07	NA	1.20E-06	1.3E-06		3.2E-04	NA	3.1E-03	3.4E-03
Surface Water Total - Dry Event							1.3E-06					3.4E-03
Surface Water	Surface Water	Gowanus Canal (Wet event)	Tetrachloroethylene (PCE)	1.7E-07	NA	1.8E-06	2.0E-06	Liver	1.2E-04	NA	1.3E-03	1.4E-03
Chemical Total				1.7E-07	NA	1.8E-06	2.0E-06		1.2E-04	NA	1.3E-03	1.4E-03
Surface Water Total - Wet Event							2.0E-06					1.4E-03
Receptor Total							7.9E-05				Receptor HI Total	3.4E-03

HI = Hazard Index

EPA's receptor total and target organ total include the sum of exposed and near shore sediment and the maximum of dry event and wet event surface water. In this able the receptor total and target organ total includes the sum of exposed and near shore sediment and both the dry event and wet event surface water because both are possible and involve different compounds of potential concern.

TABLE 10.2.RME
RISK SUMMARY
REASONABLE MAXIMUM EXPOSURE
Gowanus Canal Remedial Investigation, Brooklyn, New York

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

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Sediment	Surface Sediment	Exposed and near shore sediment in Gowanus Canal	benz(a)anthracene (12-16)	9.9E-07	NA	2.8E-06	3.8E-06		NA	NA	NA	0E+00
			benz(a)anthracene (16-18)	1.7E-07	NA	4.7E-07	6.3E-07		NA	NA	NA	0E+00
			benzo(a)pyrene (12-16)	8.4E-06	NA	2.4E-05	3.2E-05		NA	NA	NA	0E+00
			benzo(a)pyrene (16-18)	1.4E-06	NA	3.9E-06	5.3E-06		NA	NA	NA	0E+00
			benzo(b)fluoranthene (12-16)	8.8E-07	NA	2.5E-06	3.4E-06		NA	NA	NA	0E+00
			benzo(b)fluoranthene (16-18)	1.5E-07	NA	4.2E-07	5.6E-07		NA	NA	NA	0E+00
			dibenz(a,h)anthracene (12-16)	4.8E-07	NA	1.4E-06	1.9E-06		NA	NA	NA	0E+00
			dibenz(a,h)anthracene (16-18)	8.1E-08	NA	2.3E-07	3.1E-07		NA	NA	NA	0E+00
			indeno(1,2,3-cd)pyrene (12-16)	3.8E-07	NA	1.1E-06	1.5E-06		NA	NA	NA	0E+00
			indeno(1,2,3-cd)pyrene (16-18)	6.4E-08	NA	1.8E-07	2.4E-07		NA	NA	NA	0E+00
Chemical Total				1.3E-05	NA	3.7E-05	5.0E-05		0.0E+00	NA	0.0E+00	0.0E+00
Exposed Surface Sediment Total							5.0E-05					0.0E+00
Surface Water	Surface Water	Gowanus Canal (Dry event)	-	-	-	-	-	-	-	-	-	-
Chemical Total				0.0E+00	NA	0.0E+00	0.0E+00		0.0E+00	NA	0.0E+00	0.0E+00
Surface Water Total - Dry Event							0.0E+00					0.0E+00

TABLE 10.2.RME

RISK SUMMARY

REASONABLE MAXIMUM EXPOSURE

Gowanus Canal Remedial Investigation, Brooklyn, New York

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

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface Water	Surface Water	Gowanus Canal (Wet event)	-	-	-	-	-	-	-	-	-	-
Chemical Total				0.0E+00	NA	0.0E+00	0.0E+00		0.0E+00	NA	0.0E+00	0.0E+00
Surface Water Total - Wet Event							0.0E+00					0.0E+00
Receptor Total							5.0E-05				Receptor HI Total	0.0E+00

HI = Hazard Index

Receptor total and target organ total include the sum of exposed and near shore sediment and the maximum of dry event and wet event surface water.

TABLE 10.3.RME
RISK SUMMARY
REASONABLE MAXIMUM EXPOSURE
Gowanus Canal Remedial Investigation, Brooklyn, New York

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

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Sediment	Surface Sediment	Exposed and near shore sediment in Gowanus Canal	Benz(a)anthracene (0-2)	1.3E-05	NA	9.2E-06	2.2E-05		NA	NA	NA	0E+00
			Benz(a)anthracene (2-6)	7.5E-06	NA	5.5E-06	1.3E-05		NA	NA	NA	0E+00
			benzo(a)pyrene (0-2)	1.1E-04	NA	7.7E-05	1.8E-04		NA	NA	NA	0E+00
			benzo(a)pyrene (2-6)	6.4E-05	NA	4.6E-05	1.1E-04		NA	NA	NA	0E+00
			benzo(b)fluoranthene (0-2)	1.1E-05	NA	8.1E-06	1.9E-05		NA	NA	NA	0E+00
			benzo(b)fluoranthene (2-6)	6.7E-06	NA	4.9E-06	1.2E-05		NA	NA	NA	0E+00
			benzo(k)fluoranthene (0-2)	6.4E-07	NA	4.7E-07	1.1E-06		NA	NA	NA	0E+00
			benzo(k)fluoranthene (2-6)	3.8E-07	NA	2.8E-07	6.6E-07		NA	NA	NA	0E+00
			dibenz(a,h)anthracene (0-2)	6.1E-06	NA	4.5E-06	1.1E-05		NA	NA	NA	0E+00
			dibenz(a,h)anthracene (2-6)	3.7E-06	NA	2.7E-06	6.3E-06		NA	NA	NA	0E+00
			indeno(1,2,3-cd)pyrene (0-2)	4.8E-06	NA	3.5E-06	8.4E-06		NA	NA	NA	0E+00
			indeno(1,2,3-cd)pyrene (2-6)	2.9E-06	NA	2.1E-06	5.0E-06		NA	NA	NA	0E+00
			arsenic	1.1E-06	NA	1.8E-07	1.3E-06	Skin, Vascular	2.8E-02	NA	4.8E-03	3.3E-02
			PCBs (non-dioxin-like)	4.3E-07	NA	3.3E-07	7.6E-07	Ocular, Finger, and Toenails	1.2E-01	NA	9.7E-02	2.2E-01
Chemical Total				2.3E-04	NA	1.7E-04	3.9E-04		1.5E-01	NA	1.0E-01	2.5E-01
Exposed Surface Sediment Total							3.9E-04					2.5E-01
Surface Water	Surface Water	Gowanus Canal (Dry event)	Chromium (0-2)	6.4E-07	NA	2.9E-06	3.5E-06	Not identified	1.5E-03	NA	6.7E-03	8.2E-03
			Chromium (2-6)	3.8E-07	NA	1.7E-06	2.1E-06					
Chemical Total				1.0E-06	NA	4.6E-06	5.6E-06		1.5E-03	NA	6.7E-03	8.2E-03
Surface Water Total - Dry Event							5.6E-06					8.2E-03

TABLE 10.3.RME

RISK SUMMARY

REASONABLE MAXIMUM EXPOSURE

Gowanus Canal Remedial Investigation, Brooklyn, New York

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

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface Water	Surface Water	Gowanus Canal (Wet event)	Chromium (0-2)	2.9E-07	NA	1.3E-06	1.6E-06	Not Identified	6.8E-04	NA	3.0E-03	3.7E-03
			Chromium (2-6)	1.7E-07	NA	7.8E-07	9.5E-07					
			Tetrachloroethylene (PCE)	2.7E-07	NA	1.3E-06	1.6E-06	Liver	5.8E-04	NA	2.9E-03	3.4E-03
Chemical Total				7.3E-07	NA	3.4E-06	4.1E-06		1.3E-03	NA	5.9E-03	7.1E-03
Surface Water Total - Wet Event							4.1E-06					7.1E-03
Receptor Total							4.0E-04				Receptor HI Total	2.6E-01

HI = Hazard Index

Receptor total and target organ total include the sum of exposed and near shore sediment and the maximum of dry event and wet event surface water.

TABLE 10.Recreation.Summary.RME
RISK ASSESSMENT SUMMARY
REASONABLE MAXIMUM EXPOSURE
Gowanus Canal Remedial Investigation, Brooklyn, New York

Scenario Timeframe: Current/Future
Receptor Population: Recreational
Receptor Age: Adult, Adolescent, and Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Sediment	Total Surface Sediment Adult	Exposed and near shore sediment in Gowanus Canal	Benz(a)anthracene	1.2E-06	NA	5.7E-06	7.0E-06		NA	NA	NA	0E+00
			Benzo(a)pyrene	1.0E-05	NA	4.8E-05	5.9E-05		NA	NA	NA	0E+00
			Benzo(b)fluoranthene	1.1E-06	NA	5.1E-06	6.2E-06		NA	NA	NA	0E+00
			Dibenz(a,h)anthracene	5.9E-07	NA	2.8E-06	3.4E-06		NA	NA	NA	0E+00
			Indeno(1,2,3-cd)pyrene	4.7E-07	NA	2.2E-06	2.7E-06		NA	NA	NA	0E+00
			Total for Adult	1.4E-05	NA	6.4E-05	7.8E-05		NA	NA	NA	0.0E+00
	Total Surface Sediment Adolescent	Exposed and near shore sediment in Gowanus Canal	Benz(a)anthracene (12-16)	9.9E-07	NA	2.8E-06	3.8E-06		NA	NA	NA	0E+00
			Benz(a)anthracene (16-18)	1.7E-07	NA	4.7E-07	6.3E-07		NA	NA	NA	0E+00
			Benzo(a)pyrene (12-16)	8.4E-06	NA	2.4E-05	3.2E-05		NA	NA	NA	0E+00
			Benzo(a)pyrene (16-18)	1.4E-06	NA	3.9E-06	5.3E-06		NA	NA	NA	0E+00
			Benzo(b)fluoranthene (12-16)	8.8E-07	NA	2.5E-06	3.4E-06		NA	NA	NA	0E+00
			Benzo(b)fluoranthene (16-18)	1.5E-07	NA	4.2E-07	5.6E-07		NA	NA	NA	0E+00
			Dibenz(a,h)anthracene (12-16)	4.8E-07	NA	1.4E-06	1.9E-06		NA	NA	NA	0E+00
			Dibenz(a,h)anthracene (16-18)	8.1E-08	NA	2.3E-07	3.1E-07		NA	NA	NA	0E+00
			Indeno(1,2,3-cd)pyrene (12-16)	3.8E-07	NA	1.1E-06	1.5E-06		NA	NA	NA	0E+00
			Indeno(1,2,3-cd)pyrene (16-18)	6.4E-08	NA	1.8E-07	2.4E-07		NA	NA	NA	0E+00
			Total for Adolescent	1.3E-05	NA	3.7E-05	5.0E-05		NA	NA	NA	0.0E+00
	Total Surface Sediment Child	Exposed and near shore sediment in Gowanus Canal	Benz(a)anthracene (0-2)	1.3E-05	NA	9.2E-06	2.2E-05		NA	NA	NA	0E+00
			Benz(a)anthracene (2-6)	7.5E-06	NA	5.5E-06	1.3E-05		NA	NA	NA	0E+00
			benzo(a)pyrene (0-2)	1.1E-04	NA	7.7E-05	1.8E-04		NA	NA	NA	0E+00
			benzo(a)pyrene (2-6)	6.4E-05	NA	4.6E-05	1.1E-04		NA	NA	NA	0E+00
			benzo(b)fluoranthene (0-2)	1.1E-05	NA	8.1E-06	1.9E-05		NA	NA	NA	0E+00
			benzo(b)fluoranthene (2-6)	6.7E-06	NA	4.9E-06	1.2E-05		NA	NA	NA	0E+00
			benzo(k)fluoranthene (0-2)	6.4E-07	NA	4.7E-07	1.1E-06		NA	NA	NA	0E+00
			benzo(k)fluoranthene (2-6)	3.8E-07	NA	2.8E-07	6.6E-07		NA	NA	NA	0E+00
			dibenz(a,h)anthracene (0-2)	6.1E-06	NA	4.5E-06	1.1E-05		NA	NA	NA	0E+00
			dibenz(a,h)anthracene (2-6)	3.7E-06	NA	2.7E-06	6.3E-06		NA	NA	NA	0E+00
			indeno(1,2,3-cd)pyrene (0-2)	4.8E-06	NA	3.5E-06	8.4E-06		NA	NA	NA	0E+00
			indeno(1,2,3-cd)pyrene (2-6)	2.9E-06	NA	2.1E-06	5.0E-06		NA	NA	NA	0E+00
			arsenic	1.1E-06	NA	1.8E-07	1.3E-06	Skin, Vascular	2.8E-02	NA	4.8E-03	3.3E-02
			PCBs (non-dioxin-like)	4.3E-07	NA	3.3E-07	7.6E-07	Ocular, Finger, and Toenails	1.2E-01	NA	9.7E-02	2.2E-01
			Total for Child	2.3E-04	NA	1.7E-04	3.9E-04		1.5E-01	NA	1.0E-01	2.5E-01

TABLE 10.Recreation.Summary.RME
RISK ASSESSMENT SUMMARY
REASONABLE MAXIMUM EXPOSURE
Gowanus Canal Remedial Investigation, Brooklyn, New York

Scenario Timeframe: Current/Future
Receptor Population: Recreational
Receptor Age: Adult, Adolescent, and Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
	Total Surface Sediment Adult, Adolescent, and Child	Exposed and near shore sediment in Gowanus Canal	Benz(a)anthracene	2.2E-05	NA	2.4E-05	4.6E-05					
			Benzo(a)pyrene	1.9E-04	NA	2.0E-04	3.9E-04					
			Benzo(b)fluoranthene	2.0E-05	NA	2.1E-05	4.1E-05					
			Benzo(k)fluoranthene	1.0E-06	NA	7.5E-07	1.8E-06					
			Dibenz(a,h)anthracene	1.1E-05	NA	1.2E-05	2.2E-05					
			Indeno(1,2,3-cd)pyrene	8.7E-06	NA	9.1E-06	1.9E-05					
			Arsenic	1.1E-06	NA	1.8E-07	1.3E-06					
			PCBs (non-dioxin-like)	4.3E-07	NA	3.3E-07	7.6E-07					
	Total for Adult, Adolescent, and Child			2.5E-04	NA	2.7E-04	5.2E-04			Total Hazard Index from Sediment (Adult)		0E+00
	Total Risk from Sediment Across all Age Groups						5E-04	Total Hazard Index from Sediment (Adolescent)				0E+00
								Total Hazard Index from Sediment (Child)				3E-01
Surface Water (Dry Event)	Total Surface Water Adult	Surface Water in Gowanus Canal	Chromium	1.2E-07	NA	1.2E-06	1.3E-06	Not identified	3.2E-04	NA	3.1E-03	3.4E-03
			Total for Adult	1.2E-07	NA	1.2E-06	1.3E-06		3.2E-04	NA	3.1E-03	3.4E-03
	Total Surface Water Adolescent	Surface Water in Gowanus Canal	-	-	-	-	-	-	-	-	-	-
			Total for Adolescent	0.0E+00	NA	0.0E+00	0.0E+00		0.0E+00	NA	0.0E+00	0.0E+00
	Total Surface Water Child	Surface Water in Gowanus Canal	Chromium (0-2)	6.4E-07	NA	2.9E-06	3.5E-06	Not identified	1.5E-03	NA	6.7E-03	8.2E-03
			Chromium (2-6)	3.8E-07	NA	1.7E-06	2.1E-06					
			Total for Child	1.0E-06	NA	4.6E-06	5.6E-06		1.5E-03	NA	6.7E-03	8.2E-03
	Total Surface Water Adult, Adolescent, and Child	Surface Water in Gowanus Canal	Chromium	1.1E-06	NA	5.8E-06	6.9E-06					
	Total for Adult, Adolescent, and Child			1.1E-06	NA	5.8E-06	6.9E-06		Total Hazard Index from Surface Water (dry event) (Adult)			3E-03
	Total Risk from Surface Water (dry event) Across all Age Groups						7E-06	Total Hazard Index from Surface Water (dry event) (Adolescent)				0E+00
								Total Hazard Index from Surface Water (dry event) (Child)				8E-03

TABLE 10.Recreation.Summary.RME
RISK ASSESSMENT SUMMARY
REASONABLE MAXIMUM EXPOSURE
Gowanus Canal Remedial Investigation, Brooklyn, New York

Scenario Timeframe: Current/Future
Receptor Population: Recreational
Receptor Age: Adult, Adolescent, and Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface Water (Wet Event)	Total Surface Water Adult	Surface Water in Gowanus Canal	Tetrachloroethylene (PCE)	1.7E-07	NA	1.8E-06	2.0E-06	Liver	0.000124149	NA	0.001325221	1E-03
			Total for Adult	1.7E-07	NA	1.8E-06	2.0E-06		1.2E-04	NA	1.3E-03	1.4E-03
	Total Surface Water Adolescent	Surface Water in Gowanus Canal	-	-	-	-	-	-	-	-	-	-
			Total for Adolescent	0.0E+00	NA	0.0E+00	0.0E+00		0.0E+00	NA	0.0E+00	0.0E+00
	Total Surface Water Child	Surface Water in Gowanus Canal	Chromium (0-2)	2.9E-07	NA	1.3E-06	1.6E-06	Not identified	6.8E-04	NA	3.0E-03	4E-03
			Chromium (2-6)	1.7E-07	NA	7.8E-07	9.5E-07					
			Tetrachloroethylene (PCE)	2.7E-07	NA	1.3E-06	1.6E-06	Liver	5.8E-04	NA	2.9E-03	3E-03
			Total for Child	7.3E-07	NA	3.4E-06	4.1E-06		1.3E-03	NA	5.9E-03	7.1E-03
	Total Surface Water Adult, Adolescent, and Child	Surface Water in Gowanus Canal	Chromium	4.6E-07	NA	2.1E-06	2.5E-06					
			Tetrachloroethylene (PCE)	4.4E-07	NA	3.2E-06	3.6E-06					
	Total for Adult, Adolescent, and Child			9.0E-07	NA	5.2E-06	6.1E-06		Total Hazard Index from Surface Water (wet event) (Adult)			1E-03
	Total Risk from Surface Water (wet event) Across all Age Groups						6E-06	Total Hazard Index from Surface Water (wet event) (Adolescent)				0E+00
								Total Hazard Index from Surface Water (wet event) (Child)				7E-03
Total Risk from Sediment and Surface Water Across All Age Groups							5E-04	Total Hazard Index from Sediment and Surface Water (Adult)				3E-03
								Total Hazard Index from Sediment and Surface Water (Adolescent)				0E+00
								Total Hazard Index from Sediment and Surface Water (Child)				3E-01

NA = Not applicable

Receptor total and target organ total include the sum of exposed and near shore sediment and the maximum of dry event and wet event surface water.

TABLE 10.7.RME

RISK SUMMARY

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	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface Water/ Sediment	Fish and Crab Tissue	Striped Bass in Gowanus Canal	Dioxin-Like PCB TEQ	3.0E-05	NA	NA	3.0E-05	NA	NA	NA	NA	0E+00
			Nondioxin-Like	3.7E-05	NA	NA	3.7E-05	NA	NA	NA	NA	0E+00
			Total PCB	NA	NA	NA	0.0E+00	Ocular, Finger, and Toe Nails	3.8E+00	NA	NA	4E+00
			Arsenic	4.6E-06	NA	NA	4.6E-06	Skin, Vascular	4.0E-02	NA	NA	4.0E-02
			Mercury	NA	NA	NA	0.0E+00	Developmental Neurological	3.5E-01	NA	NA	3.5E-01
Chemical Total				7.1E-05	NA	NA	7.1E-05		4.2E+00	NA	NA	4.2E+00
Striped Bass in Gowanus Canal Total							7.1E-05					4.2E+00
Surface Water/ Sediment	Fish and Crab Tissue	White Perch in Gowanus Canal	Dioxin-Like PCB TEQ	7.8E-06	NA	NA	7.8E-06	NA	NA	NA	NA	0.0E+00
			Nondioxin-Like	7.5E-06	NA	NA	7.5E-06	NA	NA	NA	NA	0.0E+00
			Total PCB	NA	NA	NA	0.0E+00	Ocular, Finger, and Toe Nails	7.7E-01	NA	NA	7.7E-01
Chemical Total				1.5E-05	NA	0.00E+00	1.5E-05		7.7E-01	NA	0.0E+00	7.7E-01
White Perch in Gowanus Canal Total							1.5E-05					7.7E-01
Surface Water/ Sediment	Fish and Crab Tissue	Eel in Gowanus Canal	Dieldrin	1.1E-05	NA	NA	1.1E-05	Liver	5.6E-02	NA	NA	5.6E-02
			Dioxin-Like PCB TEQ	9.2E-05	NA	NA	9.2E-05	NA	NA	NA	NA	0.0E+00
			Nondioxin-Like	1.0E-04	NA	NA	1.0E-04	NA	NA	NA	NA	0.0E+00
			Total PCB	NA	NA	NA	0.0E+00	Ocular, Finger, and Toe Nails	1.1E+01	NA	NA	1.1E+01
			Arsenic	3.2E-06	NA	NA	3.2E-06	Skin, Vascular	2.7E-02	NA	NA	2.7E-02
			Chromium	NA	NA	NA	0.0E+00	Not identified	7.3E-05	NA	NA	7.3E-05
			Mercury	NA	NA	NA	0.0E+00	Developmental Neurological	4.2E-01	NA	NA	4.2E-01
Chemical Total				2.1E-04	NA	0.0E+00	2.1E-04		1.2E+01	NA	0.0E+00	1.2E+01
Eel in Gowanus Canal Total							2.1E-04					1.2E+01

TABLE 10.7.RME
RISK SUMMARY
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	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface Water/ Sediment	Fish and Crab Tissue	Striped Bass in Gowanus Canal	Dioxin-Like PCB TEQ	3.0E-05	NA	NA	3.0E-05	NA	NA	NA	NA	0E+00
			Nondioxin-Like	3.7E-05	NA	NA	3.7E-05	NA	NA	NA	NA	0E+00
			Total PCB	NA	NA	NA	0.0E+00	Ocular, Finger, and Toe Nails	3.8E+00	NA	NA	4E+00
			Arsenic	4.6E-06	NA	NA	4.6E-06	Skin, Vascular	4.0E-02	NA	NA	4.0E-02
			Mercury	NA	NA	NA	0.0E+00	Developmental Neurological	3.5E-01	NA	NA	3.5E-01
Chemical Total				7.1E-05	NA	NA	7.1E-05		4.2E+00	NA	NA	4.2E+00
Striped Bass in Gowanus Canal Total							7.1E-05					4.2E+00
Surface Water/ Sediment	Fish and Crab Tissue	White Perch in Gowanus Canal	Dioxin-Like PCB TEQ	7.8E-06	NA	NA	7.8E-06	NA	NA	NA	NA	0.0E+00
			Nondioxin-Like	7.5E-06	NA	NA	7.5E-06	NA	NA	NA	NA	0.0E+00
			Total PCB	NA	NA	NA	0.0E+00	Ocular, Finger, and Toe Nails	7.7E-01	NA	NA	7.7E-01
Chemical Total				1.5E-05	NA	0.00E+00	1.5E-05		7.7E-01	NA	0.0E+00	7.7E-01
White Perch in Gowanus Canal Total							1.5E-05					7.7E-01
Surface Water/ Sediment	Fish and Crab Tissue	Eel in Gowanus Canal	Dieldrin	1.1E-05	NA	NA	1.1E-05	Liver	5.6E-02	NA	NA	5.6E-02
			Dioxin-Like PCB TEQ	9.2E-05	NA	NA	9.2E-05	NA	NA	NA	NA	0.0E+00
			Nondioxin-Like	1.0E-04	NA	NA	1.0E-04	NA	NA	NA	NA	0.0E+00
			Total PCB	NA	NA	NA	0.0E+00	Ocular, Finger, and Toe Nails	1.1E+01	NA	NA	1.1E+01
			Arsenic	3.2E-06	NA	NA	3.2E-06	Skin, Vascular	2.7E-02	NA	NA	2.7E-02
			Chromium	NA	NA	NA	0.0E+00	Not identified	7.3E-05	NA	NA	7.3E-05
			Mercury	NA	NA	NA	0.0E+00	Developmental Neurological	4.2E-01	NA	NA	4.2E-01
Chemical Total				2.1E-04	NA	0.0E+00	2.1E-04		1.2E+01	NA	0.0E+00	1.2E+01
Eel in Gowanus Canal Total							2.1E-04					1.2E+01

TABLE 10.7.RME
RISK SUMMARY
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	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface Water/ Sediment	Fish and Crab Tissue	Blue Crab in Gowanus Canal										
			Benzo(a)pyrene	7.3E-06	NA	NA	7.3E-06	NA	NA	NA	NA	0.0E+00
			Dibenz(a,h)anthracene	2.4E-06	NA	NA	2.4E-06	NA	NA	NA	NA	0.0E+00
			Dioxin-Like PCB TEQ	6.6E-05	NA	NA	6.6E-05	NA	NA	NA	NA	0.0E+00
			Nondioxin-Like	2.4E-05	NA	NA	2.4E-05	NA	NA	NA	NA	0.0E+00
			Total PCB	NA	NA	NA	0.0E+00	Ocular, Finger, and Toe Nails	2.7E+00	NA	NA	2.7E+00
			Arsenic	1.7E-05	NA	NA	1.7E-05	Skin, Vascular	1.4E-01	NA	NA	1.4E-01
			Mercury	NA	NA	NA	0.0E+00	Developmental Neurological	4.1E-01	NA	NA	4.1E-01
Chemical Total				1.2E-04	NA	0.0E+00	1.2E-04		3.3E+00	NA	0.0E+00	3.3E+00
Crab in Gowanus Canal Total							1.2E-04					3.3E+00
Receptor Total - Fish							3E-04	Receptor HI Total - Fish				2E+01
Receptor Total - Blue Crab							1E-04	Receptor HI Total - Blue Crab				3E+00

HI = Hazard Index

Target Organ Totals for Fish

Total Developmental HI Across All Media =	8E-01
Total Fingers and Toe Nails HI Across All Media =	2E+01
Total Liver HI Across All Media =	6E-02
Total Neurological HI Across All Media =	8E-01
Total Ocular HI Across All Media =	2E+01
Total Skin HI Across All Media =	7E-02
Total Vascular HI Across All Media =	7E-02

Target Organ Totals for Blue Crab

Total Developmental HI Across All Media =	4E-01
Total Fingers and Toe Nails HI Across All Media =	3E+00
Total Neurological HI Across All Media =	4E-01
Total Ocular HI Across All Media =	3E+00
Total Skin HI Across All Media =	1E-01
Total Vascular HI Across All Media =	1E-01

TABLE 10.8.RME

RISK SUMMARY

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	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface Water/ Sediment	Fish and Crab Tissue	Striped Bass in Gowanus Canal										
			Dioxin-Like PCB TEQ	8.1E-06	NA	NA	8.1E-06	NA	NA	NA	NA	0E+00
			Nondioxin-Like	9.8E-06	NA	NA	9.8E-06	NA	NA	NA	NA	0E+00
			Total PCB	NA	NA	NA	0.0E+00	Ocular, Finger, and Toe Nails	3.0E+00	NA	NA	3E+00
			Arsenic	1.2E-06	NA	NA	1.2E-06	Skin, Vascular	3.2E-02	NA	NA	3.2E-02
			Mercury	NA	NA	NA	0.0E+00	Developmental Neurological	2.8E-01	NA	NA	2.8E-01
Chemical Total				1.9E-05	NA	NA	1.9E-05		3.4E+00	NA	NA	3.4E+00
Striped Bass in Gowanus Canal Total							1.9E-05					3.4E+00
Surface Water/ Sediment	Fish and Crab Tissue	White Perch in Gowanus Canal										
			Dioxin-Like PCB TEQ	2.1E-06	NA	NA	2.1E-06	NA	NA	NA	NA	0.0E+00
			Nondioxin-Like	2.0E-06	NA	NA	2.0E-06	NA	NA	NA	NA	0.0E+00
			Total PCB	NA	NA	NA	0.0E+00	Ocular, Finger, and Toe Nails	6.2E-01	NA	NA	6.2E-01
Chemical Total				4.1E-06	NA	0.00E+00	4.1E-06		6.2E-01	NA	0.0E+00	6.2E-01
White Perch in Gowanus Canal Total							4.1E-06					6.2E-01
Surface Water/ Sediment	Fish and Crab Tissue	Eel in Gowanus Canal										
			Dieldrin	3.1E-06	NA	NA	3.1E-06	Liver	4.5E-02	NA	NA	4.5E-02
			Dioxin-Like PCB TEQ	2.5E-05	NA	NA	2.5E-05	NA	NA	NA	NA	0.0E+00
			Nondioxin-Like	2.7E-05	NA	NA	2.7E-05	NA	NA	NA	NA	0.0E+00
			Total PCB	NA	NA	NA	0.0E+00	Ocular, Finger, and Toe Nails	8.9E+00	NA	NA	8.9E+00
			Chromium	NA	NA	NA	0.0E+00	Not identified	5.9E-05	NA	NA	5.9E-05
			Mercury	NA	NA	NA	0.0E+00	Developmental Neurological	3.4E-01	NA	NA	3.4E-01
Chemical Total				5.5E-05	NA	0.0E+00	5.5E-05		9.2E+00	NA	0.0E+00	9.2E+00
Eel in Gowanus Canal Total							5.5E-05					9.2E+00

TABLE 10.8.RME

RISK SUMMARY

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	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface Water/ Sediment	Fish and Crab Tissue	Blue Crab in Gowanus Canal										
			Benzo(a)pyrene (12-16)*	3.9E-06	NA	NA	3.9E-06	NA	NA	NA	NA	0.0E+00
			Benzo(a)pyrene (16-18)*	6.5E-07	NA	NA	6.5E-07	NA	NA	NA	NA	0.0E+00
			Dibenz(a,h)anthracene (12-16)*	1.3E-06	NA	NA	1.3E-06	NA	NA	NA	NA	0.0E+00
			Dibenz(a,h)anthracene (16-18)*	2.2E-07	NA	NA	2.2E-07	NA	NA	NA	NA	0.0E+00
			Dioxin-Like PCB TEQ	1.8E-05	NA	NA	1.8E-05	NA	NA	NA	NA	0.0E+00
			Nondioxin-Like	6.5E-06	NA	NA	6.5E-06	NA	NA	NA	NA	0.0E+00
			Total PCB	NA	NA	NA	0.0E+00	Ocular, Finger, and Toe Nails	2.2E+00	NA	NA	2.2E+00
			Arsenic	4.4E-06	NA	NA	4.4E-06	Skin, Vascular	1.1E-01	NA	NA	1.1E-01
			Mercury	NA	NA	NA	0.0E+00	Developmental Neurological	3.3E-01	NA	NA	3.3E-01
Chemical Total				3.5E-05	NA	0.0E+00	3.5E-05		2.6E+00	NA	0.0E+00	2.6E+00
Crab in Gowanus Canal Total							3.5E-05					2.6E+00
Receptor Total - Fish							8E-05	Receptor HI Total - Fish				1E+01
Receptor Total - Blue Crab							3E-05	Receptor HI Total - Blue Crab				3E+00

Target Organ Totals for Fish

Total Developmental HI Across All Media =	6E-01
Total Fingers and Toe Nails HI Across All Media =	1E+01
Total Liver HI Across All Media =	4E-02
Total Neurological HI Across All Media =	6E-01
Total Ocular HI Across All Media =	1E+01
Total Skin HI Across All Media =	3E-02
Total Vascular HI Across All Media =	3E-02

Target Organ Totals for Blue Crab

Total Developmental HI Across All Media =	3E-01
Total Fingers and Toe Nails HI Across All Media =	2E+00
Total Neurological HI Across All Media =	3E-01
Total Ocular HI Across All Media =	2E+00
Total Skin HI Across All Media =	1E-01
Total Vascular HI Across All Media =	1E-01

HI = Hazard Index

*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.

TABLE 10.9.RME
RISK SUMMARY
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	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface Water/ Sediment	Fish and Crab Tissue	Striped Bass in Gowanus Canal	Dioxin-Like PCB TEQ	1.6E-05	NA	NA	1.6E-05	NA	NA	NA	NA	0E+00
			Nondioxin-Like	2.0E-05	NA	NA	2.0E-05	NA	NA	NA	NA	0E+00
			Total PCB	NA	NA	NA	0.0E+00	Ocular, Finger, and Toe Nails	6.1E+00	NA	NA	6E+00
			Arsenic	2.5E-06	NA	NA	2.5E-06	Skin, Vascular	6.4E-02	NA	NA	6.4E-02
			Mercury	NA	NA	NA	0.0E+00	Developmental Neurological	5.6E-01	NA	NA	5.6E-01
Chemical Total				3.8E-05	NA	NA	3.8E-05		6.8E+00	NA	NA	6.8E+00
Striped Bass in Gowanus Canal Total							3.8E-05					6.8E+00
Surface Water/ Sediment	Fish and Crab Tissue	White Perch in Gowanus Canal	Dioxin-Like PCB TEQ	4.2E-06	NA	NA	4.2E-06	NA	NA	NA	NA	0.0E+00
			Nondioxin-Like	4.0E-06	NA	NA	4.0E-06	NA	NA	NA	NA	0.0E+00
			Total PCB	NA	NA	NA	0.0E+00	Ocular, Finger, and Toe Nails	1.2E+00	NA	NA	1.2E+00
			Mercury	NA	NA	NA	0.0E+00	Developmental Neurological	1.1E-01	NA	NA	1.1E-01
Chemical Total				8.2E-06	NA	0.00E+00	8.2E-06		1.3E+00	NA	0.0E+00	1.3E+00
White Perch in Gowanus Canal Total							8.2E-06					1.3E+00
Surface Water/ Sediment	Fish and Crab Tissue	Eel in Gowanus Canal	Dieldrin	6.2E-06	NA	NA	6.2E-06	Liver	9.0E-02	NA	NA	9.0E-02
			Dioxin-Like PCB TEQ	5.0E-05	NA	NA	5.0E-05	NA	NA	NA	NA	0.0E+00
			Nondioxin-Like	5.5E-05	NA	NA	5.5E-05	NA	NA	NA	NA	0.0E+00
			Total PCB	NA	NA	NA	0.0E+00	Ocular, Finger, and Toe Nails	1.8E+01	NA	NA	1.8E+01
			Arsenic	1.7E-06	NA	NA	1.7E-06	Skin, Vascular	4.4E-02	NA	NA	4.4E-02
			Chromium	NA	NA	NA	0.0E+00	Not identified	1.2E-04	NA	NA	1.2E-04
			Mercury	NA	NA	NA	0.0E+00	Developmental Neurological	6.9E-01	NA	NA	6.9E-01
Chemical Total				1.1E-04	NA	0.0E+00	1.1E-04		1.9E+01	NA	0.0E+00	1.9E+01
Eel in Gowanus Canal Total							1.1E-04					1.9E+01

TABLE 10.9.RME
RISK SUMMARY
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	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface Water/ Sediment	Fish and Crab Tissue	Blue Crab in Gowanus Canal										
			Benzo(a)pyrene (0-2)*	1.3E-05	NA	NA	1.3E-05	NA	NA	NA	NA	0.0E+00
			Benzo(a)pyrene (2-6)*	7.9E-06	NA	NA	7.9E-06	NA	NA	NA	NA	0.0E+00
			Dibenz(a,h)anthracene (0-2)*	4.4E-06	NA	NA	4.4E-06	NA	NA	NA	NA	0.0E+00
			Dibenz(a,h)anthracene (2-6)*	2.6E-06	NA	NA	2.6E-06	NA	NA	NA	NA	0.0E+00
			Indeno(1,2,3-cd)pyrene (0-2)*	1.1E-06	NA	NA	1.1E-06	NA	NA	NA	NA	0.0E+00
			Indeno(1,2,3-cd)pyrene (2-6)*	6.6E-07	NA	NA	6.6E-07	NA	NA	NA	NA	0.0E+00
			Dioxin-Like PCB TEQ	3.6E-05	NA	NA	3.6E-05	NA	NA	NA	NA	0.0E+00
			Nondioxin-Like	1.3E-05	NA	NA	1.3E-05	NA	NA	NA	NA	0.0E+00
			Total PCB	NA	NA	NA	0.0E+00	Ocular, Finger, and Toe Nails	4.4E+00	NA	NA	4.4E+00
			Arsenic	9.0E-06	NA	NA	9.0E-06	Skin, Vascular	2.3E-01	NA	NA	2.3E-01
			Copper	NA	NA	NA	0.0E+00	Gastrointestinal	1.4E-01	NA	NA	1.4E-01
			Mercury	NA	NA	NA	0.0E+00	Developmental Neurological	6.6E-01	NA	NA	6.6E-01
Chemical Total				8.8E-05	NA	0.0E+00	8.8E-05		5.5E+00	NA	0.0E+00	5.5E+00
Crab in Gowanus Canal Total							8.8E-05					5.5E+00
Receptor Total - Fish							2E-04				Receptor HI Total - Fish	3E+01
Receptor Total - Blue Crab							9E-05				Receptor HI Total - Blue Crab	5E+00

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

Target Organ Totals for Fish

Total Developmental HI Across All Media =	1E+00
Total Fingers and Toe Nails HI Across All Media =	3E+01
Total Liver HI Across All Media =	9E-02
Total Neurological HI Across All Media =	1E+00
Total Ocular HI Across All Media =	3E+01
Total Skin HI Across All Media =	1E-01
Total Vascular HI Across All Media =	1E-01

Target Organ Totals for Blue Crab

Total Developmental HI Across All Media =	7E-01
Total Fingers and Toe Nails HI Across All Media =	4E+00
Total Gastrointestinal HI Across All Media =	1E-01
Total Neurological HI Across All Media =	7E-01
Total Ocular HI Across All Media =	4E+00
Total Skin HI Across All Media =	2E-01
Total Vascular HI Across All Media =	2E-01

TABLE 10.Fish Consumption.Summary.RME
RISK ASSESSMENT SUMMARY
REASONABLE MAXIMUM EXPOSURE
Gowanus Canal Remedial Investigation, Brooklyn, New York

Scenario Timeframe: Current/Future
Receptor Population: Recreational
Receptor Age: Adult, Adolescent, and Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Fish	Striped Bass Adult	Gowanus Canal	Dioxin-Like PCB TEQ	3.0E-05	NA	NA	3.0E-05	NA	NA	NA	NA	0.0E+00
			Nondioxin-Like	3.7E-05	NA	NA	3.7E-05	NA	NA	NA	NA	0.0E+00
			Total PCB	NA	NA	NA	0.0E+00	Ocular, Finger, and Toe Nails	3.8E+00	NA	NA	3.8E+00
			Arsenic	4.6E-06	NA	NA	4.6E-06	Skin, Vascular	4.0E-02	NA	NA	4.0E-02
			Mercury	NA	NA	NA	0.0E+00	Developmental Neurological	3.5E-01	NA	NA	3.5E-01
			Total for Adult	7.1E-05	NA	0.0E+00	7.1E-05		NA	NA	NA	4.2E+00
	Striped Bass Adolescent	Gowanus Canal	Dioxin-Like PCB TEQ	8.1E-06	NA	NA	8.1E-06	NA	NA	NA	NA	0E+00
			Nondioxin-Like	9.8E-06	NA	NA	9.8E-06	NA	NA	NA	NA	0E+00
			Total PCB	NA	NA	NA	0.0E+00	Ocular, Finger, and Toe Nails	3.0E+00	NA	NA	3E+00
			Arsenic	1.2E-06	NA	NA	1.2E-06	Skin, Vascular	3.2E-02	NA	NA	3E-02
			Mercury	NA	NA	NA	0.0E+00	Developmental Neurological	2.8E-01	NA	NA	3E-01
			Total for Adolescent	1.9E-05	NA	0.0E+00	1.9E-05		NA	NA	NA	3.4E+00
	Striped Bass Child	Gowanus Canal	Dioxin-Like PCB TEQ	1.6E-05	NA	NA	1.6E-05	NA	NA	NA	NA	0E+00
			Nondioxin-Like	2.0E-05	NA	NA	2.0E-05	NA	NA	NA	NA	0E+00
			Total PCB	NA	NA	NA	0.0E+00	Ocular, Finger, and Toe Nails	6.1E+00	NA	NA	6E+00
			Arsenic	2.5E-06	NA	NA	2.5E-06	Skin, Vascular	6.4E-02	NA	NA	6E-02
			Mercury	NA	NA	NA	0.0E+00	Developmental Neurological	5.6E-01	NA	NA	6E-01
			Total for Child	3.8E-05	NA	0.0E+00	3.8E-05		6.8E+00	NA	0.0E+00	6.8E+00
	Striped Bass Adult, Adolescent, and Child	Gowanus Canal	Dioxin-Like PCB TEQ	5.5E-05	NA	NA	5.5E-05					
			Nondioxin-Like	6.6E-05	NA	NA	6.6E-05					
			Total PCB	0.0E+00	NA	NA	0.0E+00					
			Arsenic	8.3E-06	NA	NA	8.3E-06					
			Mercury	0.0E+00	NA	NA	0.0E+00					
			Total for Adult, Adolescent, and Child	1.3E-04	NA	NA	1.3E-04				Total Hazard Index from Striped Bass (Adult)	4E+00
			Total Risk from Striped Bass Across all Age Groups				1E-04				Total Hazard Index from Striped Bass (Adolescent)	3E+00
											Total Hazard Index from Striped Bass (Child)	7E+00

TABLE 10.Fish Consumption.Summary.RME
RISK ASSESSMENT SUMMARY
REASONABLE MAXIMUM EXPOSURE
Gowanus Canal Remedial Investigation, Brooklyn, New York

Scenario Timeframe: Current/Future
Receptor Population: Recreational
Receptor Age: Adult, Adolescent, and Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Fish	White Perch Adult	Gowanus Canal	Dioxin-Like PCB TEQ	7.8E-06	NA	NA	8.7E-06	NA	NA	NA	NA	0E+00
			Nondioxin-Like	7.5E-06	NA	NA	1.0E-05	NA	NA	NA	NA	0E+00
			Total PCB	NA	NA	NA	0.0E+00	Ocular, Finger, and Toe Nails	7.7E-01	NA	NA	8E-01
			Total for Adult	1.5E-05	NA	0.0E+00	1.9E-05		NA	NA	NA	7.7E-01
	White Perch Adolescent	Gowanus Canal	Dioxin-Like PCB TEQ	2.1E-06	NA	NA	2.1E-06	NA	NA	NA	NA	0E+00
			Nondioxin-Like	2.0E-06	NA	NA	2.0E-06	NA	NA	NA	NA	0E+00
			Total PCB	NA	NA	NA	0.0E+00	Ocular, Finger, and Toe Nails	6.2E-01	NA	NA	6E-01
			Total for Adolescent	4.1E-06	NA	0.0E+00	4.1E-06		NA	NA	NA	6.2E-01
	White Perch Child	Gowanus Canal	Dioxin-Like PCB TEQ	4.2E-06	NA	NA	4.2E-06	NA	NA	NA	NA	0E+00
			Nondioxin-Like	4.0E-06	NA	NA	4.0E-06	NA	NA	NA	NA	0E+00
			Total PCB	NA	NA	NA	0.0E+00	Ocular, Finger, and Toe Nails	1.2E+00	NA	NA	1E+00
			Mercury	NA	NA	NA	0.0E+00	Developmental Neurological	1.1E-01	NA	NA	1E-01
			Total for Child	8.2E-06	NA	0.0E+00	8.2E-06		1.3E+00	NA	0.0E+00	1.3E+00
	White Perch Adult, Adolescent, and Child	Gowanus Canal	Dioxin-Like PCB TEQ	1.4E-05	NA	NA	1.4E-05					
			Nondioxin-Like	1.4E-05	NA	NA	1.4E-05					
			Total PCB	0.0E+00	NA	NA	0.0E+00					
	Total for Adult, Adolescent, and Child			2.8E-05	NA	NA	2.8E-05			Total Hazard Index from White Perch (Adult)		8E-01
	Total Risk from White Perch Across all Age Groups						3E-05	Total Hazard Index from White Perch (Adolescent)				6E-01
								Total Hazard Index from White Perch (Child)				1E+00

TABLE 10.Fish Consumption.Summary.RME
RISK ASSESSMENT SUMMARY
REASONABLE MAXIMUM EXPOSURE
Gowanus Canal Remedial Investigation, Brooklyn, New York

Scenario Timeframe: Current/Future
Receptor Population: Recreational
Receptor Age: Adult, Adolescent, and Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Fish	American Eel Adult	Gowanus Canal	Dieldrin	1.1E-05	NA	NA	1.1E-05	Liver	5.6E-02	NA	NA	6E-02
			Dioxin-Like PCB TEQ	9.2E-05	NA	NA	9.2E-05	NA	NA	NA	NA	0E+00
			Nondioxin-Like	1.0E-04	NA	NA	1.0E-04	NA	NA	NA	NA	0E+00
			Total PCB	NA	NA	NA	0.0E+00	Ocular, Finger, and Toe Nails	1.1E+01	NA	NA	1E+01
			Arsenic	3.2E-06	NA	NA	3.2E-06	Skin, Vascular	2.7E-02	NA	NA	3E-02
			Chromium	NA	NA	NA	0.0E+00	Not identified	7.3E-05	NA	NA	7E-05
			Mercury	NA	NA	NA	0.0E+00	Developmental Neurological	4.2E-01	NA	NA	4E-01
			Total for Adult	2.1E-04	NA	0.0E+00	2.1E-04		1.2E+01	NA	NA	1.2E+01
	American Eel Adolescent	Gowanus Canal	Dieldrin	3.1E-06	NA	NA	3.1E-06	Liver	4.5E-02	NA	NA	4E-02
			Dioxin-Like PCB TEQ	2.5E-05	NA	NA	2.5E-05	NA	NA	NA	NA	0E+00
			Nondioxin-Like	2.7E-05	NA	NA	2.7E-05	NA	NA	NA	NA	0E+00
			Total PCB	NA	NA	NA	0.0E+00	Ocular, Finger, and Toe Nails	8.9E+00	NA	NA	9E+00
			Chromium	NA	NA	NA	0.0E+00	Not Identified	5.9E-05	NA	NA	6E-05
			Mercury	NA	NA	NA	0.0E+00	Developmental Neurological	3.4E-01	NA	NA	3E-01
			Total for Adolescent	5.5E-05	NA	0.0E+00	5.5E-05		NA	NA	NA	9.2E+00
	American Eel Child	Gowanus Canal	Dieldrin	6.2E-06	NA	NA	6.2E-06	Liver	9.0E-02	NA	NA	9E-02
			Dioxin-Like PCB TEQ	5.0E-05	NA	NA	5.0E-05	NA	NA	NA	NA	0E+00
			Nondioxin-Like	5.5E-05	NA	NA	5.5E-05	NA	NA	NA	NA	0E+00
			Total PCB	NA	NA	NA	0.0E+00	Ocular, Finger, and Toe Nails	1.8E+01	NA	NA	2E+01
			Arsenic	1.7E-06	NA	NA	1.7E-06	Skin, Vascular	4.4E-02	NA	NA	4E-02
			Chromium	NA	NA	NA	0.0E+00	Not identified	1.2E-04	NA	NA	1E-04
			Mercury	NA	NA	NA	0.0E+00	Developmental Neurological	6.9E-01	NA	NA	7E-01
			Total for Child	1.1E-04	NA	0.0E+00	1.1E-04		1.9E+01	NA	0.0E+00	1.9E+01
	American Eel Adult, Adolescent, and Child	Gowanus Canal	Dieldrin	2.1E-05	NA	NA	2.1E-05					
			Dioxin-Like PCB TEQ	1.7E-04	NA	NA	1.7E-04					
			Nondioxin-Like	1.9E-04	NA	NA	1.9E-04					
			Total PCB	0.0E+00	NA	NA	0.0E+00					
			Arsenic	4.8E-06	NA	NA	4.8E-06					
			Chromium	0.0E+00	NA	NA	0.0E+00					
			Mercury	0.0E+00	NA	NA	0.0E+00					
	Total for Adult, Adolescent, and Child			3.8E-04	NA	NA	3.8E-04			Total Hazard Index from American Eel (Adult)		1E+01
	Total Risk from American Eel Across all Age Groups						3.8E-04	Total Hazard Index from American Eel (Adolescent)				9E+00
								Total Hazard Index from American Eel (Child)				2E+01
Total Risk from all Fish Across All Age Groups							5E-04	Total Hazard Index from all Fish (Adult)				2E+01
								Total Hazard Index from all Fish (Adolescent)				1E+01
								Total Hazard Index from all Fish (Child)				3E+01

NA = Not applicable

Receptor total and target organ total include the sum of exposed and near shore sediment and the maximum of dry event and wet event surface water.

TABLE 10.Crab Consumption.Summary.RME
RISK ASSESSMENT SUMMARY
REASONABLE MAXIMUM EXPOSURE
Gowanus Canal Remedial Investigation, Brooklyn, New York

Scenario Timeframe: Current/Future
Receptor Population: Recreational
Receptor Age: Adult, Adolescent, and Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Crab	Blue Crab Adult	Gowanus Canal	Benzo(a)pyrene	7.3E-06	NA	NA	7.3E-06	NA	NA	NA	NA	0.0E+00
			Dibenz(a,h)anthracene	2.4E-06	NA	NA	2.4E-06	NA	NA	NA	NA	0.0E+00
			Dioxin-Like PCB TEQ	6.6E-05	NA	NA	6.6E-05	NA	NA	NA	NA	0.0E+00
			Nondioxin-Like	2.4E-05	NA	NA	2.4E-05	NA	NA	NA	NA	0.0E+00
			Total PCB	NA	NA	NA	0.0E+00	Ocular, Finger, and Toe Nails	2.7E+00	NA	NA	2.7E+00
			Arsenic	1.7E-05	NA	NA	1.7E-05	Skin, Vascular	1.4E-01	NA	NA	1.4E-01
			Mercury	NA	NA	NA	0.0E+00	Developmental Neurological	4.1E-01	NA	NA	4.1E-01
			Total for Adult	1.2E-04	NA	0.0E+00	1.2E-04		NA	NA	NA	3.3E+00
	Blue Crab Adolescent	Gowanus Canal	Benzo(a)pyrene (12-16)*	3.9E-06	NA	NA	3.9E-06	NA	NA	NA	NA	0E+00
			Benzo(a)pyrene (16-18)*	6.5E-07	NA	NA	6.5E-07	NA	NA	NA	NA	0E+00
			Dibenz(a,h)anthracene (12-16)*	1.3E-06	NA	NA	1.3E-06	NA	NA	NA	NA	0E+00
			Dibenz(a,h)anthracene (16-18)*	2.2E-07	NA	NA	2.2E-07	NA	NA	NA	NA	0E+00
			Dioxin-Like PCB TEQ	1.8E-05	NA	NA	1.8E-05	NA	NA	NA	NA	0E+00
			Nondioxin-Like	6.5E-06	NA	NA	6.5E-06	NA	NA	NA	NA	0E+00
			Total PCB	NA	NA	NA	0.0E+00	Ocular, Finger, and Toe Nails	2.2E+00	NA	NA	2.2E+00
			Arsenic	4.4E-06	NA	NA	4.4E-06	Skin, Vascular	1.1E-01	NA	NA	1.1E-01
			Mercury	NA	NA	NA	0.0E+00	Developmental Neurological	3.3E-01	NA	NA	3.3E-01
			Total for Adolescent	3.5E-05	NA	0.0E+00	3.5E-05		NA	NA	NA	2.6E+00
	Blue Crab Child	Gowanus Canal	Benzo(a)pyrene (0-2)*	1.3E-05	NA	NA	1.3E-05	NA	NA	NA	NA	0E+00
			Benzo(a)pyrene (2-6)*	7.9E-06	NA	NA	7.9E-06	NA	NA	NA	NA	
			Dibenz(a,h)anthracene (0-2)*	4.4E-06	NA	NA	4.4E-06	NA	NA	NA	NA	
			Dibenz(a,h)anthracene (2-6)*	2.6E-06	NA	NA	2.6E-06	NA	NA	NA	NA	
			Indeno(1,2,3-cd)pyrene (0-2)*	1.1E-06	NA	NA	1.1E-06	NA	NA	NA	NA	
			Indeno(1,2,3-cd)pyrene (2-6)*	6.6E-07	NA	NA	6.6E-07	NA	NA	NA	NA	
			Dioxin-Like PCB TEQ	3.6E-05	NA	NA	3.6E-05	NA	NA	NA	NA	
			Nondioxin-Like	1.3E-05	NA	NA	1.3E-05	NA	NA	NA	NA	
			Total PCB	NA	NA	NA	0.0E+00	Ocular, Finger, and Toe Nails	4.4E+00	NA	NA	4.4E+00
			Arsenic	9.0E-06	NA	NA	9.0E-06	Skin, Vascular	2.3E-01	NA	NA	2.3E-01
			Copper	NA	NA	NA	0.0E+00	Gastrointestinal	1.4E-01	NA	NA	1.4E-01
			Mercury	NA	NA	NA	0.0E+00	Developmental Neurological	6.6E-01	NA	NA	6.6E-01
			Total for Child	8.8E-05	NA	0.0E+00	8.8E-05		5.5E+00	NA	0.0E+00	5.5E+00

TABLE 10.Crab Consumption.Summary.RME
RISK ASSESSMENT SUMMARY
REASONABLE MAXIMUM EXPOSURE
Gowanus Canal Remedial Investigation, Brooklyn, New York

Scenario Timeframe: Current/Future
Receptor Population: Recreational
Receptor Age: Adult, Adolescent, and Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
	Blue Crab Adult, Adolescent, and Child	Gowanus Canal	Benzo(a)pyrene	3.3E-05	NA	NA	3.3E-05					
			Dibenz(a,h)anthracene	1.1E-05	NA	NA	1.1E-05					
			Indeno(1,2,3-cd)pyrene	1.8E-06	NA	NA	1.8E-06					
			Dioxin-Like PCB TEQ	1.2E-04	NA	NA	1.2E-04					
			Nondioxin-Like	4.4E-05	NA	NA	4.4E-05					
			Total PCB	0.0E+00	NA	NA	0.0E+00					
			Arsenic	3.0E-05	NA	NA	3.0E-05					
			Copper	0.0E+00	NA	NA	0.0E+00					
			Mercury	0.0E+00	NA	NA	0.0E+00					
	Total for Adult, Adolescent, and Child			2.4E-04	NA	NA	2.4E-04			Total Hazard Index from Blue Crab (Adult)		3E+00
	Total Risk from Blue Crab Across all Age Groups						2.4E-04	**Total Hazard Index from Blue Crab (Adolescent)**				3E+00
								Total Hazard Index from Blue Crab (Child)				5E+00
Total Risk from Blue Crab Across All Age Groups							2E-04	**Total Hazard Index from Blue Crab (Adult)**				3E+00
								Total Hazard Index from Blue Crab (Adolescent)				3E+00
								Total Hazard Index from Blue Crab (Child)				5E+00

NA = Not applicable

Receptor total and target organ total include the sum of exposed and near shore sediment and the maximum of dry event and wet event surface water.

Attachment

Environmental Protection

Carter H. Strickland, Jr.
Commissioner

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November 22, 2011

Marc S. Greenberg, Ph.D.
Environmental Toxicologist
U.S. EPA - Environmental Response Team
OSWER/OSRTI/TIFSD/ERT

Re: Gowanus Canal Superfund Site: Estimation of PAH Concentrations on Solids from CSO Water Column Data

Dear Dr. Greenberg:

This memorandum summarizes some of the technical issues associated with the data collected and the analyses discussed by EPA at the CSTAG meeting, as they relate to contaminant loads associated with New York City (City) Combined Sewer Outfalls (CSOs). The City is hopeful that this analysis will be helpful to the CSTAG panel in their review process. The City's assessment of EPA's analysis is summarized in the following sections. The City would also like to restate its concerns regarding data gaps in the Draft RI Report and the current Conceptual Site Model ("CSM") for the Gowanus Canal, as presented in the RI. These concerns were previously presented by the City to EPA. These concerns are also summarized in the following sections.

The City has used the data presented in the RI Report for sediments collected in CSOs to conduct an independent evaluation of the potential impact of CSOs on the canal, and to develop a Conceptual Site Model (CSM) for the canal. These results were presented to CSTAG and demonstrate that PAH concentrations in CSO sediments, as presented in the RI Report, are equivalent to background concentrations, and are less than human health risk-based values. The EPA has discussed an alternative analysis in which they characterized PAH loads in CSOs as significantly greater than the City's analysis. The City has not seen the EPA analysis, as it was not presented in the RI Report. It appears that USEPA is using the whole water data presented in the RI to estimate particulate matter concentrations for PAHs for risk assessment purposes.

This memo presents an analysis of the problems associated with estimating the PAH concentrations in CSO solids using the whole water data presented in the RI. There are several concerns with the methodology used in sampling whole water data and in the laboratory results reported for these data. These include: high and variable detection limits were reported for chemical and TSS data; poor agreement was observed for field duplicates; assumptions made regarding PAH partitioning in estimating particulate concentrations may not be valid: and discrete surface water samples used for CSOs are not representative of CSOs. These uncertainities in the data can result in estimated particulate concentrations that may be more than an order of magnitude greater than actual values. These results have significant implications for load calculations, risk assessment, and remedial action decisions for the Site. Given the concerns with EPA's whole water sample data collection methodology, analysis, and the approach used to derive PAH concentration on the solids, the City believes that EPA's usage of these derived concentrations is problematic. In general, EPA's calculation methods are overly conservative for PAH compounds and the data are very poor for estimating concentrations of the more particle reactive PAH compounds. While the whole water data collected by EPA could be used to develop a preliminary assessment of the risk due to CSO water, it should not be used to derive conclusions on particulate matter. Further, using data presented in the RI for background samples and CSO whole water samples, the City has determined that, using EPA's methodology, the estimated B(a)P concentration on particulates for CSO samples with B(a)P detections are within or below the range of reference area results. This analysis would indicate that CSO and background area solids have essentially the same B(a)P levels. These analyses are discussed in more detail in the following sections.

1. Concerns with Data Collected by EPA for Remedial Investigation (RI) and its Use to Derive Remedial Decisions:

As reported in the RI Report, EPA collected sediment and surface water samples from the 1) reference site (Gowanus Bay and Upper NY Bay), 2) CSOs, and 3) Gowanus Canal. Ten locations in Gowanus Bay were selected by EPA to characterize the reference site. At the reference locations surface water samples were collected during dry weather and one wet weather event. Water samples were collected from ten CSOs during a single dry weather event and three wet weather events in an attempt to characterize CSO water and solids that may enter the Canal during CSO discharge events. Note that not all ten CSOs were sampled during all three wet weather events; however, each of the ten sampled CSOs has at least one wet weather sample.

Sediment samples were collected from the 10 locations representing the reference or background locations. In order to characterize the sediment from the CSOs, EPA sampled seven CSO locations from within sewer pipes and interceptors. An attempt was made to sample 10 CSO locations, but sediment was not found at 3 of the proposed locations.

Twenty-five locations were sampled for sediment and surface water samples from the canal in order to characterize the canal itself. Sediment and surface water samples were analyzed for TAL metals and TCL organics.

The City has used the data collected by EPA in the RI Report to conduct an independent evaluation of the CSOs and develop an initial framework for a conceptual site model for the Canal. However, there are many concerns regarding the data collected by EPA. Concerns are as follows:

a) <u>Whole Water Data Sampling Method for CSOs:</u> To characterize the general level of contamination in the discharge water from a CSO, composite sampling is required. The EPA collected almost exclusively discrete (grab) water samples. A grab sample represents the instantaneous conditions at the time of collection and does not represent or integrate the contaminant concentration variations over the period of discharge during a rainfall event. A single 12-hour composite sample was collected from only one CSO (RH-034) during one wet weather event. The remaining whole water samples are highly variable and don't characterize average CSO discharges.

b) <u>Total Suspended Solids (TSS) Results from the CSOs and Background:</u> The total suspended solids results from the surface water data for background and CSOs are shown in Table 1a and 1b respectively. For the background site, the average dry weather TSS value is 78 mg/L with a median of 86 mg/l. For wet weather sampling similar values are reported. However, reports in the literature (NYCDEP 2010, Litten 2003, Garvey 1990) conducted in the NY Harbor report the TSS in the harbor to be in the range of 3-20 mg/L. This discrepancy between the EPA's results and those of prior observers raise a major concern for the EPA data set. High TSS values reported by EPA's laboratory could be due to an error in measurement. Measurement of TSS in salt water requires special care in the selection of an appropriate filter pad and proper rinsing of the filter pad. If this is not done correctly, dissolved salts from the salt water sample will remain on the filter pad resulting in a false high TSS reported result.

Table 1a. Total Suspended Solids Results for Background

Sample ID	TSS (mg/L) DRY Weather	TSS (mg/L) Wet Weather Event 1
326	45	63
327	90	97
328	94	77
329	90	83
330	104	62
331	106	94
332	82	80
333	60	79
334	42	91
335	64	63
Average	**78**	**79**
Median	**86**	**80**

Related to this concern, the City notes that for the CSO results, the average of the reported TSS values is very similar for both dry (149 mg/L) and wet (136 mg/L) weather samples (see Table 1b). Since storm water is expected to contain less suspended matter than municipal wastewater, it is expected that the TSS levels in a CSO flow during a wet weather event should be lower than dry weather event. Despite the close agreement of the average TSS levels for dry and wet events, the individual TSS values for the three wet weather events ranged from 19 mg/l to 989 mg/L. Notable in the wet weather TSS levels were two apparently extreme values obtained in wet weather event 2, 377 and 989 mg/L. However, evaluation of the rainfall intensity showed that wet weather event 2 had the lowest rainfall intensity of all the rainfall events. If these two values are excluded from the mean wet weather TSS calculation, the average TSS values reduces to 70 mg/L, which is more consistent with the City's measured TSS levels (65-70 mg/L[1]) for CSOs during wet weather events. However, the wide variation in the results and the sensitivity of the mean value to just two values is considered symptomatic of poor TSS data in general. The City believes that the discrete sampling method employed by EPA fails to characterize the TSS levels in the CSO discharge during a wet weather event.

Table 1b. Total Suspended Solids Result for CSOs

CSO	TSS (mg/L) Dry Weather	TSS (mg/L) Wet Weather Event 1	TSS (mg/L) Wet Weather Event 2	TSS (mg/L) Wet Weather Event 3
OH-005	171	46		19
OH-006	78			132
OH-007	61			40
RH-031	161		377	56
RH-033	71	24		66
RH-034	123	38	70	
RH-035	220		989	126
RH-036	100	45		18
RH-037	38	102		91
RH-038	467	186		35
Average	**149**	**137**		
Median	**112**	**61**		

c) <u>CSO Water Sampling Analysis:</u> For the CSO water data, SVOC analysis was conducted on a whole water basis, providing no information on dissolved and suspended matter concentrations, an important consideration in estimating impacts from the CSOs. This is an important analysis because chemicals partition between the dissolved and particulate phases depending on their solubilities, and this can have a significant impact on chemical concentrations in the particulate matter. In contrast to SVOCs, metals were analyzed for dissolved and particulate phases in an attempt to get this type of information but the results are problematic and do not provide precise estimates of suspended matter-borne contaminants. Additional concerns with the results of this analysis include:

a) <u>Variable detection limits:</u> From the results provided by EPA, it is apparent that EPA's laboratory did not achieve consistent reporting limits (RL) in their analysis of contaminants in whole water. For the CSO results, reporting limits of both 1 ug/L and 0.1

[1] TSS values in sanitary sewage average about 115 mg/L (NYCDEP, 2002) and in stormwater average about 60 mg/L (Hazen and Sawyer, P.C., 1993). Analyses conducted for the *Gowanus Canal WBWS Facility Plan Report, August 2008 indicate that* CSOs are roughly 90% stormwater and 10% sanitary sewage, and a typical TSS concentration for CSO is about 65-70 mg/L.

ug/L were reported. The value of 1 ug/L was reported for the majority of the results from wet weather event 1. The issue with this RL is that most of the detected values of the subsequent wet weather samples from the CSOs are less than 0.5 ug/L, i.e. less than half the reporting limit for the first event. The high detection limit of 1 ug/L thus renders the wet weather event 1 results unsuitable for further evaluation and substantively reduces the data set.

b) Concerns with field duplicates (for both surface water and sediment sampling): Field duplicates were collected by EPA for surface water and sediment samples. For surface water, field duplicates were analyzed for two CSOs, RH-033 (wet weather event 1) and OH-007 (wet weather event 3). A single field duplicate for CSO sediments was collected for sample RH-035. Results of the field duplicates for some contaminants for RH-033 (wet weather event 1) are shown in Table 2a. For this sample, multiple detection limits were used by EPA's lab to characterize the field duplicates, limiting the usability of the data. In Table 2b, the results for a CSO sediment field duplicate are shown. In this instance, the results show very poor precision with detected levels in one sample more than 2 times higher than the detected values or the detection limits in the second sample.

Table 2a. Field Duplicate Results for Surface Water

Analyte	RH-033 - Wet Weather Event 1				Notes
	Result ug/L)	Qualifier	Result - uplicate (ug/L)	Qualifier	
Acenaphthylene	1	U	0.1	U	A
Benzo(a)pyrene	1	U	0.1	U	A
Naphthalene	1	U	10		B
Benzo(k)fluoranthene	1	U	0.066	J	A
Chrysene	1	U	0.13		A

Notes:
A: Disparate detection limits reduce data usability.
B: Result value is 10 times lower than the corresponding duplicate result.

Table 2b. Field Duplicate Results for CSO Sediment Samples

Analyte	CSO - RH-035			
	Result	Qualifier	Result - Duplicate	Qualifier
Lead (mg/kg)	38		3320	
Benzo(a)anthracene (ug/kg)	270		120	U
Benzo(a)pyrene (ug/kg)	490		140	
Benzo(b)fluoranthene (ug/kg)	440		130	
Benzo(g,h,i)perylene (ug/kg)	340		92	J
Benzo(k)fluoranthene (ug/kg)	400	J	120	U
Chrysene (ug/kg)	260		120	U
Dibenz(a,h)anthracene (ug/kg)	280		120	UJ
Fluoranthene (ug/kg)	600		120	U
Indeno(1,2,3-c,d)pyrene (ug/kg)	460		170	
Phenanthrene (ug/kg)	370		120	U
Pyrene (ug/kg)	560		120	U

Note that result value is more than two times greater than the corresponding duplicate value/ detection limit. This is the only duplicate pair for CSO sediments.

c) <u>Results for Metals:</u> For metals, the surface water data was analyzed for dissolved and whole water. For some metals the whole water results were lower than the dissolved results, a physically impossible result that reveals the poor precision of the data and the sampling approach. Table 3 shows results for some metals where this is observed.

Table 3. Inconsistency and Poor Characterization of Metals for Dissolved and Particulate Phase Results

CSO	Wet Weather Event	Metal	Total (ug/L)	Qualifier	Dissolved Phase (ug/L)	Qualifier	Notes
RH-036	3	Barium	11.2	J	20	J	A
RH-037	1	Copper	51		217	J	A
RH-033	1	Cadmium	2.7	J	10	U	B
RH-031	2	Cadmium	0.4	J	1.0	U	B
RH-033	3	Zinc	40		52	J	A

Notes:
A: Dissolved concentration is higher than the total concentration so suspended matter concentration is undefined.
B: Non-detected dissolved concentration value is higher than the reported total concentration value.

In conclusion, the City believes that the data used by EPA to characterize the CSOs is inadequate and should be used with caution in assessing the impact of CSOs on the Canal or for making remedial decisions.

2. **Estimation of Contaminant Concentration on Particulate Phase using Whole Water Data:**

At the November 3, 2011 CSTAG meeting, EPA Region 2 indicated that it is using whole water data to estimate particulate concentrations for PAHs. The City has yet to be provided with this analysis, and has several questions and concerns regarding the underlying methodology and its conclusions. Based on the description provided by EPA at the November 3 meeting, it seems that EPA's methodology may make conservative assumptions that all the reported PAH concentrations are present on the particulate matter, and that the dissolved phase concentration is zero. Based on the data quality issues discussed above, the City has concerns regarding this approach. For purposes of this discussion, the City is using B(a)P for illustrative purposes, given its importance in the risk analysis and its hydrophobic nature.

Table 4 lists the B(a)P and TSS concentrations in water obtained from the sampled CSOs. Of the 21 samples (including field duplicates) that were collected by EPA, fifteen had non-detect values for B(a)P concentrations reported by the laboratory. Additionally two different RLs (1 ug/L and 0.1 ug/L) were reported by EPA's laboratory for B(a)P in Events 1 and 3. Use of ½ RL as an estimate of the sample concentration when compiling statistics on mean or median concentration is a common practice. Use of ½ RL for the majority of the data set for B(a)P estimates would be problematic. The non-detect values with an RL of 1 ug/L (30 percent of these samples) should not be included in the evaluation because five of the six detected results are well below half the RL. Thus the RL for these samples is sufficiently high so as to lie outside the range of the detections. These data are effectively useless in trying to estimate B(a)P concentrations since they provide only a crude upper bound to the actual sample concentration. Loss of these sample results substantively reduces the amount of data that is available for CSO characterization. In total, of 21 measurements of B(a)P, 6 were nondetect at a RL of 1 ug/L, 9 were nondetect at a RL of 0.1 ug/L and six were detections in the range of 0.15 ug/L to 0.59 ug/L. These values are not particularly different from water column concentrations reported in the Gowanus Bay reference area (0.17 ug/L to 1.4 ug/L). Table 4 also demonstrates that the B(a)P concentrations calculated using EPA's assumed method results in very low concentrations when actual detected values are used. For example in event #2 the 2 detected values result in B(a)P concentrations of 150 ug/kg and 425 ug/kg. In contrast, when assigning a value of 0.5 ug/L as ½RL for the ND samples in event #1, the B(a)P concentrations are much greater, as high as 20,800 ug/kg.

Table 4. Benzo(a)pyrene and TSS Concentration in Sampled CSO Data

Wet Weather Event	CSO	B(A)P (ug/L)	Qualifier	TSS (mg/L)	Qualifier	Estimated B(a)P Concentration on Solids (ug/kg) (1)	B(a)P Solids Concentration assuming Equilibrium Partitioning(ug/kg) (2)
Event 1	OH-005	1	U	46		10,900	10,800
Event 1	RH-033	1	U			20,800	20,400
		0.1	U	24	J	2,100	2,000
Event 1	RH-034	1	U	38		13,200	13,000
Event 1	RH-036	1	U	45		11,100	11,000
Event 1	RH-037	1	U	102		4,900	4,900
Event 1	RH-038	0.1	U	186		270	270
Event 2	RH-031	0.16	J	377		425	425
Event 2	RH-034	0.1	UJ	70		700	700
Event 2	RH-035	0.15	J	989		150	150
Event 3	OH-005	0.28		19		15,000	14,000
Event 3	OH-006	1	U	132		3,800	3,800
Event 3	OH-007	0.1	U			1,250	1,234
		0.1	U	40			
Event 3	RH-031	0.59		56		10,500	10,400
Event 3	RH-033	0.1	U	66		760	750
Event 3	RH-034	0.1	U			930	920
Event 3	RH-035	0.16		126		1,300	1,300
Event 3	RH-036	0.1	U	18		2,800	2,700
Event 3	RH-037	0.29		91		3,200	3,200
Event 3	RH-038	0.1	U	35		1,430	1,400

(1)	Assumes EPA's method for estimating values consists of dividing the whole water concentration by the TSS value. ND values were assumed to be substituted as 1/2RL.
(2)	Note: For the equilibrium partitioning methodology, equilibrium partitioning coefficients for individual PAHs were derived using Koc values from the Agency for Toxic Substances and Disease Registry (ATSDR) and the maximum organic carbon concentration on the CSOs. B(a)P concentrations on solids for nondetect samples were estimated using ½ the detection limit value and are considered highly uncertain.

An additional concern arises from B(a)P solubility. B(a)P has a low solubility in water and is highly particle reactive (high K_{oc}). As a result, samples with the highest TSS are expected to have among the highest B(a)P concentrations since so little of the B(a)P is dissolved. However, EPA's whole water data do not support this. From the table it can be seen that the sample with the highest TSS of 989 mg/L has the lowest detected B(a)P concentrations (0.15 ug/L) while the highest detected B(a)P concentration (0.56 ug/L) is associated with a TSS concentration that is 18 times lower (56 mg/L). Figure 1a shows a plot of B(a)P whole water values vs. corresponding TSS results and Figure 1b shows the estimated B(a)P concentrations on particulates derived from whole water result and TSS. From the plots it can be seen that the B(a)P concentrations vary inversely with TSS, *i.e.*, B(a)P concentrations decrease as the TSS values increase.

Figure 1a. Whole Water Benzo(a)Pyrene Concentration vs. TSS for Detected Results

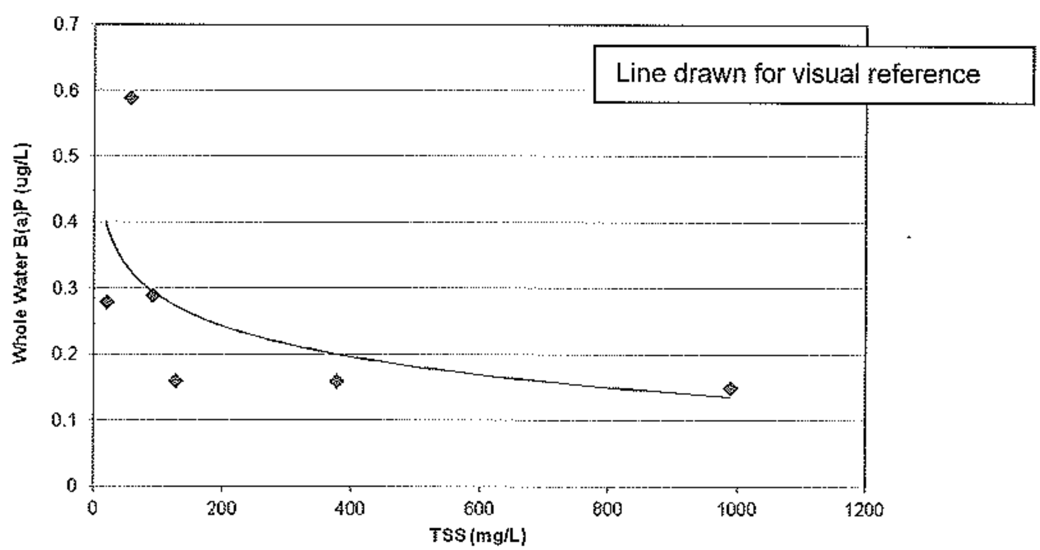
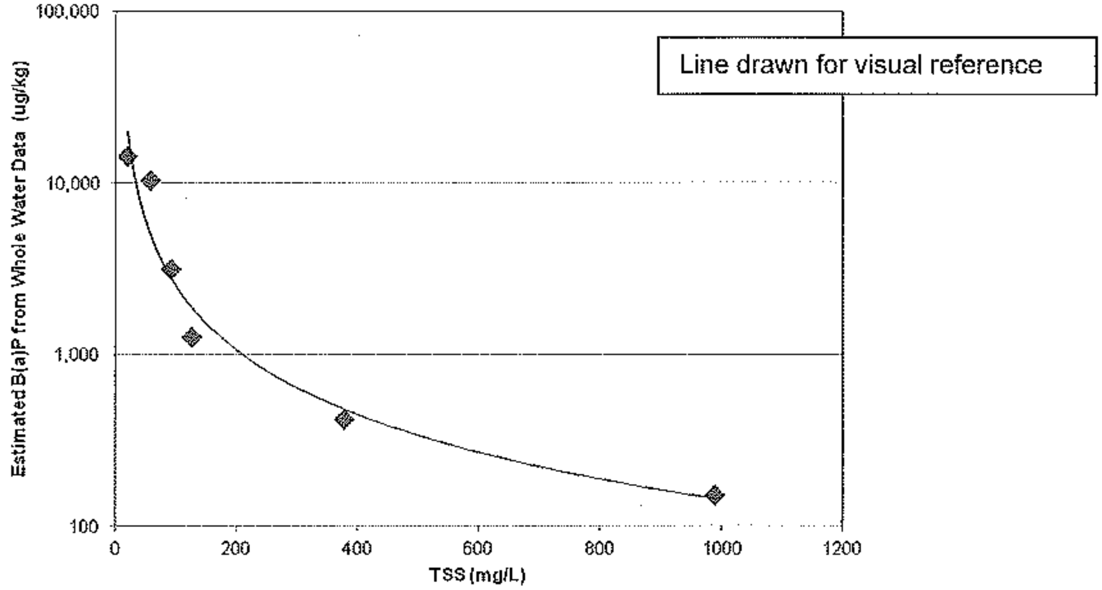


Figure 1b. Estimated Benzo(a)Pyrene Concentration on Particulates vs. TSS for Detected Results



These results indicate that B(a)P concentrations in CSO water correlate inversely with the solids content. While some of the variability may be due to the fact that separate samples was collected for PAH and TSS, this variability is not sufficient to yield the observed trend. Rather this trend indicates that when CSOs deliver large quantities of suspended matter (*i.e.*, high TSS concentrations), the B(a)P concentrations on those solids will be quite low. Given this relationship, a volume weighted average concentration for B(a)P will be substantially lower than the simple arithmetic mean of the samples. As a minimum, these results indicate that B(a)P concentration in CSO discharges are not well understood.

TSS and B(a)P whole water concentrations were used to calculate the B(a)P concentration on the solids to replicate EPA's verbally described method. This approach assumes that the dissolved phase concentration is zero and all B(a)P mass is particle bound. A second approach was conducted to account for dissolved phase using equilibrium partitioning. The particulate concentrations from both approaches are not significantly different, indicating that for B(a)P, EPA's approach produces reasonable upper bound concentrations, given the assumption of equilibrium in the samples. However, this may not be the case, given the short residence time of CSO water within the sewer lines during rainfall driven discharge. Additionally, both of these approaches ignore the potential impacts of oil phases that may be present in CSO discharges on the B(a)P distribution, a concern that cannot be addressed without sampling of dissolved, suspended and oil (if present) phases. Thus the B(a)P results are still subject to much uncertainty. While the B(a)P results suggest that much of this compound may be particle-bound, this is not be the case for low molecular weight PAHs with high solubility, as discussed below. The average B(a)P concentrations on the solids calculated using EPA's methodology and conservative assumptions for detected results range from 150 ug/kg to 14,700 ug/kg with a median concentration of 2200 ug/kg. Using similar methodology, the concentration on particulates was estimated for background. During dry and wet weather events the estimated B(a)P concentrations for the detected results range from 2700 mg/kg to 18,000 mg/kg with a median concentration of 3,800 mg/kg. Estimated B(a)P concentration on particulates for CSO samples with B(a)P detections (150 to 15,000 mg/kg) are within or below the range of reference area results (2,700 to 18,000 mg/kg). This analysis would indicate that CSO and background area solids have essentially the same B(a)P levels.

In conclusion, the City does not agree with EPA's assertions that the CSO data are sufficient to accurately estimate the loads of B(a)P to the Gowanus Canal and that B(a)P levels on CSO solids will of themselves represent concentrations substantively above baseline. The City asserts that the EPA methods will likely overestimate the CSO loads.

Estimating the Total PAH Concentration on Particulates:

The above calculations showed that both EPA's and the City's methods estimate similar B(a)P concentrations for suspended solids in CSO discharges assuming equilibrium. However, this is not the case for lighter PAHs or Total PAH concentrations. Estimating the Total PAH particulate concentrations by assuming no dissolved phase will result in much higher estimates of solids concentration. This is because the whole water data for CSOs shows a high fraction of low molecular weight (LMW) PAHs especially naphthalene, which are much more soluble and less particle reactive. Table 5 lists the Naphthalene, LMW PAH and Total PAH concentrations for CSOs.

Table 5. Whole Water Concentration for Naphthalene, LMW PAH and Total PAH

Event	CSO	Naphthalene (ug/L)	**LMW PAH (ug/L)**	Percentage of Naphthalene in LMW PAH (Naphthalene/ LMW PAH)	**Total PAH (ug/L)**	Percentage of LMW PAH in Total PAHs (LMW PAH/ Total PAH)
vent 1	H-005		ND		ND	
vent 1	RH-033	ND	**1.1**		**1.1**	100%
		10	**13.1**	76%	**15.5**	84%
vent 1	H-034	0.6	**0.6**	100%	**3.7**	15%
vent 1	H-036	ND	ND		ND	
vent 1	H-037	29	**31.2**	93%	**31.2**	100%
vent 1	H-038	22	**26.5**	83%	**28.1**	95%
vent 2	H-031	3.3	**5.2**	63%	**6.8**	77%
vent 2	H-034	1.4	**1.9**	75%	**2.3**	80%
vent 2	H-035	1.7	**2.7**	62%	**3.6**	77%
vent 3	H-005	0.12	**0.4**	29%	**2.6**	16%
vent 3	H-006	ND	**ND**		**1.6**	0%
vent 3	OH-007	0.23	**0.9**	27%	**1.8**	46%
		0.35	**1.3**	28%	**2.3**	55%
vent 3	H-031	3.4	**5.5**	61%	**10.1**	55%
vent 3	H-033	0.56	**1.5**	37%	**2.2**	69%
vent 3	H-034	0.098	**0.6**	15%	**1.7**	38%
vent 3	H-035	0.57	**0.9**	61%	**2.5**	37%
vent 3	H-036	ND	**ND**		**0.7**	0%
vent 3	H-037	ND	**1.5**		**4.7**	32%
vent 3	H-038	4.7	**6.2**	76%	**7.5**	82%

Notes:

1) Total PAH concentration was calculated using detected results of 16 PAHs, viz, acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-c,d)pyrene, naphthalene, phenanthrene, and Pyrene.

2) ND: Non Detect.

3) Samples highlighted in blue are field duplicate pairs. Field duplicates for RH-033 shows particularly poor agreement, differing by more than an order of magnitude.

From the table it can be seen that the LMW PAHs represent a significant portion of the Total PAH concentration for majority of the samples, especially when the TPAH concentration is greater than 5ug/L. Across all samples, LMW PAH averages about 56 percent of Total PAH. Given the high solubility of this fraction, the dissolved phase must be considered in developing an accurate estimate of the concentration of contaminants on solids. This can be approximated using equilibrium partitioning, which describes steady state conditions but may not fully characterize the short-term non-equilibrium conditions that may occur during a storm event, as noted above. Table 6 lists the estimated particulate concentrations for the entire set of CSO samples using two approaches, one where the dissolved phase is assumed to be zero and another using equilibrium partitioning.

Table 6. PAH Concentration on Particulates

			Solids Concentration assuming no Dissolved Phase		Solids Concentration assuming Equilibrium Partitioning	
Event	CSO	TSS (mg/L)	LMW PAH (mg/kg)	TPAH (mg/kg)	LMW PAH (mg/kg)	TPAH (mg/kg)
Event 1	OH-005	46	ND			
Event 1	RH-033		46	46	2	2
		24	545	647	11	75
Event 1	RH-034	38	14	98	0	59
Event 1	RH-036	45	ND			
Event 1	RH-037	102	306	306	12	12
Event 1	RH-038	186	143	151	14	22
Event 2	RH-031	377	14	18	3	7
Event 2	RH-034	70	27	33	2	8
Event 2	RH-035	989	3	4	1	2
Event 3	OH-005	19	22	135	1	66
Event 3	OH-006	132	ND	12	ND	11
Event 3	OH-007		21	46	2	19
		40	31	57	3	25
Event 3	RH-031	56	99	180	8	67
Event 3	RH-033	66	23	33	3	9
Event 3	RH-034	54	12	31	1	16
Event 3	RH-035	126	7	20	1	11
Event 3	RH-036	18	ND	38	ND	13
Event 3	RH-037	91	17	52	2	34
Event 3	RH-038	35	177	215	5	27
		Average	**89**	**112**	**4**	**26**

Note: For the equilibrium partitioning methodology, equilibrium partitioning coefficients for individual PAHs were derived using Koc values from the Agency for Toxic Substances and Disease Registry (ATSDR) and the maximum organic carbon concentration on the CSOs

From the table it can be seen that the Total and LMW PAH particle concentrations estimated by the EPA method are consistently higher than the more realistic equilibrium-based estimates. On average, the EPA method overestimates the LMW PAH particle concentrations by 16 fold and the Total PAH concentration by more than 5 fold. From this analysis, it is clear that the EPA estimate basis is very uncertain and likely to be overly conservative. Relative to equilibrium-based estimates, EPA's methodology would significantly overestimate any risks presented by these compounds

Summary of PAH Analysis:

Given the issues with EPA's whole water sample data collection methodology, analysis, and approach to derive PAH concentration on the solids, the City believes that EPA's usage of these derived concentrations is problematic. In general, EPA's calculation methods are overly conservative for lighter PAH compounds whereas the data themselves are very poor for estimating concentrations of the more particle reactive PAH compounds. While the whole water data collected by EPA could be used to develop a preliminary assessment of the risk due to CSO water, it should not be used to derive conclusions on particulate matter.

Estimated B(a)P concentration on particulates for CSO samples with B(a)P detections are within or below the range of reference area results This analysis would indicate that CSO and background area solids have essentially the same B(a)P levels.

In conclusion, the City does not agree with EPA's assertions that the CSO data are sufficient to accurately estimate the loads of B(a)P to the Gowanus Canal and that B(a)P levels on CSO solids will of themselves represent concentrations substantively above baseline. The City asserts that the EPA methods will likely overestimate the CSO loads.

Conceptual Site Model Discussion

The City would like to restate concerns which were previously presented to EPA regarding data gaps in the Draft RI and with the CSM for the Gowanus Canal, as it is presented in the RI.

As stated in the City's May 25, 2011 letter report to EPA, the CSM (and attendant underlying data) need to be expanded and refined in the following areas:

- More Specific Characterization of Key Upland Sites and Groundwater-Surface Water Interaction: The Draft RI contains a limited discussion of the potential contamination present on the upland sites, and whether soil or groundwater contamination at these sites could be current or future sources of contamination to the Canal. The City is particularly concerned about the progress of the on- and off-site investigations at the former Fulton and Metropolitan manufactured gas plants (MGPs), as a full characterization of the location, magnitude, and extent of all coal tar emanating from these sites is an essential component of the investigation of the Canal. The same type of investigation is also merited at other key upland sites. The lack of information on these upland sites is compounded by the Draft RI's incomplete assessment of the groundwater-surface water interaction, as it does not identify specific locations of contaminant seeps or significant tidal interactions. Unless and until significant sources of upland contamination are identified (including all coal tar contamination), and the contaminant fate and transport dynamics are fully understood, there remains a high possibility that such contamination will continue and interfere with the ultimate remedy for the Canal.

- <u>Further Assessment of Non-CSO Point Sources</u>: The Draft RI contains only a limited analysis of the contaminant contribution during wet weather from the over 200 unpermitted discharge pipes located within the Canal, most of which drain from industrial properties. Additionally, the Draft RI does not adequately analyze contaminant/sediment loads associated with overland stormwater flow. Without any characterization or quantification of the contamination from these uncontrolled ongoing sources, it is unclear how contaminant loads from these sources will be addressed in the FS.

- Lack of Mechanistic Model of Contaminant Fate and Transport: Mechanistic models capable of quantifying the fate and transport of contamination from a variety of sources and in a variety of environmental media are essential for quantifying the contaminant loads associated with ongoing sources and evaluating phenomena unique to sediment sites such as the re-suspension and transport of surface sediments due to tidal or anthropogenic influences. For instance, it is essential to understand the movement of sediments from Gowanus Bay and the Upper New York Harbor into the Gowanus Canal before a remedial action can be appropriately selected and designed. Yet, the Draft RI does not rely upon, or even contain a plan to develop, a mechanistic model to assist in selecting and designing remedial strategies for the Gowanus Canal, for performing sensitivity analyses to refine remedial efforts, or for evaluating the potential for recontamination after the remedy is complete. Indeed, the Draft RI does not contain enough information to develop a mechanistic model at this time. Development of such a model is especially essential for Gowanus, as the hydrodynamics analyzed in the Draft RI will be modified when the City re-activates the flushing tunnel to improve current water quality. Considering the complexity, overall cost and importance of the remedial action on Gowanus Canal, we recommend that the FS process not be completed without first developing a mechanistic model.

Sincerely,

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