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Draft

Feasibility Study Gowanus Canal

Prepared for

U.S. Environmental Protection Agency

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Prepared by

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Executive Summary

This draft feasibility study (FS) report was prepared for the U.S. Environmental Protection Agency (USEPA) Region 2 by CH2M HILL to present the results of the feasibility analysis of remedial alternatives for the Gowanus Canal Superfund Site, in Brooklyn, Kings County, New York. This draft FS was prepared under Task Order 072 of the USEPA AES10 contract.

On March 2, 2010, USEPA placed the Gowanus Canal (USEPA ID#: NYN000206222) on its National Priorities List of hazardous waste sites requiring further evaluation. Accordingly, USEPA Region 2 performed a remedial investigation and feasibility study (RI/FS) of the canal according to the requirements of the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA, or "Superfund"), as amended. The RI was completed in January 2011 (USEPA, 2011) and the FS was initiated. The results of this FS will be used to develop a Proposed Plan for remedial action and a Record of Decision for the canal.

Feasibility Study Objectives and Scope of Work

This FS develops and evaluates remedial alternatives for Gowanus Canal sediments that will reduce or eliminate unacceptable risks to human health and the environment from exposure to contaminated sediment and surface water in the canal. The FS was prepared following USEPA's *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (USEPA, 1988) and *Contaminated Sediment Remediation Guidance for Hazardous Waste Sites* (USEPA, 2005).

Addressing contaminant contributions to the canal from upland properties, combined sewer overflows (CSOs), and other pipe outfalls is a prerequisite to a sustainable remedy for canal sediments, and as such, USEPA is seeking to reduce or eliminate these sources. The New York State Department of Environmental Conservation (NYSDEC) is addressing investigations and response actions related to the upland properties adjacent to the canal. The New York City Department of Environmental Protection (NYCDEP), through an Administrative Order on Consent[1] with NYSDEC, has begun to address CSOs. It is anticipated that additional CSO measures will be required to prevent recontamination of the canal. Discharges to the canal from unpermitted outfall structures must also be addressed. Source control measures are in the process of being developed, and these measures are included by reference as a component of all of the alternatives for contaminated sediments presented in this FS.

Remedial Action Objectives

The remedial action objectives for the Gowanus Canal are as follows:

[1] DEC Case #CO2-20000107-8 dated January 14, 2005, and updated April 14, 2008.

- Ecological
  - Reduce to acceptable levels toxicity to benthic organisms in the canal from direct contact with polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), and metals in sediment
  - Reduce to acceptable levels the risk to herbivorous birds from dietary exposure to PAHs
- Human Health
  - Reduce to acceptable levels the risk to human health from the incidental ingestion of and dermal contact with PAHs in sediment and surface water during recreational use of the canal or from exposure to canal overflow
  - Reduce the risk to human health from ingestion of PCB-contaminated fish and shellfish collected from the canal
- NAPL Mitigation
  - Prevent the migration of non-aqueous-phase liquid (NAPL) into the canal after the remedial action is completed
  - Prevent NAPL from serving as a source of contaminants to groundwater discharging to the canal

NAPL mitigation will require a combination of upland source control measures and the use of sediment remediation technologies to prevent recontamination of the canal after the remedy is implemented.

Development and Application of Preliminary Remediation Goals

Because there are no promulgated standards or criteria that apply to the cleanup of contaminated sediments in New York, preliminary remediation goals (PRGs) for sediments in the Gowanus Canal were developed based on the results of the ecological risk assessment (ERA) and human health risk assessment (HHRA) that were performed during the RI.

The comparison of PAH concentrations in sediment to PRGs shows that the entire soft-sediment column throughout the project area should be addressed in the FS. In addition, PAH concentrations in the majority of native sediment underlying the soft sediment north of the Gowanus Expressway also exceed PRGs.

Additionally, NAPL is present in native sediment north of the Gowanus Expressway to at least the maximum depth investigated in the RI (i.e., generally 6 feet below the interface between soft and native sediments). NAPL saturation was not observed in the native sediment south of the Gowanus Expressway.

Identification and Screening of Remedial Technologies

Technology screening was conducted following the technology-screening guidance described in the USEPA *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (USEPA, 1988). In addition, the technologies identified and screened are consistent with the USEPA *Contaminated Sediment Remediation Guidance for Hazardous Waste Sites* (USEPA, 2005). Potential remedial technologies and process options were screened according to the following three established criteria:

- Technical effectiveness
- Implementability
- Cost

Remedial technologies and process options that would not effectively address sediment contamination within the Gowanus Canal were eliminated. The technologies and process options that were retained from the initial screening process were carried forward for the development of remedial alternatives.

Development and Screening of Remedial Alternatives

The descriptions of the remedial alternatives in this FS are conceptual and have been developed to a level of detail sufficient for the purposes of evaluating the alternatives against the National Contingency Plan (NCP) criteria, developing cost estimates of plus 50 to minus 30 percent, and comparing the alternatives. The alternative that will eventually be selected for the site will be further developed during the remedial design process, and the specific methodologies and construction sequences utilized may change based on additional information that is gathered as part of predesign investigations.

The following alternatives were developed:

- Alternative 1: No Action
- Alternative 2
  - Dredge soft sediment to a specified elevation
  - Cap with isolation layer and armor layer
- Alternative 3
  - Dredge soft sediment to a specified elevation
  - Cap with treatment layer, isolation layer, and armor layer
- Alternative 4
  - Dredge entire soft sediment column
  - Cap with isolation layer and armor layer
- Alternative 5
  - Dredge entire soft sediment column
  - Cap with treatment layer, isolation layer, and armor layer
- Alternative 6
  - Dredge entire soft sediment column
  - Solidify top 3-5 feet of native sediment in targeted areas
  - Cap with isolation layer and armor layer
- Alternative 7
  - Dredge entire soft sediment column
  - Solidify top 3-5 feet of native sediment in targeted areas
  - Cap with treatment layer, isolation layer, and armor layer

The following treatment and disposal options for dredged sediments were also identified:

- Option A: Offsite thermal desorption and beneficial use
- Option B: Offsite disposal (landfill)
- Option C: Offsite cogeneration and beneficial use
- Option D: Offsite stabilization and offsite beneficial use
- Option E: Onsite stabilization and onsite beneficial use
- Option F: Offsite stabilization and placement in onsite constructed confined disposal facility (CDF)
- Option G: Onsite stabilization and placement in onsite constructed CDF

Alternatives 2 through 7 include bulkhead stabilization throughout the entire canal and the removal of some native sediment in remediation target area (RTA) 2 to accommodate a cap and maintain the depths required for navigation. An alternative including partial removal of soft sediment in RTA 2 was not considered due to the high degree of NAPL contamination throughout the soft sediment in that area of the canal. It is anticipated that the remedial action in the canal will be performed using a phased approach, with the upper and middle reaches of the canal (RTA 1 and RTA 2) remediated first.

In order for any of the proposed remedial alternatives to be effective, upland sources of contamination—including discharges from CSOs, from the former MGP sites and other contaminated sites along the canal, and from the unpermitted pipes along the canal—must be controlled. These upland source controls need to be coordinated and implemented in concert with the selected sediment remedy to prevent recontamination of the canal following remedy implementation. All of the alternatives in this FS rely upon the successful implementation of these controls; therefore, they are included as the first component of all alternatives. The source control measures that will be developed are included by reference in this FS.

Emerging sediment remediation technologies may be evaluated during the remedial design and may be incorporated into the selected remedy, if determined to be effective and implementable during bench testing or pilot studies. In situ stabilization (ISS) is one such technology that may be further examined. If additional analyses and testing indicate that it would be implementable and effective within the canal, this technology may be integrated into the selected alternative. ISS may be considered for areas where NAPL-impacted native sediment is exposed after dredging. If determined to be implementable and effective, this technology could be applied to further reduce the potential for NAPL migration from the native sediment to the canal.

Potential alternatives were screened first with respect to effectiveness, implementability, and cost to reduce the number of alternatives to be analyzed in detail. On the basis of that screening evaluation, Alternatives 1, 5, and 7 were retained for further development and detailed evaluation.

Evaluation of Remedial Alternatives

The NCP defines nine criteria, classified as threshold, balancing, or modifying, to be used for the detailed analysis of remedial alternatives. The remedial alternatives were evaluated against the first seven of nine criteria:

- Threshold criteria
  - Overall protection of human health and the environment
  - Compliance with applicable or relevant and appropriate requirements
- Balancing criteria
  - Long-term effectiveness and permanence
  - Reduction of toxicity, mobility, or volume through treatment
  - Short-term effectiveness
  - Implementability
  - Cost

The two modifying criteria – public and state acceptance – are used later in the process to evaluate the proposed remedy. In addition to the NCP criteria, the alternatives were qualitatively evaluated with respect to sustainability and green remediation metrics.

The detailed analysis was performed using a two-step process. During the first step, each alternative was evaluated individually against the NCP criteria and the sustainability/green remediation metrics. In the second step, a comparative analysis was performed using the same criteria to identify key differences between alternatives. Tables ES-1a through ES-1c and ES-2a through ES-2c present the results of the individual and comparative evaluation of the alternatives for each RTA, respectively.

Remedial Design Considerations

The evaluations performed in this FS have identified a number of elements that may require further consideration during the remedial design. The surveys, evaluations, and analyses listed below are not prescriptive or inclusive but simply summarize possible data collection activities identified during the development and analysis of alternatives.

- Development of a groundwater model for the entire project area
- Additional data collection and analysis to determine NAPL seepage rates
- Additional evaluation of ISS or other developing technologies that could increase the overall protection and permanence of the remedy
- Additional evaluation and analysis of the sustainability impacts of the selected remedy
- Other data collection activities and surveys such as a bulkhead stability evaluation, bathymetric and sediment-probing surveys to refine volumes and establish baseline conditions prior to remedial action, and sediment chemistry surveys to establish baseline, or preremedy, conditions
- Additional bench-scale testing to support disposal options
- Hydrodynamic modeling to support cap design

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TABLE ES-1a
Detailed Evaluation of Alternatives – RTA 1
Gowanus Canal Feasibility Study
Brooklyn, New York

Criteria	Alternative 1: No Action	Alternative 5: Dredge Entire Column of Soft Sediment Cap with Treatment Layer, Sand-and-Gravel Layer, Armor Layer	Alternative 7: Dredge Entire Column of Soft Sediment Solidify Top 3–5 Feet of Native Sediment in Targeted Areas Cap with Treatment Layer, Sand-and-Gravel Layer, Armor Layer
Threshold Criteria			
Overall protection of human health and the environment	Alternative will not provide protection of human health and the environment. • RAOs would not be achieved • Human health and ecological risks associated with contaminated sediment would not be reduced or eliminated. • NAPL migration to the water column would continue. • Contaminant concentrations in other media (e.g. surface water) would not be reduced.	Alternative will provide protection of human health and the environment. • RAOs would be achieved upon completion of the remedy, which is estimated to be approximately 5 years after the start of construction. • Removal of soft sediment and capping of native sediment would reduce and control long-term risks associated with contaminated sediment. Placement of a cap would: o Control risks associated with remaining sediment by preventing exposure. o Reduce and control toxicity to benthic organisms and eliminate risks to herbivorous birds. o Control risks to human health via direct contact and incidental ingestion. o Prevent NAPL migration from sediment to the water column. • Surface water quality would be improved by preventing contact between surface water and sediment; sheens would be controlled or eliminated.	Alternative would provide protection of human health and the environment. Application of ISS in targeted areas is expected to provide additional protectiveness against NAPL migration from sediment.
Compliance with ARARs	• ARARs are not applicable because no remedial action is taken.	Alternative can be designed to comply with substantive requirements of the ARARs.	Same as Alternative 5.
Balancing Criteria			
Long-term effectiveness and permanence	**Low** - Alternative would not result in any significant change in the risks associated with contaminated sediment.	Alternative would provide a **high** level of long-term effectiveness and permanence: • Alternative would meet RAOs. • Alternative would result in significant, permanent risk reduction due to soft sediment removal. • The sediment cap would provide long-term control of the risks associated with the native sediment remaining in the canal, provided that appropriate long-term monitoring and maintenance plans are implemented. • Long-term effectiveness of disposal options are: o High for Options A, B, and C because material is transferred offsite and treated or contained in a managed landfill. o Low to moderate for Options D and E. ▪ The long-term effectiveness will depend on the actual beneficial use and the conditions to which the stabilized sediment will be exposed. A greater degree of effectiveness would be expected from a use where the material is relatively contained and not subjected to significant water fluctuations or freeze/thaw cycles. ▪ Stabilization would be performed to a degree such that the sediment associated contaminants would be bound within the matrix and the stabilized sediment would remain onsite under Option E. ▪ The stabilized sediment would need to meet the end-use performance criteria. ▪ Permanent institutional controls and long-term monitoring would be needed under Option E.	Alternative would provide a **high** level of long-term effectiveness and permanence. • Same as Alternative 5, except that targeted ISS would provide additional long-term control of the NAPL migration in the canal.
Magnitude and type of residual risk		This evaluation is focused on the magnitude and management of residual risks associated with sediment remaining onsite (i.e., sediment that is stabilized and beneficially used onsite and contaminated sediment remaining in the canal following remedy implementation). Sediment treated and disposed at offsite facilities are not included in this discussion because it would be removed from the site. • Sediment removal and capping would: o Alleviate the risks associated with the sediments removed from the canal. o Reduce the risks associated with contaminated native sediments that remain in the canal by capping. o Provide long-term control of risks associated with sediment remaining in the canal. Adsorptive caps to control NAPL migration can be designed for a set life expectancy where NAPL migration rates are known (see Appendix A for additional discussion). Additional data collection and evaluation to determine site-specific NAPL seepage rates will be required during remedial design to determine the appropriate cap design (i.e., granular oleophilic clay layer thickness). • Residual risks associated with disposal Option E (onsite stabilization and onsite beneficial use) would be as follows: o Treatment residuals would consist of stabilized sediment, which would significantly reduce the mobility of sediment contaminants and reduce the associated risks. o Onsite beneficial use of the stabilized material will require identifying a beneficial use and will also require the stabilized material to meet leachability specifications and strength specifications appropriate to the identified use. o The ability of the stabilized sediment to meet performance criteria will depend upon the designated end use of the material, and further testing is required for these disposal options.	Same as Alternative 5, with the addition that the implementation of ISS would be expected to further reduce risk of NAPL migration, if proven to be effective and implementable during pilot and treatability testing.

TABLE ES-1a
Detailed Evaluation of Alternatives – RTA 1
Gowanus Canal Feasibility Study
Brooklyn, New York

Criteria	Alternative 1: No Action	Alternative 5: Dredge Entire Column of Soft Sediment Cap with Treatment Layer, Sand-and-Gravel Layer, Armor Layer	Alternative 7: Dredge Entire Column of Soft Sediment Solidify Top 3–5 Feet of Native Sediment in Targeted Areas Cap with Treatment Layer, Sand-and-Gravel Layer, Armor Layer
		o The FS assumes that the end use would be such that direct human and ecological contact with the stabilized sediment would be limited. o The level of residual risk would be considered low to moderate for this alternative because treatment does not destroy the contaminants and the treated material would remain onsite. o Remedy can be designed so that the sediments stabilized and beneficially used are those with fewer NAPL impacts.	
Adequacy and reliability of controls		• Dredging o Mechanical dredging is an established technology and would meet the performance specifications for the removal component of the alternative. o Bathymetric surveys would be conducted to confirm target removal depths and samples would be collected on a defined grid to confirm sediment cap layer thicknesses. • Capping o Capping is an established technology and can be designed to meet the performance specifications of the alternative, provided that effective source controls have been implemented and the cap is constructed and maintained in accordance with the design specifications established for long-term isolation of the contaminated sediments. As noted above, additional data collection and evaluation are required to finalize the cap design. o Long-term monitoring and periodic maintenance would be required to assure cap integrity. o The O&M plan developed during the remedial design would determine the monitoring and maintenance frequencies required to assure and maintain cap integrity based on site-specific factors. o Physical (e.g., bathymetric) surveys and the collection of samples on a defined grid would be needed to assess cap layer thickness, cap performance and integrity, contaminant movement, and/or recontamination concerns. Samples for chemical analysis should also be collected at regular predetermined intervals. o The long-term monitoring plan should also specify monitoring requirements after severe storm events to assess cap integrity. o Cap repairs would be performed as needed. o Component failures (i.e., sediment cap failure) could potentially result in sheens on the water surface and limited exposure to ecological or human receptors; however, catastrophic failure of the cap is unlikely if appropriate long-term O&M plans are implemented. • Disposal o Disposal Options A (thermal treatment), and C (co-generation) would be expected to meet required performance specifications following treatability and pilot testing. o Option B (offsite landfill) is an established means of disposal. o Disposal Options D (offsite stabilization and offsite beneficial use) and E (onsite stabilization and beneficial use) require identifying a beneficial use and also require the stabilized material to meet leachability specifications, as well as strength specifications appropriate to the identified use. The ability of the stabilized sediment to meet performance criteria will depend upon the designated end use of the material and further testing is required for these disposal options. The FS assumes that the end use would be such that direct contact human and ecological contact with the stabilized sediment would be limited. o Additional O&M beyond that associated with the sediment cap would be required for Options A, B, C, or D. Long-term monitoring would be required for Option E (onsite stabilization and beneficial use). o Permanent institutional controls would also be required for Option E. The institutional controls would specify appropriate measures for digging within the fill material, and long-term monitoring would be applied to review their sustained application. The institutional controls may need to be applied to one or more properties, depending on where the material is used. Depending on the number of properties and the location where the fill is placed, significant effort and coordination may be needed to ensure successful implementation and enforcement of these controls.	Same as Alternative 5, with the addition that if additional evaluations and pilot studies indicate that in situ solidification (ISS) is implementable and effective within the canal, targeted areas of NAPL-saturated native sediment would be treated with ISS to further reduce the potential for NAPL migration. The conceptual cap specifications have been designed to be protective without the use of ISS; however, if ISS is determined to be viable for the Gowanus Canal, then its application would be expected to provide additional protection and support the long-term effectiveness of the selected remedy.
Reduction of toxicity, mobility, or volume through treatment	**Low** Alternative does not include a treatment component and does not meet the statutory preference for treatment as a principal element of a remedy.	The overall reduction of NAPL mobility by the oleophilic cap is expected to be **high.** The reduction of toxicity, mobility, or volume (TMV) of the dredged sediment by treatment ranges from **moderate to high** depending on the disposal option. Alternative 5 is considered to have **high** overall reduction of TMV based on the volume of sediment removed from the canal.	Same as Alternative 5, with the addition that the implementation of ISS would be expected to further reduce NAPL mobility, if ISS is proven to be effective and implementable during pilot and treatability testing.

TABLE ES-1a
Detailed Evaluation of Alternatives – RTA 1
Gowanus Canal Feasibility Study
Brooklyn, New York

Criteria	Alternative 1: No Action	Alternative 5: Dredge Entire Column of Soft Sediment Cap with Treatment Layer, Sand-and-Gravel Layer, Armor Layer	Alternative 7: Dredge Entire Column of Soft Sediment Solidify Top 3–5 Feet of Native Sediment in Targeted Areas Cap with Treatment Layer, Sand-and-Gravel Layer, Armor Layer
Reduction in toxicity, mobility, or volume (TMV)		• Dredging does not reduce toxicity, mobility or volume through treatment. • The granular oleophilic clay cap component of the alternative will reduce the mobility of NAPL and is considered a treatment technology. • The reduction of TMV of the dredged sediment is summarized below. Thermal treatment (Option A) and cogeneration (thermal destruction, Option C) meet the statutory preference for treatment as a principal element. The relative reductions of TMV of the disposal/beneficial use options are: o Option A (thermal treatment): **High** reduction of TMV. Dredged sediments would be treated using thermal desorption. The TMV associated with the organic contaminants would be significantly reduced. o Option B (offsite landfill): **Moderate** reduction of TMV. Dredged sediments would be stabilized prior to transfer to a landfill. Volume and toxicity would not be affected, but contaminant mobility would be reduced by placing the material in a controlled environment. Overall TMV would be transferred to the offsite disposal facility. o Option C (co-generation): **High** reduction of TMV. Organic contaminants would be destroyed through treatment. The overall ranking of this disposal option is **high**. o Option D (offsite stabilization and offsite beneficial use): **Moderate** reduction of TMV. Dredged sediments would be stabilized prior to transfer to offsite beneficial use location. Volume and toxicity would not be affected, but contaminant mobility would be reduced. Overall TMV would be transferred to the offsite location. o Option E (onsite stabilization and onsite beneficial use): **Moderate** reduction of TMV. Dredged sediments would be stabilized prior to placement in onsite beneficial use location. Volume and toxicity would not be affected, but contaminant mobility would be reduced. Overall TMV would remain onsite.	Same as Alternative 5, except that the overall reduction in NAPL mobility is anticipated to be greater with the addition of ISS in targeted areas of the canal.
Irreversibility		• Sorption in the oleophilic clay cap is irreversible, but once the cap is saturated, it will not be able to absorb more NAPL. • Solidification and stabilization are considered irreversible if the stabilized material is placed into a controlled environment. • Thermal treatment (Option A), thermal destruction (Option C), and the stabilization component of Option B is irreversible. The degree of irreversibility of stabilization associated with Options D and E will depend upon the selected beneficial use and the conditions to which the stabilized material is exposed.	Same as Alternative 5, with the addition that ISS is also an irreversible process.
Type and quantity of treatment residuals and associated risks		The type and quantity of residuals and the associated magnitude and management of risks is dependent upon the disposal option, as follows: • Option A (thermal treatment): o Residuals would consist of treated sediment. o Treated sediment would be beneficially used (e.g., daily cover at landfills). o Level of residual risk associated with this option is **low** since contaminants would be desorbed and destroyed in an afterburner. • Option B (offsite landfill): o Would not result in treatment residuals. o Stabilized sediment would be disposed in a landfill. o Residual risk associated with this option is **low** because material is disposed in a controlled offsite facility. • Option C (co-generation): o Residuals would consist of treated sediment. o Treated sediment would be beneficially used (e.g., daily cover at landfills). o The level of residual risk associated with this option is **low** since organic contaminants would be destroyed. • Options D (offsite stabilization and offsite beneficial use) and E (onsite stabilization and onsite beneficial use): o Stabilized sediment would be beneficially used either offsite (Option D) or onsite (Option E). o The level of residual risk would be considered **low to moderate** because treatment stabilizes but does not destroy the contaminants. The contaminant mobility would be significantly reduced, and the treated material would be beneficially used. The residual risk for Option D is lower because the material would be transferred offsite. • Sediment treated by thermal treatment (Option A) and co-generation (Option C) may contain concentrated levels of inorganic constituents, which may limit the beneficial use of the material.	Same as Alternative 5.
Short-term effectiveness	High; no actions are taken under this alternative.	The short-term effectiveness of this alternative is **moderate** due to construction duration and the potential risks and environmental impacts described below. • Short-term effectiveness of all disposal options is considered moderate to high.	Same as Alternative 5.

TABLE ES-1a
Detailed Evaluation of Alternatives – RTA 1
Gowanus Canal Feasibility Study
Brooklyn, New York

Criteria	Alternative 1: No Action	Alternative 5: Dredge Entire Column of Soft Sediment Cap with Treatment Layer, Sand-and-Gravel Layer, Armor Layer	Alternative 7: Dredge Entire Column of Soft Sediment Solidify Top 3–5 Feet of Native Sediment in Targeted Areas Cap with Treatment Layer, Sand-and-Gravel Layer, Armor Layer
Risks to community, workers, and the associated controls		• Potential risks to the community would include noise and vibrations during bulkhead replacement and increased levels of traffic, dust, noise, and odors during the dredging and handling of contaminated sediment. Engineering controls and best management practices can mitigate most potential risks: o Access to the active work and support zones would be prohibited. o Notification of schedule for bulkhead repair and remedy implementation would be provided to the property owners and tenants. o Dust and noise levels would be monitored. o Work periods may be restricted to specific timeframes for especially noisy operations (e.g., sheet pile installation). o Traffic effects can be managed by performing work in canal from barges and using water transport to move materials to and from the canal. o Staging areas would need to be established in areas zoned for industrial use. o Odors are expected during dredging and may not be able to be fully controlled. • Potential risks to workers would include physical hazards associated with general construction, potential exposure to and direct contact with dredged sediment and NAPL, noise, odors, dust, and vapors. These would be mitigated through: o Engineering controls and best management practices. o Compliance with appropriate health and safety plans and site management plans. o Use of appropriate personal protective equipment.	Same as Alternative 5. Implementation of ISS would likely be restricted to specific timeframes. Potential exposure risks from ISS would be mitigated as described under Alternative 5.
Environmental Impacts of Remedy and Controls		• Short-term environmental effects during implementation may include potential NAPL releases to surface water, turbidity increases within the canal, and releases of some sediment-associated contamination. Example control measures to mitigate these impacts include the following: o Dredge cells would contain suspended sediments (turbidity and sediment associated contaminants) and NAPL releases that result from the dredging process. Water within the dredge cells would be removed and treated before the sheet piles are removed. o The duration of these releases would be very short and would only occur during construction.	Same as Alternative 5, with the addition that ISS would be performed within the dredge cells to contain potential NAPL and turbidity releases.
Duration of short-term risks		• The duration of the short-term risks would be the time required for construction, which is estimated to be approximately 5 years.	Same as Alternative 5.
Implementability	Not applicable; no actions are taken under this alternative.	The overall implementability this alternative is **moderate.** The implementability of the disposal options is variable.	Same as Alternative 5 for dredging, capping, and disposal options. Implementability of ISS is likely to be more limited since this technology is not yet commercially proven for application to marine environments for the control of NAPL migration.
Technical feasibility		• Alternative is technically implementable and dredging and capping are established, field-proven technologies; however, pilot testing may be required to determine the most suitable cap placement methods based on the site-specific sediment characteristics. • Dredging and capping would be performed from barges using standard construction equipment. • The potential interference from debris within the canal will need to be considered during design. • Bulkhead repair and replacement will require property-specific designs, and construction must be planned and proceed and be coordinated carefully to minimize / prevent effects on the adjacent, upland properties. • The short- and long-term monitoring requirements can be performed using standard practices and technologies. • Implementability and feasibility of additional actions would be limited if penetration of the cap is required.	Same as Alternative 5 for dredging and capping aspects. Treatability studies and pilot testing will be required during remedial design to determine the stabilization reagents and dosages, delivery mechanism, and overall technical feasibility of ISS.
Administrative feasibility		• Alternative will require coordination between regulatory agencies (USEPA, USACE, NYSDEC, and NYCDEP), PRPs, property owners along the canal, and other stakeholders. • Bulkhead repair and replacement will require coordination with property owners and tenants. Due to the number of different properties and type of bulkheads affected, this effort will be considerable. • Implementation of disposal Option E (onsite stabilization and onsite beneficial use) is dependent upon stakeholder acceptability and effective implementation of institutional controls. This disposal option may be challenging to implement due to stakeholder acceptance. • Permanent institutional controls would also be required for disposal Option E. Depending on the number of properties and the location where the fill is placed, significant effort and coordination may be needed to ensure successful implementation and enforcement of these controls. The difficulties associated with implementation of institutional controls are also further discussed in Section 4.6.3.	Same as Alternative 5.

TABLE ES-1a
Detailed Evaluation of Alternatives – RTA 1
Gowanus Canal Feasibility Study
Brooklyn, New York

Criteria	Alternative 1: No Action	Alternative 5: Dredge Entire Column of Soft Sediment Cap with Treatment Layer, Sand-and-Gravel Layer, Armor Layer	Alternative 7: Dredge Entire Column of Soft Sediment Solidify Top 3–5 Feet of Native Sediment in Targeted Areas Cap with Treatment Layer, Sand-and-Gravel Layer, Armor Layer
Availability of services and materials		• Equipment and specialists required for the sheet piling installation, dredging, and capping would be commercially available. • The volume of capping materials required is large and procuring large quantities of specialty materials, such as the oleophilic clay, will require significant advance coordination and possibly use of multiple vendors. • Available thermal treatment and co-generation facilities (Options A and C, respectively) are also limited within the geography, which may restrict the ability to competitively bid these services. • Landfill capacity for contaminated river sediments within the geography may be limited. Landfill availability will influence the implementability of disposal Option B (offsite landfill) within the region. Available landfill facilities and associated capacities will need to be identified during the remedy selection process. Facilities outside the region could be used; however, transportation costs would increase. • Onsite and offsite beneficial uses of stabilized sediment would need to be identified. In order for Options D and E to be implemented, an end use would need to be determined and treatability testing would need to be performed to evaluate the stabilization agents and dosing required and to assess whether the treated material would meet all the end-use requirements (e.g., leachability and strength characteristics). • Treatability testing will be needed to determine if available thermal treatment and co-generation facilities can accept solidified/stabilized sediment and to determine the final waste characterization.	Same as Alternative 5 for dredging, capping, and disposal components. ISS is an emerging technology, and there are few contractors with a proven performance of ISS implementation in marine environments.
Cost ($Million)[1]	0	Option A: 45 Option B: 47 Option C: 52 Option D: 45 Option E: 38	Option A: 48 Option B: 50 Option C: 55 Option D: 48 Option E: 41

Notes:
[1] Total present worth cost; cost does not include O&M or base implementation cost. Values presented include cost of dredging, capping, ISS (Alternative 7 only), and disposal. See Table 4-7 for additional cost detail for each alternative and associated disposal options. Further, source control measures will be needed to ensure that the sediment remedy achieves the RAOs and is sustainable. Source control is the first component of all alternatives except No Action. Source control measures are in the process of being developed; therefore, the costs are not included in this FS. The source control measures are included by reference in this FS.

ARAR – applicable or relevant and appropriate requirement
CDF – confined disposal facility
ISS – in-situ solidification
NAPL – non aqueous phase liquid
NYCDEP – New York City Department of Environmental Protection
NYSDEC – New York State Department of Environmental Conservation
O&M – operations and maintenance
PRP – potentially responsible party
RAO – remedial action objective
RTA – remediation target area
TMV – toxicity, mobility, or volume
USACE – United States Army Corps of Engineers
USEPA – United States Environmental Protection Agency

TABLE ES-1b
Detailed Evaluation of Alternatives – RTA 2
Gowanus Canal Feasibility Study
Brooklyn, New York

Criteria	Alternative 1: No Action	Alternative 5: Dredge Entire Column of Soft Sediment Cap with Treatment Layer, Sand-and-Gravel Layer, Armor Layer	Alternative 7: Dredge Entire Column of Soft Sediment Solidify Top 3–5 Feet of Native Sediment in Targeted Areas Cap with Treatment Layer, Sand-and-Gravel Layer, Armor Layer
Threshold Criteria			
Overall protection of human health and the environment	Alternative will not provide protection of human health and the environment. • RAOs would not be achieved • Human health and ecological risks associated with contaminated sediment would not be reduced or eliminated. • NAPL migration to the water column would continue. • Contaminant concentrations in other media (e.g. surface water) would not be reduced.	Alternative will provide protection of human health and the environment. • RAOs would be achieved upon completion of the remedy, which is estimated to be approximately 5 years after the start of construction. • Removal of soft sediment and capping of native sediment would reduce and control long-term risks associated with contaminated sediment. Placement of a cap would: ○ Control risks associated with remaining sediment by preventing exposure. ○ Reduce and control toxicity to benthic organisms and eliminate risks to herbivorous birds. ○ Control risks to human health via direct contact and incidental ingestion. ○ Prevent NAPL migration from sediment to the water column. • Surface water quality would be improved by preventing contact between surface water and sediment; sheens would be controlled or eliminated.	Alternative would provide protection of human health and the environment. Application of ISS in targeted areas is expected to provide additional protectiveness against NAPL migration from sediment.
Compliance with ARARs	• ARARs are not applicable because no remedial action is taken.	Alternative can be designed to comply with substantive requirements of the ARARs.	Same as Alternative 5.
Balancing Criteria			
Long-term effectiveness and permanence	**Low** - Alternative would not result in any significant change in the risks associated with contaminated sediment.	Alternative would provide a **high** level of long-term effectiveness and permanence: • Alternative would meet RAOs. • Alternative would result in significant, permanent risk reduction due to soft sediment removal. • The sediment cap would provide long-term control of the risks associated with the native sediment remaining in the canal, provided that appropriate long-term monitoring and maintenance plans are implemented. • Long-term effectiveness of disposal options are: ○ High for Options A, B, and C because material is transferred offsite and treated or contained in a managed landfill.	Alternative would provide a **high** level of long-term effectiveness and permanence. • Same as Alternative 5, with the exception that targeted ISS would provide additional long-term control of the NAPL migration in the canal.
Magnitude and type of residual risk		This evaluation is focused on the magnitude and management of residual risks associated with sediment remaining onsite (i.e., sediment that is stabilized and beneficially used onsite and contaminated sediment remaining in the canal following remedy implementation). Sediment treated and disposed at offsite facilities are not included in this discussion because it would be removed from the site. • Sediment removal and capping would: ○ Alleviate the risks associated with the sediments removed from the canal. ○ Reduce the risks associated with contaminated native sediments that remain in the canal by capping. • Provide long-term control of risks associated with sediment remaining in the canal. Adsorptive caps to control NAPL migration can be designed for a set life expectancy where NAPL migration rates are known (see Appendix A for additional discussion). Additional data collection and evaluation to determine site-specific NAPL seepage rates will be required during remedial design to determine the appropriate cap design (i.e., granular oleophilic clay layer thickness).There are no residual risks associated with the three disposal options considered for RTA 2, because all sediment would be transferred offsite.	Same as Alternative 5, with the addition that the implementation of ISS would be expected to further reduce the risk of NAPL migration, if proven to be effective and implementable during pilot and treatability testing.
Adequacy and reliability of controls		• Dredging ○ Mechanical dredging is an established technology and would meet the performance specifications for the removal component of the alternative. ○ Bathymetric surveys would be conducted to confirm target removal depths and samples would be collected on a defined grid to confirm sediment cap layer thicknesses. • Capping ○ Capping is an established technology and can be designed to meet the performance specifications of the alternative, provided that effective source controls have been implemented and the cap is constructed and maintained in accordance with the design specifications established for long-term isolation of the contaminated sediments. As noted above, additional data collection and evaluation are required to finalize the cap design. ○ Long-term monitoring and periodic maintenance would be required to assure cap integrity.	Same as Alternative 5, with the addition that if additional evaluations and pilot studies indicate that in situ solidification (ISS) is implementable and effective within the canal, targeted areas of NAPL-saturated native sediment would be treated with ISS to further reduce the potential for NAPL migration. The conceptual cap specifications have been designed to be protective without the use of ISS; however, if ISS is determined to be viable for the Gowanus Canal, then its application would be expected to provide additional protection and support the long-term effectiveness of the selected remedy.

TABLE ES-1b
Detailed Evaluation of Alternatives – RTA 2
Gowanus Canal Feasibility Study
Brooklyn, New York

Criteria	Alternative 1: No Action	Alternative 5: Dredge Entire Column of Soft Sediment Cap with Treatment Layer, Sand-and-Gravel Layer, Armor Layer	Alternative 7: Dredge Entire Column of Soft Sediment Solidify Top 3–5 Feet of Native Sediment in Targeted Areas Cap with Treatment Layer, Sand-and-Gravel Layer, Armor Layer
		○ The O&M plan developed during the remedial design would determine the monitoring and maintenance frequencies required to assure and maintain cap integrity based on site-specific factors. ○ Physical (e.g., bathymetric) surveys and the collection of samples on a defined grid would be needed to assess cap layer thickness, cap performance and integrity, contaminant movement, and/or recontamination concerns. Samples for chemical analysis should also be collected at regular predetermined intervals. ○ The long-term monitoring plan should also specify monitoring requirements after severe storm events to assess cap integrity. ○ Cap repairs would be performed as needed. ○ Component failures (i.e., sediment cap failure) could potentially result in sheens on the water surface and limited exposure to ecological or human receptors; however, catastrophic failure of the cap is unlikely if appropriate long-term O&M plans are implemented. • Disposal ○ Disposal Options A (thermal treatment) and C (co-generation) would be expected to meet required performance specifications following treatability and pilot testing. ○ Option B (offsite landfill) is an established means of disposal. ○ Additional O&M beyond that associated with the sediment cap would not be required for the disposal and treatment options evaluated for RTA 2.	
Reduction of toxicity, mobility, or volume through treatment	**Low** Alternative does not include a treatment component and does not meet the statutory preference for treatment as a principal element of a remedy.	The overall reduction of NAPL mobility by the oleophilic cap is expected to be **high.** The reduction of toxicity, mobility, or volume (TMV) of the dredged sediment by treatment ranges from **moderate to high** depending on the disposal option. Alternative 5 is considered to have **high** overall reduction of TMV based on the volume of sediment removed from the canal.	Same as Alternative 5, with the addition that the implementation of ISS would be expected to further reduce NAPL mobility, if proven to be effective and implementable during pilot and treatability testing.
Reduction in toxicity, mobility, or volume (TMV)		• Dredging does not reduce toxicity, mobility or volume through treatment. • The granular oleophilic clay cap component of the alternative will reduce the mobility of NAPL and is considered a treatment technology. • The reduction of TMV of the dredged sediment is summarized below. Thermal treatment (Option A) and cogeneration (thermal destruction, Option C) meet the statutory preference for treatment as a principal element. The relative reductions of TMV of the disposal/beneficial use options are: ○ Option A (thermal treatment): **High** reduction of TMV. Dredged sediments would be treated using thermal desorption. The TMV associated with the organic contaminants would be significantly reduced or alleviated. ○ Option B (offsite landfill): **Moderate** reduction of TMV. Dredged sediments would be stabilized prior to transfer to a landfill. Volume and toxicity would not be affected, but contaminant mobility would be reduced by placing the material in a controlled environment. Overall TMV would be transferred to the offsite disposal facility. ○ Option C (co-generation): **High** reduction of TMV. Organic contaminants would be destroyed through treatment. The overall ranking of this disposal option is **high**.	Same as Alternative 5, except that the overall reduction in NAPL mobility is anticipated to be greater with the addition of ISS in targeted areas of the canal.
Irreversibility		• Sorption in the oleophilic clay cap is irreversible, but once the cap is saturated, it will not be able to absorb more NAPL. • Solidification and stabilization are considered irreversible if the stabilized material is placed into a controlled environment. • Thermal treatment (Option A), thermal destruction (Option C), and the stabilization component of Option B are irreversible.	Same as Alternative 5, with the addition that ISS is also an irreversible process.
Type and quantity of treatment residuals and associated risks		The type and quantity of residuals and the associated magnitude and management of risks is dependent upon the disposal option, as follows: • Option A (thermal treatment): ○ Residuals would consist of treated sediment. ○ Treated sediment would be beneficially used (e.g., daily cover at landfills). ○ Level of residual risk associated with this option is **low** since contaminants would be desorbed and destroyed in an afterburner. • Option B (offsite landfill): ○ Would not result in treatment residuals. ○ Stabilized sediment would be disposed in a landfill. ○ Residual risk associated with this option is **low** because material is disposed in a controlled offsite facility.	Same as Alternative 5.

TABLE ES-1b
Detailed Evaluation of Alternatives – RTA 2
Gowanus Canal Feasibility Study
Brooklyn, New York

Criteria	Alternative 1: No Action	Alternative 5: Dredge Entire Column of Soft Sediment Cap with Treatment Layer, Sand-and-Gravel Layer, Armor Layer	Alternative 7: Dredge Entire Column of Soft Sediment Solidify Top 3–5 Feet of Native Sediment in Targeted Areas Cap with Treatment Layer, Sand-and-Gravel Layer, Armor Layer
		• Option C (co-generation): ○ Residuals would consist of treated sediment. ○ Treated sediment would be beneficially used (e.g., daily cover at landfills). ○ The level of residual risk associated with this option is **low** since organic contaminants would be destroyed. • Sediment treated by thermal treatment (Option A) and co-generation (Option C) may contain concentrated levels of inorganic constituents, which may limit the beneficial use of the material.	
Short-term effectiveness	High; no actions are taken under this alternative.	The short-term effectiveness of this alternative is **moderate** due to construction duration and the potential risks and environmental impacts described below. • Short-term effectiveness of all disposal options is considered moderate to high.	Same as Alternative 5.
Risks to community, workers, and the associated controls		• Potential risks to the community would include noise and vibrations during bulkhead replacement and increased levels of traffic, dust, noise, and odors during the dredging and handling of contaminated sediment. Engineering controls and best management practices can mitigate most potential risks: ○ Access to the active work and support zones would be prohibited. ○ Notification of schedule for bulkhead repair and remedy implementation would be provided to the property owners and tenants. ○ Dust and noise levels would be monitored. ○ Work periods may be restricted to specific timeframes for especially noisy operations (e.g., sheet pile installation). ○ Traffic effects can be managed by performing work in canal from barges and using water transport to move materials to and from the canal. ○ Staging areas would need to be established in areas zoned for industrial use. ○ Odors are expected during dredging and may not be able to be fully controlled. • Potential risks to workers would include physical hazards associated with general construction, potential exposure to and direct contact with dredged sediment and NAPL, noise, odors, dust, and vapors. These would be mitigated through: ○ Engineering controls and best management practices. ○ Compliance with appropriate health and safety plans and site management plans. ○ Use of appropriate personal protective equipment.	Same as Alternative 5. Implementation of ISS would likely be restricted to specific timeframes. Potential exposure risks from ISS would be mitigated as described under Alternative 5.
Environmental Impacts of Remedy and Controls		• Short-term environmental effects during implementation may include potential NAPL releases to surface water, turbidity increases within the canal, and releases of some sediment-associated contamination. Example control measures to mitigate these impacts include the following: ○ Dredge cells would contain suspended sediments (turbidity and sediment associated contaminants) and NAPL releases that result from the dredging process. Water within the dredge cells would be removed and treated before the sheet piles are removed. ○ The duration of these releases would be very short and would only occur during construction.	Same as Alternative 5, with the addition that ISS would be performed within the dredge cells to contain potential NAPL and turbidity releases.
Duration of short-term risks		• The duration of the short-term risks would be the time required for construction, which is estimated to be approximately 5 years.	Same as Alternative 5.
Implementability	Not applicable; no actions are taken under this alternative.	The overall implementability this alternative is **moderate.** The implementability of the disposal options is variable.	Same as Alternative 5 for dredging, capping, and disposal options. Implementability of ISS is likely to be more limited since this technology is not yet commercially proven for application to marine environments for the control of NAPL migration.
Technical feasibility		• Alternative is technically implementable and dredging and capping are established, field-proven technologies; however, pilot testing may be required to determine the most suitable cap placement methods based on the site-specific sediment characteristics. • Dredging and capping would be performed from barges using standard construction equipment. • The potential interference from debris within the canal will need to be considered during design. • Bulkhead repair and replacement will require property-specific designs, and construction must be planned and proceed and be coordinated carefully to minimize / prevent effects on the adjacent, upland properties. • The short- and long-term monitoring requirements can be performed using standard practices and technologies. • Implementability and feasibility of additional actions would be limited if penetration of the cap is required.	Same as Alternative 5 for dredging and capping aspects. Treatability studies and pilot testing will be required during remedial design to determine the stabilization reagents and dosages, delivery mechanism, and overall technical feasibility of ISS.

TABLE ES-1b
Detailed Evaluation of Alternatives – RTA 2
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Brooklyn, New York

Criteria	Alternative 1: No Action	Alternative 5: Dredge Entire Column of Soft Sediment Cap with Treatment Layer, Sand-and-Gravel Layer, Armor Layer	Alternative 7: Dredge Entire Column of Soft Sediment Solidify Top 3–5 Feet of Native Sediment in Targeted Areas Cap with Treatment Layer, Sand-and-Gravel Layer, Armor Layer
Administrative feasibility		• Alternative will require coordination between regulatory agencies (USEPA, USACE, NYSDEC, and NYCDEP), PRPs, property owners along the canal, and other stakeholders. • Bulkhead repair and replacement will require coordination with property owners and tenants. Due to the number of different properties and type of bulkheads affected, this effort will be considerable.	Same as Alternative 5.
Availability of services and materials		• Equipment and specialists required for the sheet piling installation, dredging, and capping would be commercially available. • The volume of capping materials required is large and procuring large quantities of specialty materials, such as the oleophilic clay, will require significant advance coordination and possibly use of multiple vendors. • Available thermal treatment and co-generation facilities (Options A and C, respectively) are also limited within the geography, which may restrict the ability to competitively bid these services. • Landfill capacity for contaminated river sediments within the geography may be limited. Landfill availability will influence the implementability of Option B (offsite landfill) within the region. Available landfill facilities and associated capacities will need to be identified during the remedy selection process. Facilities outside of the region could be used; however, transportation costs would increase. • Treatability testing will be needed to determine if available thermal treatment and co-generation facilities can accept solidified/stabilized sediment and to determine the final waste characterization.	Same as Alternative 5 for dredging, capping, and disposal components. ISS is an emerging technology, and there are few contractors with a proven performance of ISS implementation in marine environments.
Cost ($Million)[1]	0	Option A: 117 Option B: 122 Option C: 136	Option A: 130 Option B: 135 Option C: 149

Notes:
[1] Total present worth cost; cost does not include O&M or base implementation cost. Values presented include cost of dredging, capping, ISS (Alternative 7 only), and disposal. See Table 4-7 for additional cost detail for each alternative and associated disposal options. Further, source control measures will be needed to ensure that the sediment remedy achieves the RAOs and is sustainable. Source control is the first component of all alternatives except No Action. Source control measures are in the process of being developed; therefore, the costs are not included in this FS. The source control measures are included by reference in this FS.

ARAR – applicable or relevant and appropriate requirement
CDF – confined disposal facility
ISS – in-situ solidification
NAPL – non aqueous phase liquid
NYCDEP – New York City Department of Environmental Protection
NYSDEC – New York State Department of Environmental Conservation
O&M – operations and maintenance
PRP – potentially responsible party
RAO – remedial action objective
RTA – remediation target area
TMV – toxicity, mobility, or volume
USACE – United States Army Corps of Engineers
USEPA – United States Environmental Protection Agency

TABLE ES-1c
Detailed Evaluation of Alternatives – RTA 3
Gowanus Canal Feasibility Study
Brooklyn, New York

Criteria	Alternative 1: No Action	Alternative 5: Dredge Entire Column of Soft Sediment Cap with Treatment Layer, Sand-and-Gravel Layer, Armor Layer	Alternative 7: Dredge Entire Column of Soft Sediment Solidify Top 3-5 Feet of Native Sediment in Targeted Areas Cap with Treatment Layer, Sand-and-Gravel Layer, Armor Layer
Threshold Criteria			
Overall protection of human health and the environment	Alternative will not provide protection of human health and the environment. • RAOs would not be achieved • Human health and ecological risks associated with contaminated sediment would not be reduced or eliminated. • NAPL migration to the water column would continue. • Contaminant concentrations in other media (e.g. surface water) would not be reduced.	Alternative will provide protection of human health and the environment. • RAOs would be achieved upon completion of the remedy, which is estimated to be approximately 5 years after the start of construction. • Removal of soft sediment and capping of native sediment would reduce and control long-term risks associated with contaminated sediment. Placement of a cap would: ○ Control risks associated with remaining sediment by preventing exposure. ○ Reduce and control toxicity to benthic organisms and eliminate risks to herbivorous birds. ○ Control risks to human health via direct contact and incidental ingestion. ○ Prevent NAPL migration from sediment to the water column. • Surface water quality would be improved by preventing contact between surface water and sediment; sheens would be controlled or eliminated.	Alternative would provide protection of human health and the environment. Application of ISS in targeted areas is expected to provide additional protectiveness against NAPL migration from sediment.
Compliance with ARARs	• ARARs are not applicable because no remedial action is taken.	Alternative can be designed to comply with substantive requirements of the ARARs.	Same as Alternative 5.
Balancing Criteria			
Long-term effectiveness and permanence	**Low** - Alternative would not result in any significant change in the risks associated with contaminated sediment.	Alternative would provide a **high** level of long-term effectiveness and permanence: • Alternative would meet RAOs. • Alternative would result in significant, permanent risk reduction due to soft sediment removal. • The sediment cap would provide long-term control of the risks associated with the native sediment remaining in the canal, provided that appropriate long-term monitoring and maintenance plans are implemented. • Long-term effectiveness of disposal options are: ○ High for Options A, B, and C because material is transferred offsite and treated or contained in a managed landfill. ○ Low to moderate for Options D and E. ▪ The long-term effectiveness will depend on the actual beneficial use and the conditions to which the stabilized sediment will be exposed. A greater degree of effectiveness would be expected from a use where the material is relatively contained and not subjected to significant water fluctuations or to freeze/thaw cycles. ▪ Stabilization would be performed to a degree such that the sediment-associated contaminants would be bound within the matrix and the stabilized sediment would remain onsite under Option E. ▪ The stabilized sediment would need to meet the end-use performance criteria. ▪ Permanent institutional controls and long-term monitoring would be needed under this option. ○ High for Options F and G as the material would be solidified/stabilized to such a degree that the sediment-associated contaminants would be permanently bound within the matrix prior to its placement in an onsite engineered facility.	Alternative would provide a **high** level of long-term effectiveness and permanence. • Same as Alternative 5, with the exception that targeted ISS would provide additional long-term control of the NAPL migration in the canal.
Magnitude and type of residual risk		This evaluation is focused on the magnitude and management of residual risks associated with sediment remaining onsite (i.e., sediment that is stabilized and beneficially used onsite, and contaminated sediment remaining in the canal following remedy implementation). Sediment treated and disposed at offsite facilities are not included in this discussion because it would be removed from the site. • Sediment removal and capping would: ○ Alleviate the risks associated with the sediments removed from the canal. ○ Reduce the risks associated with contaminated native sediments that remain in the canal by capping. ○ Provide long-term control of risks associated with sediment remaining in the canal. Adsorptive caps to control NAPL migration can be designed for a set life expectancy where NAPL migration rates are known (see Appendix A for additional discussion). Additional data collection and evaluation to determine site-specific NAPL seepage rates will be required during remedial design to determine the appropriate cap design (i.e., granular oleophilic clay layer thickness). • Residual risks associated with disposal Option E (onsite stabilization and onsite beneficial use), F (offsite stabilization and onsite CDF), and G (onsite stabilization and onsite CDF) would be as follows: ○ Treatment residuals would consist of stabilized sediment, which would significantly reduce the mobility of sediment contaminants and reduce the associated risks.	Same as Alternative 5, with the addition that the implementation of ISS would be expected to further reduce risk of NAPL migration, if proven to be effective and implementable during pilot and treatability testing.

TABLE ES-1c
Detailed Evaluation of Alternatives – RTA 3
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Brooklyn, New York

Criteria	Alternative 1: No Action	Alternative 5: Dredge Entire Column of Soft Sediment Cap with Treatment Layer, Sand-and-Gravel Layer, Armor Layer	Alternative 7: Dredge Entire Column of Soft Sediment Solidify Top 3-5 Feet of Native Sediment in Targeted Areas Cap with Treatment Layer, Sand-and-Gravel Layer, Armor Layer
		○ Onsite beneficial use of the stabilized material will require identifying a beneficial use and will also require the stabilized material to meet leachability specifications and strength specifications appropriate to the identified use. ○ The ability of the stabilized sediment to meet performance criteria will depend upon the designated end use of the material, and further testing is required for these disposal options. ○ The FS assumes that the end use would be such that direct contact human and ecological contact with the stabilized sediment would be limited. ○ Placement in constructed CDF (Options F and G) would require routine monitoring and maintenance to assure materials remain isolated. ○ The level of residual risk would be considered low to moderate for these alternatives because treatment does not destroy the contaminants and the treated material would remain onsite. ○ Remedy can be designed so that the sediments stabilized and beneficially used or placed in the onsite CDF are those with fewer NAPL impacts.	
Adequacy and reliability of controls		• Dredging ○ Mechanical dredging is an established technology and would meet the performance specifications for the removal component of the alternative. ○ Bathymetric surveys would be conducted to confirm target removal depths and samples would be collected on a defined grid to confirm sediment cap layer thicknesses. • Capping ○ Capping is an established technology and can be designed to meet the performance specifications of the alternative, provided that effective source controls have been implemented and the cap is constructed and maintained in accordance with the design specifications established for long-term isolation of the contaminated sediments. As noted above, additional data collection and evaluation are required to finalize the cap design. ○ Long-term monitoring and periodic maintenance would be required to assure cap integrity. ○ The O&M plan developed during the remedial design would determine the monitoring and maintenance frequencies required to assure and maintain cap integrity based on site-specific factors. ○ Physical (e.g., bathymetric) surveys and the collection of samples on a defined grid would be needed to assess cap layer thickness, cap performance and integrity, contaminant movement, and/or recontamination concerns. Samples for chemical analysis should also be collected at regular predetermined intervals. ○ The long-term monitoring plan should also specify monitoring requirements after severe storm events to assess cap integrity. ○ Cap repairs would be performed as needed. ○ Component failures (i.e., sediment cap failure) could potentially result in sheens on the water surface and limited exposure to ecological or human receptors; however, catastrophic failure of the cap is unlikely if appropriate long-term O&M plans are implemented. • Disposal ○ Disposal Options A (thermal treatment), and C (co-generation) would be expected to meet required performance specifications following treatability and pilot testing. ○ Option B (offsite landfill) is an established means of disposal. ○ Options D (offsite stabilization and offsite beneficial use) and E (onsite stabilization and beneficial use) require identifying a beneficial use and also require that the stabilized material meet leachability specifications as well as strength specifications appropriate to the identified use. The ability of the stabilized sediment to meet performance criteria will depend upon the designated end use of the material, and further testing is required for these disposal options. The FS assumes that the end use would be such that direct contact human and ecological contact with the stabilized sediment would be limited. ○ Additional O&M beyond that associated with the sediment cap would be required for Options A, B, C, or D. Long-term monitoring would be required for Options E (onsite stabilization and beneficial use), F, or G (stabilization and onsite CDF). The O&M for the CDF would consist of inspections and a low level of maintenance. ○ Institutional controls would be required if disposal Options E, F, or G are selected. ○ The permanent institutional controls required for disposal Option E would specify appropriate measures for digging within the fill material, and long-term monitoring would be applied to review their sustained application. The institutional controls may need to be applied to one or more properties, depending on where the material is used. Depending on the number of properties and the location where the fill is placed, significant effort and coordination may be needed to ensure successful implementation and enforcement of these controls.	Same as Alternative 5, with the stipulation that if additional evaluations and pilot studies indicate that in situ solidification (ISS) is implementable and effective within the canal, targeted areas of NAPL-saturated native sediment would be treated with ISS to further reduce the potential for NAPL migration. The conceptual cap specifications have been designed to be protective without the use of ISS; however, if ISS is determined to be viable for the Gowanus Canal, then its application would be expected to provide additional protection and support the long-term effectiveness of the selected remedy.

TABLE ES-1c
Detailed Evaluation of Alternatives – RTA 3
Gowanus Canal Feasibility Study
Brooklyn, New York

Criteria	Alternative 1: No Action	Alternative 5: Dredge Entire Column of Soft Sediment Cap with Treatment Layer, Sand-and-Gravel Layer, Armor Layer	Alternative 7: Dredge Entire Column of Soft Sediment Solidify Top 3-5 Feet of Native Sediment in Targeted Areas Cap with Treatment Layer, Sand-and-Gravel Layer, Armor Layer
Reduction of toxicity, mobility, or volume through treatment	**Low** Alternative does not include a treatment component and does not meet the statutory preference for treatment as a principal element of a remedy.	The overall reduction of NAPL mobility by the oleophilic cap is expected to be **high.** The reduction of toxicity, mobility, or volume (TMV) of the dredged sediment by treatment ranges from **moderate to high** depending on the disposal option. Alternative 5 is considered to have **high** overall reduction of TMV based on the volume of sediment removed from the canal.	Same as Alternative 5, with the addition that the implementation of ISS would be expected to further reduce NAPL mobility, if proven to be effective and implementable during pilot and treatability testing.
Reduction in toxicity, mobility, or volume (TMV)		• Dredging does not reduce toxicity, mobility or volume through treatment. • The granular oleophilic clay cap component of the alternative will reduce the mobility of NAPL and is considered a treatment technology. • The reduction of TMV of the dredged sediment is summarized below. Thermal treatment (Option A) and cogeneration (thermal destruction, Option C) meet the statutory preference for treatment as a principal element. The relative reductions of TMV of the disposal/beneficial use options are: ○ Option A (thermal treatment): **High** reduction of TMV. Dredged sediments would be treated using thermal desorption. The TMV associated with the organic contaminants would be significantly reduced. ○ Option B (offsite landfill): **Moderate** reduction of TMV. Dredged sediments would be stabilized prior to transfer to a landfill. Volume and toxicity would not be affected, but contaminant mobility would be reduced by placing the material in a controlled environment. Overall TMV would be transferred to the offsite disposal facility. ○ Option C (co-generation): **High** reduction of TMV. Organic contaminants would be destroyed through treatment. The overall ranking of this disposal option is **high**. ○ Option D (offsite stabilization and offsite beneficial use): **Moderate** reduction of TMV. Dredged sediments would be stabilized prior to their transfer to an offsite beneficial-use location. Volume and toxicity would not be affected, but contaminant mobility would be reduced. Overall TMV would be transferred to the offsite location. ○ Option E (onsite stabilization and onsite beneficial use): **Moderate** reduction of TMV. Dredged sediments would be stabilized prior to placement in onsite beneficial-use location. Volume and toxicity would not be affected, but contaminant mobility would be reduced. Overall TMV would remain onsite. ○ Options F and G (stabilization and onsite CDF): **Moderate** reduction of TMV. Solidification and stabilization agents added to the dredged sediment would result in material forming a solid monolith. The toxicity and volume would not be reduced, but the mobility of the contaminants would be significantly reduced. The sediments placed in the CDF would be those with fewer NAPL impacts.	Same as Alternative 5, except that the overall reduction in NAPL mobility is anticipated to be greater with the addition of ISS in targeted areas of the canal.
Irreversibility		• Sorption in the oleophilic clay cap is irreversible, but once the cap is saturated, it will not be able to absorb more NAPL. • Solidification and stabilization are considered irreversible if the stabilized material is placed into a controlled environment. • Thermal treatment (Option A), thermal destruction (Option C), and the stabilization component of Options B, F, and G are irreversible. The degree of irreversibility of stabilization associated with Options D and E will depend upon the selected beneficial use and the conditions to which the stabilized material are exposed.	Same as Alternative 5, with the addition that ISS is also an irreversible process.
Type and quantity of treatment residuals and associated risks		The type and quantity of residuals and the associated magnitude and management of risks is dependent upon the disposal option, as follows: • Option A (thermal treatment): ○ Residuals would consist of treated sediment. ○ Treated sediment would be beneficially used (e.g., daily cover at landfills). ○ Level of residual risk associated with this option is **low** since contaminants would be desorbed and destroyed in an afterburner. • Option B (offsite landfill): ○ Would not result in treatment residuals. ○ Stabilized sediment would be disposed in a landfill. ○ Residual risk associated with this option is **low** because material is disposed in a controlled offsite facility. • Option C (co-generation): ○ Residuals would consist of treated sediment. ○ Treated sediment would be beneficially used (e.g., daily cover at landfills). ○ The level of residual risk associated with this option is **low** since organic contaminants would be destroyed. • Options D (offsite stabilization and offsite beneficial use) and E (onsite stabilization and onsite beneficial use): ○ Stabilized sediment would be beneficially used either offsite (Option D) or onsite (Option E). ○ The level of residual risk would be considered **low to moderate** because treatment stabilizes but does not	Same as Alternative 5.

TABLE ES-1c
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Criteria	Alternative 1: No Action	Alternative 5: Dredge Entire Column of Soft Sediment Cap with Treatment Layer, Sand-and-Gravel Layer, Armor Layer	Alternative 7: Dredge Entire Column of Soft Sediment Solidify Top 3-5 Feet of Native Sediment in Targeted Areas Cap with Treatment Layer, Sand-and-Gravel Layer, Armor Layer
		destroy the contaminants. The contaminant mobility would be significantly reduced, and the treated material would be beneficially used. The residual risk for Option D is lower because the material would be transferred offsite. • Sediment treated by thermal treatment (Option A) and co-generation (Option C) may contain concentrated levels of inorganic constituents, which may limit the beneficial use of the material. • Options F and G (stabilization and onsite CDF): ○ Stabilized sediment would be placed in a CDF. ○ CDF would require routine monitoring and maintenance to assure materials remain isolated. ○ The level of residual risk would be considered **low to moderate** because treatment stabilizes but does not destroy the contaminants, and the treated material would remain onsite. • Materials with fewer NAPL impacts can be placed in the CDF.	
Short-term effectiveness	High; no actions are taken under this alternative.	The short-term effectiveness of this alternative is **moderate** due to construction duration and the potential risks and environmental impacts described below. • Short-term effectiveness of all disposal options is considered moderate to high.	Same as Alternative 5
Risks to community, workers, and the associated controls		• Potential risks to the community would include noise and vibrations during bulkhead replacement and increased levels of traffic, dust, noise, and odors during the dredging and handling of contaminated sediment. Engineering controls and best management practices can mitigate most potential risks: ○ Access to the active work and support zones would be prohibited. ○ Notification of schedule for bulkhead repair and remedy implementation would be provided to the property owners and tenants. ○ Dust and noise levels would be monitored. ○ Work periods may be restricted to specific timeframes for especially noisy operations (e.g., sheet pile installation). ○ Traffic effects can be managed by performing work in canal from barges and using water transport to move materials to and from the canal. ○ Staging areas would need to be established in areas zoned for industrial use. ○ Odors are expected during dredging and may not be able to be fully controlled. • Potential risks to workers would include physical hazards associated with general construction, potential exposure to and direct contact with dredged sediment and NAPL, noise, odors, dust, and vapors. These would be mitigated through: ○ Engineering controls and best management practices. ○ Compliance with appropriate health and safety plans and site management plans. ○ Use of appropriate personal protective equipment.	Same as Alternative 5. Implementation of ISS would likely be restricted to specific timeframes. Potential exposure risks from ISS would be mitigated as described under Alternative 5.
Environmental Impacts of Remedy and Controls		• Short-term environmental effects during implementation in RTA 3 may include turbidity increases within the canal and releases of some sediment-associated contamination. Significant releases of NAPL from RTA 3 are not anticipated. Example control measures to mitigate these impacts include the following: ○ Silt curtains would control turbidity in RTA 3. ○ The duration of these releases would be very short and would only occur during construction.	Same as Alternative 5, with the addition that ISS would be performed within the dredge cells to contain potential NAPL and turbidity releases.
Duration of short-term risks		• The duration of the short-term risks would be the time required for construction, which is estimated to be approximately 5 years.	Same as Alternative 5.
Implementability	Not applicable; no actions are taken under this alternative.	The overall implementability this alternative is **moderate.** The implementability of the disposal options is variable.	Same as Alternative 5 for dredging, capping, and disposal options. Implementability of ISS is likely to be more limited since this technology is not yet commercially proven for application to marine environments for the control of NAPL migration.
Technical feasibility		• Alternative is technically implementable and dredging and capping are established, field-proven technologies; however, pilot testing may be required to determine the most suitable cap placement methods based on the site-specific sediment characteristics. • Dredging and capping would be performed from barges using standard construction equipment. • The potential interference from debris within the canal will need to be considered during design. • Bulkhead repair and replacement will require property-specific designs, and construction must be planned and proceed and be coordinated carefully to minimize / prevent effects on the adjacent, upland properties.	Same as Alternative 5 for dredging and capping aspects. Treatability studies and pilot testing will be required during remedial design to determine the stabilization reagents and dosages, delivery mechanism, and overall technical feasibility of ISS.

TABLE ES-1c
Detailed Evaluation of Alternatives – RTA 3
Gowanus Canal Feasibility Study
Brooklyn, New York

Criteria	Alternative 1: No Action	Alternative 5: Dredge Entire Column of Soft Sediment Cap with Treatment Layer, Sand-and-Gravel Layer, Armor Layer	Alternative 7: Dredge Entire Column of Soft Sediment Solidify Top 3-5 Feet of Native Sediment in Targeted Areas Cap with Treatment Layer, Sand-and-Gravel Layer, Armor Layer
		• The short- and long-term monitoring requirements can be performed using standard practices and technologies. • Implementability and feasibility of additional actions would be limited if penetration of the cap is required.	
Administrative feasibility		• Alternative will require coordination between regulatory agencies (USEPA, USACE, NYSDEC, and NYCDEP), PRPs, property owners along the canal, and other stakeholders. • Bulkhead repair and replacement will require coordination with property owners and tenants. Due to the number of different properties and type of bulkheads affected, this effort will be considerable. • Implementation of disposal Option E (onsite stabilization and onsite beneficial use) is dependent upon stakeholder acceptability, and effective implementation of institutional controls. This disposal option may be challenging to implement due to stakeholder acceptance. • Permanent institutional controls would also be required for disposal Option E. Depending on the number of properties and the location where the fill is placed, significant effort and coordination may be needed to ensure successful implementation and enforcement of these controls. The difficulties associated with implementation of institutional controls are also further discussed in Section 4.6.3. • Implementation of disposal Options F and G (onsite constructed CDF) is dependent on the identification of a suitable location(s), concurrence from other stakeholders, and effective implementation of institutional controls. This option may be difficult to implement due to stakeholder acceptability challenges.	Same as Alternative 5.
Availability of services and materials		• Equipment and specialists required for the sheet piling installation, dredging, and capping would be commercially available. • The volume of capping materials required is large and procuring large quantities of specialty materials, such as the oleophilic clay, will require significant advance coordination and possibly use of multiple vendors. • Available thermal treatment and co-generation facilities (Options A and C, respectively) are also limited within the geography, which may restrict the ability to competitively bid these services. • Landfill capacity for contaminated river sediments within the geography may be limited. Landfill availability will influence the implementability of disposal Option B (offsite landfill) within the region. Available landfill facilities and associated capacities will need to be identified during the remedy selection process. Facilities outside of the region could be used; however, transportation costs would increase. • Onsite and offsite beneficial uses of stabilized sediment would need to be identified. In order for disposal options D and E to be implemented, an end use would need to be determined and treatability testing would need to be performed to evaluate the stabilization agents and dosing required and to assess whether the treated material would meet all the end-use requirements (e.g., leachability and strength characteristics). • Treatability testing will be needed to determine if available thermal treatment and co-generation facilities can accept solidified/stabilized sediment and to determine the final waste characterization.	Same as Alternative 5 for dredging, capping, and disposal components. ISS is an emerging technology and contractors with a proven performance of ISS implementation in marine environments are few.
Cost[1]	0	Option A: 131 Option B: 137 Option C: 155 Option D: 133 Option E: 107 Option F: 103 Option G: 96	Option A: 131 Option B: 137 Option C: 155 Option D: 133 Option E: 107 Option F: 103 Option G: 96

Notes:
[1] Total present worth cost; cost does not include O&M or base implementation cost. Values presented include cost of dredging, capping, ISS (Alternative 7 only), and disposal. See Table 4-7 for additional cost detail for each alternative and associated disposal options. Further, source control measures will be needed to ensure that the sediment remedy achieves the RAOs and is sustainable. Source control is the first component of all alternatives except No Action. Source control measures are in the process of being developed; therefore, the costs are not included in this FS. The source control measures are included by reference in this FS. Areas for ISS have not been identified in RTA 3; therefore costs have not been included in this FS. ISS may be applied to RTA 3 if predesign investigations indicate areas of NAPL saturated sediment where ISS may be beneficial.

ARAR – applicable or relevant and appropriate requirement
CDF – confined disposal facility
ISS – in-situ solidification
NAPL – non aqueous phase liquid
NYCDEP – New York City Department of Environmental Protection
NYSDEC – New York State Department of Environmental Conservation
O&M – operations and maintenance
PRP – potentially responsible party
RAO – remedial action objective
RTA – remediation target area
TMV – toxicity, mobility, or volume
USACE – United States Army Corps of Engineers
USEPA – United States Environmental Protection Agency

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TABLE ES-2a
Comparative Analysis of Alternatives RTA 1
Gowanus Canal Feasibility Study
Brooklyn, New York

Dredging and Capping Alternatives	Threshold Criteria: Overall Protection of Human Health and the Environment	Threshold Criteria: Compliance with ARARs	Balancing Criteria: Long-Term Effectiveness	Balancing Criteria: Reduction of Toxicity, Mobility, or Volume	Balancing Criteria: Short-Term Effectiveness	Balancing Criteria: Implementability	Balancing Criteria: Cost ($Million)[1]
Alternative 1 No Action	○	○	○	○	●	●	0
Alternative 5 Dredge entire column of soft sediment Cap with treatment layer, isolation sand layer, and armor layer	●	●	●	●	◑	◑	15
Alternative 7 Dredge entire column of soft sediment Solidify top 3-5 feet of underlying native sediment in select areas Cap with treatment layer, isolation sand layer, and armor layer	●	●	● 2	●	◑	◔	18
Disposal Options Associated with Dredging and Capping alternatives							
Option A: Thermal desorption, offsite beneficial use	●	●	●	●	◕	◑	30
Option B: Offsite disposal (landfill)	●	●	●	◑	◕	◕	32
Option C: Co-gen, offsite beneficial use	●	●	●	●	◕	◑	37
Option D: Offsite stabilization, offsite beneficial use[3]	●	●	◔	◑	◕	◑	30
Option E: Onsite stabilization, onsite beneficial use[3]	●	●	◔	◑	◕	◑	23

[1]Present worth: 30-year period of performance (*I* = 2.3 percent). Cost does not include O&M or base implementation cost. See Table 4-7 and Appendix F for additional cost detail.
[2] If pilot testing and treatability studies indicate ISS will be effective and implementable within the canal, Alternative 7 would be expected to have greater long-term effectiveness than Alternative 5.
[3]The relative rankings of the stabilization and beneficial use disposal options could be modified following the identification of a specific beneficial use.

Source control measures will be needed to ensure that the sediment remedy achieves the RAOs and is sustainable. Source control is the first component of all alternatives except No Action. Source control measures are in the process of being developed; therefore, the costs are not included in this FS. The source control measures are included by reference in this FS

Legend:

Threshold Criteria:

○ Does not satisfy criterion

● Satisfies criterion

Balancing Criteria:

○ Low

◔ Low to Moderate

◑ Moderate

◕ Moderate to High

● High

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TABLE ES-2b
Comparative Analysis of Alternatives RTA 2
Gowanus Canal Feasibility Study
Brooklyn, New York

Dredging and Capping Alternatives	Threshold Criteria: Overall Protection of Human Health and the Environment	Threshold Criteria: Compliance with ARARs	Balancing Criteria: Long-Term Effectiveness	Balancing Criteria: Reduction of Toxicity, Mobility, or Volume	Balancing Criteria: Short-Term Effectiveness	Balancing Criteria: Implementability	Balancing Criteria: Cost ($Million)[1]
Alternative 1 No Action	○ (Does not satisfy criterion)	○ (Does not satisfy criterion)	○ (Low)	○ (Low)	● (High)	● (High)	0
Alternative 5 Dredge entire column of soft sediment Cap with treatment layer, isolation sand layer, and armor layer	● (Satisfies criterion)	● (Satisfies criterion)	● (High)	● (High)	◐ (Moderate)	◐ (Moderate)	35
Alternative 7 Dredge entire column of soft sediment Solidify top 3-5 feet of underlying native sediment in select areas Cap with treatment layer, isolation sand layer, and armor layer	● (Satisfies criterion)	● (Satisfies criterion)	● (High) [2]	● (High)	◐ (Moderate)	Low to Moderate	48
Disposal Options Associated with Dredging and Capping alternatives							
Option A: Thermal desorption, offsite beneficial use	● (Satisfies criterion)	● (Satisfies criterion)	● (High)	● (High)	Moderate to High	◐ (Moderate)	82
Option B: Offsite disposal (landfill)	● (Satisfies criterion)	● (Satisfies criterion)	● (High)	◐ (Moderate)	Moderate to High	Moderate to High	87
Option C: Co-gen, offsite beneficial use	● (Satisfies criterion)	● (Satisfies criterion)	● (High)	● (High)	Moderate to High	◐ (Moderate)	101

[1]Present worth: 30-year period of performance (*I* = 2.3 percent). Cost does not include O&M or base implementation cost. See Table 4-7 and Appendix F for additional cost detail.
[2] If pilot testing and treatability studies indicate ISS will be effective and implementable within the canal, Alternative 7 would be expected to have greater long-term effectiveness than Alternative 5.
Source control measures will be needed to ensure that the sediment remedy achieves the RAOs and is sustainable. Source control is the first component of all alternatives except No Action. Source control measures are in the process of being developed; therefore, the costs are not included in this FS. The source control measures are included by reference in this FS.

Legend:

Threshold Criteria:

○ Does not satisfy criterion

● Satisfies criterion

Balancing Criteria:

○ Low

Low to Moderate

◐ Moderate

Moderate to High

● High

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TABLE ES-2c
Comparative Analysis of Alternatives RTA 3
Gowanus Canal Feasibility Study
Brooklyn, New York

Dredging and Capping Alternatives	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness	Reduction of Toxicity, Mobility, or Volume	Short-Term Effectiveness	Implementability	Cost ($Million)[1]
Alternative 1 No Action	○	○	○	○	●	●	0
Alternative 5 Dredge entire column of soft sediment Cap with treatment layer, isolation sand layer, and armor layer	●	●	●	●	◑	◑	29
Alternative 7 Dredge entire column of soft sediment Solidify top 3-5 feet of underlying native sediment in select areas Cap with treatment layer, isolation sand layer, and armor layer	●	●	● [2]	●	◑	◔	29
Disposal Options Associated with Dredging and Capping alternatives							
Option A: Thermal desorption, offsite beneficial use	●	●	●	●	◕	◑	102
Option B: Offsite disposal (landfill)	●	●	●	◑	◕	◕	108
Option C: Co-gen, offsite beneficial use	●	●	●	●	◕	◑	126
Option D: Offsite stabilization, offsite beneficial use[3]	●	●	◔	◑	◕	◑	104
Option E: Onsite stabilization, onsite beneficial use[3]	●	●	◔	◑	◕	◑	78
Option F: Offsite stabilization, disposal in onsite CDF	●	●	◕	◑	◕	◑	74
Option G: Onsite stabilization, disposal in onsite CDF	●	●	◕	◑	◕	◑	67

[1]Present worth: 30-year period of performance (*I* = 2.3 percent). Cost does not include O&M or base implementation cost. See Table 4-7 and Appendix F for additional cost detail.
[2] If pilot testing and treatability studies indicate ISS will be effective and implementable within the canal, Alternative 7 would be expected to have greater long-term effectiveness than Alternative 5.
[3]The relative rankings of the stabilization and beneficial use disposal options could be modified following the identification of a specific beneficial use.
Source control measures will be needed to ensure that the sediment remedy achieves the RAOs and is sustainable. Source control is the first component of all alternatives except No Action. Source control measures are in the process of being developed; therefore, the costs are not included in this FS. The source control measures are included by reference in this FS.

Legend:

Threshold Criteria:

○ Does not satisfy criterion

● Satisfies criterion

Balancing Criteria:

○ Low

◔ Low to Moderate

◑ Moderate

◕ Moderate to High

● High

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Abbreviations and Acronyms

ARAR	applicable or relevant and appropriate requirement
BERA	baseline ecological risk assessment
BTEX	benzene, toluene, ethylbenzene, and xylenes
BTU	British Thermal Unit
CDF	Confined Disposal Facility
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act of 1980
CESP	Clean Earth of Southeast Pennsylvania
CSM	conceptual site model
CSO	combined sewer overflow
CTE	central tendency exposure
DO	dissolved oxygen
EC_{20}	20 percent effects concentration
ERA	ecological risk assessment
ESB	equilibrium sediment benchmark
FCV	final chronic value
FS	feasibility study
GEI	GEI Consultants, Inc.
GRA	general response action
HHRA	human health risk assessment
ISS	in situ stabilization
LTCP	long-term control plan
MGP	manufactured-gas plant
MLLW	mean lower low water
MNR	monitored natural recovery
NAPL	non-aqueous-phase liquid
NAVD88	North American Vertical Datum of 1988
NCP	National Contingency Plan
NOAEC	no observed adverse effect concentration
NPDES	National Pollutant Discharge Elimination System
NRHP	National Register of Historic Places
NYCDEP	New York City Department of Environmental Protection
NYSDEC	New York State Department of Environmental Conservation
O&M	operations and maintenance
OSWER	USEPA Office of Solid Waste and Emergency Response
PAH	polycyclic aromatic hydrocarbon

PCB	polychlorinated biphenyl
PRG	preliminary remediation goal
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
RI	remedial investigation
RME	reasonable maximum exposure
RTA	remediation target area
SLERA	screening level ecological risk assessment
SVOC	semivolatile organic compound
TBC	to be considered
TCLP	toxicity characteristic leaching procedure
TOC	total organic carbon
TRAP	Toxicity Response Analysis Program
TU	toxicity unit
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
VOC	volatile organic compound

SECTION 1

Introduction

This draft feasibility study (FS) report was prepared for the U.S. Environmental Protection Agency (USEPA) Region 2 by CH2M HILL to present the results of the feasibility analysis of remedial alternatives for the Gowanus Canal Superfund Site, in Brooklyn, Kings County, New York. This draft FS was prepared under Task Order 072 of the USEPA AES10 contract.

The Gowanus Canal is a 1.8-mile-long, man-made canal in the Brooklyn Borough of New York City, in Kings County, New York (Figure 1-1). The canal was built in the 1860s by bulkheading and dredging a tidal creek and surrounding lowland marshes. Following construction, the canal quickly became one of the nation's busiest industrial waterways, servicing heavy industries that included manufactured-gas plants (MGPs), coal yards, cement manufacturers, tanneries, paint and ink factories, machine shops, chemical plants, and oil refineries. It was also the repository of untreated industrial wastes, raw sewage, and surface-water runoff for decades, causing it to become one of New York's most polluted waterways. Although the level of industrial activity along the canal has declined over the years, high levels of contamination remain in the sediments.

On March 2, 2010, USEPA placed the Gowanus Canal (USEPA ID#: NYN000206222) on its National Priorities List of hazardous waste sites requiring further evaluation. Accordingly, USEPA Region 2 performed a remedial investigation and feasibility study (RI/FS) of the canal according to the requirements of the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA, or "Superfund"), as amended. The RI was completed in January 2011 (USEPA, 2011) and this FS was initiated. The results of this FS will be used to develop a Proposed Plan for remedial action and a Record of Decision for the canal.

This FS focuses on remedial alternatives for contaminated sediments within the Gowanus Canal. Addressing contaminant contributions to the canal from upland properties, combined sewer overflows (CSOs) and other pipe outfalls is a prerequisite to a sustainable remedy for canal sediments and as such, USEPA is seeking to reduce or eliminate these sources. The New York State Department of Environmental Conservation (NYSDEC) is addressing investigations and response actions related to the upland properties adjacent to the canal. The New York City Department of Environmental Protection (NYCDEP), through an Administrative Order on Consent[1] with NYSDEC, has begun to address CSOs. It is anticipated that additional CSO measures will be required to prevent recontamination of the canal. Discharges to the canal from unpermitted outfall structures must also be addressed. Source control measures are in the process of being developed and these measures are included by reference as a component of all of the alternatives for contaminated sediments presented in this FS.

[1] DEC Case #CO2-20000107-8 dated January 14, 2005, and updated April 14, 2008.

1.1 Purpose and Organization of Report

This FS develops and evaluates remedial alternatives for Gowanus Canal sediments that will reduce or eliminate unacceptable risks to human health and the environment from exposure to contaminated sediment and surface water in the canal. The FS was prepared following USEPA's *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (USEPA, 1988) and *Contaminated Sediment Remediation Guidance for Hazardous Waste Sites* (USEPA, 2005). The report is organized into the following five sections:

1. **Introduction**. Briefly describes the regulatory framework, FS purpose and organization, and site setting; summarizes the results of the RI; and presents a conceptual site model (CSM) for the canal.
2. **Development and Application of Remediation Goals**. Presents the remedial action objectives (RAOs) and remediation goals for the canal, and summarizes the potential applicable or relevant and appropriate requirements (ARARs). This section also identifies the area and depth of the sediments to be targeted by the remediation.
3. **Identification and Screening of Remedial Technologies.** Identifies and describes a range of remedial approaches, technologies, and process options that could be used to address contaminated sediments in the canal, and screens them based on effectiveness, implementability, and cost.
4. **Development and Evaluation of Remedial Alternatives**. Develops remedial alternatives for canal sediments by combining the remedial approaches, technologies, and process options that were retained after the screening described in Section 3; screens the alternatives based on effectiveness, implementability, and cost; and presents detailed individual and comparative analyses of the remedial alternatives that were retained using the evaluation criteria defined in the National Oil and Hazardous Substance Pollution Contingency Plan (NCP).
5. **References**. Provides the references cited in the report.

The report appendixes provide supporting information as follows:

A—Non-Aqueous-Phase Liquid (NAPL) Technical Appendix
B—Groundwater and Combined Sewer Overflow Discharge Evaluation
C—Development of Remediation Goals
D—Gowanus Canal Propeller Wash Calculations
E—Dredging Volume Estimates
F—Estimated Costs

Additionally, the identification of historic properties within the Area of Potential Effect for the Gowanus Canal Superfund Site is being carried out by USEPA under Section 106 of the National Historic Preservation Act. Initial characterizations of the historic contexts of the canal were developed by the U.S. Army Corps of Engineers (USACE) in 2004 (Hunter Research et al., 2004). This study indicated the eligibility of the canal for nomination to the National Register of Historic Places. Subsequent investigations by USEPA in 2010 (USEPA, 2011), carried out as part of the RI, further examined large-sized objects residing on the surface of the canal bottom sediments. Further evaluation of the historic bulkheads, themselves an integral component of the canal, was also carried out.

Additional archeological research carried out under this FS focuses on two tasks: evaluating lands immediately adjacent to the canal with respect to their potential for containing intact historic properties and carrying out the initial steps in the recording the historic bulkheads lining the canal. The latter is in anticipation of any potential adverse effects in conjunction with the proposed cleanup activities.

The lands adjacent to the canal were evaluated initially from a review of historic documentation drawn from a wide range of public and corporate repositories, along with an examination of a number of private archival holdings. This is accompanied by an interpretation of soil boring data taken from current and past projects along the canal to indicate the nature of existing stratigraphic sequences relevant to any potential for surviving historical contexts.

The initial bulkhead recordation efforts are focused on the techniques of construction and maintenance as revealed in engineering and planning documents. Additional considerations address construction materials selection, evolution of design parameters, securing of historical photographic documentation, and the contemporary photo documenting of these features prior to the cleanup.

The results of this additional research will be compiled in an addendum to this FS report.

1.2 Site Setting

The Gowanus Canal is a tidally influenced, dead-end channel that opens to Gowanus Bay and Upper New York Bay (Figure 1-2). The canal experiences a semidiurnal tidal cycle (i.e., two high tides and two low tides of unequal height each tidal day), with a vertical tidal range from 4.7 to 5.7 feet. The only freshwater inflows to the canal are wet-weather CSO and stormwater discharges. Because of its narrow width, limited freshwater input, and enclosed upper end, the canal has low current speeds and limited tidal exchange with Gowanus Bay. Circulation is enhanced by the addition of water from a flushing tunnel located at the head of the canal, when the flushing tunnel is operating (NYCDEP, 2008a). The flushing tunnel is described further in Section 1.2.1.

The Gowanus Canal project area is shown in Figure 1-1. There are five east–west bridge crossings over the canal, at Union Street, Carroll Street, 3rd Street, 9th Street, and Hamilton Avenue. The Gowanus Expressway and the Culver Line of the New York City Subway pass overhead. North of Hamilton Avenue, the canal is approximately 5,600 feet long and 100 feet wide, with a maximum water depth of approximately 15 feet in the main channel at low tide. There are four short turning basins that branch to the east of the main channel at 4th Street, 6th Street, 7th Street, and 11th Street. A former basin at 1st Street and an extension of the 4th Street basin that had been referred to as the 5th Street basin were filled in between 1953 and 1965 (Hunter Research et al., 2004). An extension of the 7th Street basin has also been filled. The bottom sediments near the head of the canal and at the heads of the turning basins are exposed at low tide. South of Hamilton Avenue, the canal widens to approximately 2,200 feet and ranges in depth from -15 to -35 feet mean lower low water

(MLLW).[2] The vast majority of the shoreline of the canal is lined with retaining structures or bulkheads.

The canal is located in a mixed residential-commercial-industrial area, and it borders several residential neighborhoods, including Gowanus, Park Slope, Cobble Hill, Carroll Gardens, and Red Hook. The waterfront properties abutting the canal are primarily commercial and industrial.

1.2.1 Site History

Prior to being developed, the area around the Gowanus Canal was occupied by Gowanus Creek, its tributaries, and lowland marshes. Before the mid-1840s, the creek and its tributaries were dammed and used primarily to power tide mills (Hunter Research et al., 2004). By the mid-1840s, Brooklyn was rapidly growing, and the Gowanus marshes were considered to be a detriment to local development. In 1848, the State of New York authorized construction of the Gowanus Canal to open the area to barge traffic, flush away sewage, receive stormwater, and fill the adjacent lowlands for development. The canal was constructed between 1853 and approximately 1868, and rapid industrial development followed.

In 1911, New York City constructed and began operating the Gowanus Canal flushing tunnel to address serious water quality issues in the canal. The tunnel was constructed to connect the head of the canal with Buttermilk Channel in Upper New York Bay (Figure 1-2). It was designed to improve circulation and flush pollutants from the canal by pumping water in either direction. The tunnel starts at Degraw Street on Buttermilk Channel and ends on the west side of the canal at Douglass Street. The tunnel was operated until the mid-1960s, when it fell into disrepair and funding was unavailable to fix it. The flushing tunnel was rehabilitated and reactivated in 1999 by the NYCDEP, pumping water only from Buttermilk Channel to the Gowanus Canal using the 1911 technology. The flushing tunnel was shut down by the NYCDEP on July 19, 2010, for an extended period of facility improvements to modernize the technology and improve operations (see Section 1.2.4).

1.2.2 Dredging History and Navigational Requirements

Minimal recent dredging of the Gowanus Canal has been performed, and documentation of historical dredging is sparse. North of Hamilton Avenue, any dredging would have been performed by New York City or local commercial interests. Historical documents suggest that dredging was very limited and, when it was performed, most likely targeted the accumulation of material near outfalls on the canal (Hunter Research et al., 2004). The upper reaches of the canal were dredged by NYCDEP in 1975 (NYCDEP, 2008a). In 1998, the area near the flushing tunnel was dredged, and nearly 1,100 cubic yards (yd^3) of material was removed to allow the tunnel to be reactivated (GEI, 2007). These sediments were removed to facilitate construction and assure an unobstructed discharge from the tunnel. There are no federal, state, or local regulatory requirements related to the depth of the canal north of Hamilton Avenue (Carr, 2011).

Below Hamilton Avenue, the USACE previously performed maintenance dredging. In 1896, the federal channel was authorized to a depth of 26 feet south of Percival Street (between

[2] The average of the lower low water height each tidal day.

Halleck and Bryant Streets, Figure 1-1). In 1952, federal work to Hamilton Avenue was authorized, with a 100-foot-wide, 18-foot-deep channel from Hamilton Street to Sigourney Street (between Bay and Halleck Streets), deepening to 30 feet between Sigourney and Percival Streets, and continuing from Percival Street to 28th Street (south of the project area), with a channel widening from 200 to 500 feet.[3] USACE suspended regular maintenance dredging in 1955, and the last maintenance dredging event occurred in 1971, where nearly 74,000 yd^3 of sediment was removed between 28th Street and Hamilton Avenue (GEI, 2007; NYCDEP, 2008a).

A number of businesses use the canal for maritime commerce. All but one of these businesses are located south of 9th Street, and none are located north of 4th Street. Commercial navigation in the canal is expected to continue in the future. A dredging alternatives analysis performed by USACE assumed a depth of -16 feet relative to North American Vertical Datum 1988 (NAVD88) for navigation between 3rd Street and Hamilton Street, and no commercial navigation north of 3rd Street (USACE, 2009).

1.2.3 Adjacent Land Use

The canal waterfront, or riparian area (defined as all blocks wholly or partially within one quarter mile of the canal), is occupied primarily by commercial and industrial properties. The riparian areas are classified as 18 percent residential, 6 percent park, and 76 percent mixed use. The entire watershed is 53 percent residential, 2 percent park, and 45 percent mixed use (NYCDEP, 2008a). Current commercial and industrial land use along the canal is shown in Figure 1-3. Current land use was identified in October 2010 based on a windshield survey of the properties along the canal coupled with a review of current tax maps. The survey did not include interviews with property owners or property inspections to refine property-use classification. Based on the windshield survey, the waterfront properties along the canal are currently used mostly for consumer-oriented businesses and operations (e.g., retail stores, small business offices), commercial purposes, municipal operations, and industrial purposes. Areas of historical commercial and industrial land use are also shown in Figure 1-3, including the locations of three former MGP sites (Fulton, Carroll Gardens/Public Place, and Metropolitan).

1.2.4 Combined Sewer Overflow and Stormwater Discharges

As noted, CSO and stormwater discharges are the only major sources of freshwater to the Gowanus Canal. Combined sewers (i.e., sewers that receive both sewage and stormwater flows) serve 92 percent of the Gowanus Canal watershed, storm sewers serve only 2 percent, and direct runoff drains 6 percent of the watershed (NYCDEP, 2008a). During wet weather, runoff enters the combined sewers and exceeds the capacity of the system when an appreciable rate of rainfall occurs. There are two combined sewer systems in the watershed that overflow to the canal: the Red Hook and Owls Head water pollution control plants. Between these systems, there are 12 permitted CSOs to the project area; 10 of these are active. In addition, there are three known stormwater outfalls discharging to Gowanus

[3] Federally authorized depths are reported by the USACE relative to MLLW. In this FS, depths and elevations are reported relative to NAVD88. The federally authorized channel depths of 18 feet and 30 feet MLLW are equivalent to approximately -21 feet and -33 feet NAVD88, respectively.

Canal. Figure 1-4 shows the locations of the outfalls. There are also highway drains discharging to the canal; these are not shown in the figures.

The greatest annual discharge volumes are from outfalls RH-034, at the head of the canal; RH-035, at the intersection of Bond and 4th Streets; and OH-007, at the north end of 2nd Avenue (121 million gallons, 111 million gallons, and 69 million gallons, respectively; NYCDEP, 2008a). A floatables boom is installed in the canal at Sackett Street to retain floating debris that enters the canal from the RH-034 outfall.

In 2008, the NYCDEP prepared the *Gowanus Canal Waterbody/Watershed Facility Plan Report* as part of its City-Wide Long-Term CSO Control Planning Project (NYCDEP, 2008a). This work is being performed under an Administrative Order on Consent between NYCDEP and NYSDEC.[4] The goal of the project is to implement a series of improvements to achieve compliance with water quality standards. Specific objectives of the plan include eliminating odors, reducing floatables, and improving dissolved oxygen (DO) concentrations to meet surface-water-quality standards. NYCDEP's planned improvements for the Gowanus Canal have the following six components: (1) continued implementation of programmatic controls, (2) modernization of the Gowanus Canal flushing tunnel, (3) reconstruction of the Gowanus Wastewater Pump Station, (4) cleaning/inspection of the OH-007 floatables/solids trap, (5) periodic water body floatables skimming, and (6) dredging. These improvements were proposed collectively to reduce the loading of contaminants to the canal in addition to improving overall water quality.

The modernization of the flushing tunnel includes replacing the existing tunnel pumping system with more-efficient pumping systems. This modernization effort will increase the volume of water conveyed through the tunnel by approximately 40 percent. In early 2010, an aeration pipe was installed within the canal to circulate super-oxygenated water while the flushing tunnel was shut down for repair. The aeration pipe went online in early July 2010, and the repairs were initiated with the flushing tunnel being shut down, on July 19, 2010. The completion date is anticipated to be September 2014.

The reconstruction of the Gowanus Wastewater Pump Station will address the pumping station at the head of the canal. The reconstruction will increase the pump station capacity, restore force main flow, and add floatables-screening devices at outfall RH-034 at the head of the canal. These improvements are anticipated to decrease CSO discharges to the canal by 127 million gallons per year (approximately 34 percent), provide screening for 32 percent of the annual CSO discharge, and reduce solids by approximately 37 percent. Improvements to the RH-034 pumping facility were initiated in February–March 2010. The completion date of this construction is also anticipated to be September 2014.

In addition, NYCDEP proposes dredging 750 feet of the canal from its head downstream and applying a 2-foot-thick sand cap so that the final water depth will be -3 feet MLLW. The dredging is intended to eliminate exposed sediments and associated odors observed at low tide, improve aesthetics, and provide improved benthic habitat. The canal has not yet been dredged. The timeline specified by the long-term control plan (LTCP) indicated that permit applications would be submitted by June 2010 and that dredging would begin within 3 years, and be completed within 5 years, of receipt of the final permits.

[4] NYSDEC Case No. CO2-20000107-8 dated January 14, 2005, and updated on April 14, 2008.

1.3 Remedial Investigation Summary

The following activities were performed for the Gowanus Canal RI, which was completed in three phases:

- Phase 1
  - Bathymetric survey
  - Survey of outfall features, including identifying outfall features, collecting and analyzing outfall water samples, and tracing outfall features to their origin
  - Cultural resources survey, including a bulkhead study
- Phase 2: Sediment coring
- Phase 3
  - Surface sediment sample collection and analysis
  - Surface water sample collection and analysis
  - Fish and shellfish tissue sample collection and analysis
  - Air sample collection and analysis
  - CSO sediment and water sample collection and analysis
  - Hydrogeologic investigation, which included (1) groundwater-monitoring-well installation and development; (2) groundwater sampling; (3) groundwater–surface water interaction sampling; (4) synoptic measurements of water levels; (5) tidal evaluation; and (6) oversight of well installation and soil-sampling activities performed by National Grid and New York City

This section summarizes the major findings of the RI.

1.3.1 Gowanus Canal Physical Characteristics

Physical characteristics of the Gowanus Canal, including bathymetry, debris, sediment characteristics, bulkhead characteristics, geology and hydrogeology, and historical and cultural characteristics, are described below.

Bathymetry

The bathymetry of the Gowanus Canal, based on a January 2010 survey, is shown in Figures 1-5a through 1-5c. The measured bottom depth elevations ranged from approximately -0.13 feet to -38 feet NAVD88. The bottom depth elevations measured within the canal north of Hamilton Avenue were typically between -0.13 feet and approximately -18 feet NAVD88 (Figures 1-5a and 1-5b); much lower sediment surface elevations were measured south of Hamilton Avenue (Figure 1-5c). The sediment surface at the head of the canal and in the eastern ends of many of the turning basins is exposed at low tide. Evidence of propeller scour in the form of a deeper sediment surface was noted in the southern portion of the canal; this area is subject to frequent tugboat activity to move and position oil and gravel barges at the various commercial terminals near the mouth of the canal.

Debris and Obstructions

Debris such as tires, sunken barges, concrete rubble, timbers, gravel, and general trash is widespread throughout the canal. Ocean Surveys, Inc., performed a debris survey in late

2005 on behalf of National Grid using magnetometer, sub-bottom profiling, and side-scan sonar technologies. The combined observations from the 2005 geophysical surveys and the 2010 field observations are illustrated in Figures 1-6a through 1-6c. Briefly, the key observations are as follows:

- Gravel covers the sediment surface of the entire main channel south of the concrete plant at the end of 5th Street to south of the 9th Street bridge and the area adjacent to the New York City asphalt plant south of Hamilton Avenue.
- Debris piles (generally concrete, iron beams, and other large, construction-type debris) were often observed near the ends of streets that ended at the canal.
- The channel, particularly the western shoreline approximately one city block downstream of the Hamilton Avenue bridge, is covered with debris.
- All the turning basins have significant accumulations of debris, including a sunken barge in the 6th Street turning basin and multiple large debris piles and wreckage of a small boat in the 4th Street turning basin.
- Tires and smaller objects identified as anomalies by side-scan sonar and magnetometer surveys are widespread throughout the canal.
- A steel and concrete gas tunnel passes under the canal in the vicinity of the Carroll Gardens/Public Place former MGP site.

A second high-resolution side-scan sonar survey was performed in 2010 as part of USEPA's cultural resources survey. Several areas of debris were also identified during this survey, as shown in Figures 1-6d through 1-6f. The 2010 survey identified a number of anomalies with potentially significant historical characteristics, as detailed in the RI report. The results of the 2005 and 2010 surveys are very similar, and the recent survey confirms that the data collected earlier are still usable.

Sediment Stratigraphy and Characteristics

The sediments within and beneath the Gowanus Canal consist of two distinct layers, as shown in Figure 1-7. The upper layer is referred to as "soft" sediment. The soft sediments have accumulated in the canal over time since the canal was first constructed. The soft sediment layer ranges in thickness from approximately 1 foot to greater than 20 feet, with an average thickness of about 10 feet. The thickest deposits were found at the head of the canal and within the turning basins. The soft sediment consists generally of a dark-gray-to-black sand-silt-clay mixture that contains variable amounts of gravel, organic matter (e.g., leaves, twigs, vegetative debris), and trash. Odors described as "organic," "septic-like," "sulfur-like," and "hydrocarbon-like" were commonly observed in the soft sediment during the RI, as were visible sheens.

The soft sediments are underlain by the alluvial and marsh deposits of the Gowanus Creek complex that were originally present. These deposits are referred to as "native" sediments in this report and consist of brown, tan, and light-gray sands, silts, silty sand, sandy clay, clay, and peat.

Table 1-1 summarizes the total organic carbon (TOC) content, grain size distribution and total percent fines content (silt plus clay fractions), percent solids, sulfide, bulk density, and percent moisture for each stratigraphic unit within the canal. Data for the reference area in Gowanus Bay and Upper New York Bay are also shown.

Shoreline and Bulkhead Characteristics

NYCDEP (2008b) documented that the shorelines of the Gowanus Canal are entirely altered and are dominantly bulkheads with small areas of riprap or piers; the bulkheads north of Hamilton Avenue are generally constructed of wood or steel. The NYCDEP report also noted four areas where the shoreline consisted of riprap: between 11th Street and the Gowanus Expressway, between 17th and 19th Streets on the eastern side of the canal, between Sigourney Street and Halleck Street, and on the eastern end of Bryant Street on the western side of the canal.

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

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

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

The 2000 survey (Brown Marine Consulting, 2000) concluded that the existing structures were sufficient only to support present loading conditions, and that any type of dredging activities could threaten bulkhead stability due to the deteriorated condition of the structures. The 2000 survey was based only on visual examinations of structures without physical or laboratory testing and recommended that a more thorough investigation of bulkhead integrity be performed if dredging is planned. The report also noted that an estimated 41.7 percent of the bulkhead length was in fair condition or worse.

Historical and Cultural Characteristics

As part of the RI activities, Dolan Research, Inc., and JMA performed a review of the bulkheads along the canal to assess their significance and their potential eligibility for nomination to the National Register of Historical Places (NRHP). This review was based on historical information from the sources cited in the previous section as well as on a 1-day bulkhead inspection from water conducted on October 19, 2010. The report from Dolan Engineering and JMA is provided in Appendix M of the RI report.

Documentary research and a high-resolution side-scan sonar survey identified known historic resources in the form of the canal bulkheads, as well as anomalies on the canal bottom, that will be subject to further investigation. The variety of bulkheads reflects an evolution of technology, a varied use of materials, and an effective means of maintaining the function of the canal, thus ensuring its role in the commercial development of Brooklyn. These resources, depending on their individual integrity, are considered to be eligible for nomination to the NRHP. Should the bulkheads be subject to adverse effects as a result of cleanup actions, a wide range of mitigating measures would be investigated and considered as part of the remedy. These measures would likely include additional documentation of bulkhead characteristics and the incorporation of archaeological and architectural investigations as appropriate.

Potential configurations of new construction that are in keeping with the historic character of the setting would be considered. As remediation methods are considered, further examination of anomalies on and within the sediments will need to be examined. This investigation could encompass further remote sensing or direct examination of the canal bottom. USEPA is in process of completing a historical study of the Gowanus Canal. The results will be made available after the date of this Draft FS Report.

Geology and Hydrogeology

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

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

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

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

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

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

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

Multiple lines of evidence were developed in the RI to characterize the hydraulic relationships between local groundwater and the Gowanus Canal. Potentiometric surfaces developed from the synoptic (instantaneous point in time) measurement events suggests that, at the water table, groundwater flows towards the Gowanus Canal. Potentiometric data from intermediate wells screened in the glacial deposits depict a more-complex pattern, with groundwater generally flowing upward toward the canal, which is typical of a discharge area. Data from a 5-day tidal evaluation indicate that at specific locations adjacent to the canal, canal elevations at high tide consistently exceeded groundwater elevations in the shallow fill/alluvium, creating hydraulic conditions for surface water to intermittently flow into shallow aquifer sediments.

1.3.2 Nature and Extent of Contamination

The horizontal and vertical distribution and extent of contamination in surface sediment (0-to-6-inch depth interval), soft sediment (from a depth of 6 inches below the sediment surface to the contact with the native Gowanus Creek sediments), and native sediment (i.e., original Gowanus Creek alluvial and marsh deposits) were characterized on the basis of field observations and chemical analysis of sediment samples. Contaminant concentrations in surface water and ambient air samples were also measured. The nature and extent of contamination in each medium are summarized below.

Sediment

Gowanus Canal sediments are affected by contaminants that are adsorbed to sediment particles and by NAPL. Contaminant concentration data for surface, subsurface soft, and native sediment samples are summarized in Table 1-2. In surface sediments (0-to-6-inch depth interval), the following constituents were found to be contributing to unacceptable ecological and human health risks (Section 1.3.3): polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), and seven metals (barium, cadmium, copper, lead, mercury, nickel, and silver). Concentrations of these constituents in surface sediment were significantly higher in the canal than at reference locations in Gowanus Bay and Upper New York Bay.

Subsurface sediment-sampling data indicated that total PAHs and volatile organic compounds (VOCs), particularly benzene, toluene, ethylbenzene, and xylenes (BTEX), were frequently detected at high concentrations in both the soft and native sediment units. PCBs and metals were all frequently detected in the soft sediment but were infrequently detected or detected at lower concentrations in the native sediments. In the subsurface soft sediment, VOCs (primarily BTEX), PAHs, PCBs, and metals were all detected at higher concentrations than those found in the surface sediments.

The sediment-coring effort indicated that NAPL contamination is present in native sediments underneath the canal between the head of the canal and the Gowanus Expressway, and in the overlying soft sediment primarily in the middle reach of the canal. The NAPL appears to be coal tar waste from three former MGP sites (Fulton, Carroll Gardens/Public Place, and Metropolitan) that is migrating through subsurface soils, under or through the bulkheads, and into the sediments in and under the canal. PAHs and BTEX are major constituents of coal tar. Appendix A provides additional information about the NAPL found in Gowanus Canal sediments, including a more detailed description of the NAPL properties and its distribution in canal sediments.

In most areas north of the Gowanus Expressway, NAPL and high-PAH concentrations were found in sediment to the maximum depth of the investigation activities, which was targeted to be 6 feet below the contact between the soft and native sediment layers. Deep borings installed in the canal adjacent to the Carroll Gardens/Public Place former MGP site by National Grid in 2010 indicate that contamination extends to a depth of greater than 50 feet.

Surface Water

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

Ambient Air

The sampling results for air samples collected from canoe-level and street-level locations along the length of the canal and from three background locations (Figure 2-9 of the RI report) indicate that the types and concentrations of VOCs and PAHs detected in air samples were similar regardless of sample location. The constituents detected were typical of those found in urban environments.

1.3.3 Summary of Ecological and Human Health Risk Assessments

The Gowanus Canal has no natural shoreline, wetlands, or upland areas. The community of potential ecological receptors using the canal includes fish-eating birds; dabbling ducks; invertebrates such as worms, amphipods, and mollusks; and crabs and fish. The potential ecological risk to these receptors from exposure to surface water and sediment in the canal was evaluated in the ecological risk assessment (ERA). The human health risk assessment (HHRA) evaluated potential risks to recreational users, anglers, residents, and industrial workers near the canal.

Ecological Risk Assessment

The combined screening level ecological risk assessment (SLERA) and baseline ecological risk assessment (BERA) performed for the Gowanus Canal completed Steps 1 and 7 of the eight-step ERA process described in the USEPA (1997) *Ecological Risk Assessment Guidance for Superfund* and its updates. The survival and reproduction of the following receptor groups were selected for evaluation in the ERA:

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

The following summarizes the key investigation methods and findings and conclusions for each receptor group.

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

- Sediment bioassays indicate a site-related potential for adverse effects to benthic communities from chemicals in sediment, with the greatest potential for adverse effects occurring in the central portion of the canal. The bioassay results also indicate the potential for less severe, but site-related adverse affects to the benthic community at several other locations scattered throughout the canal.

- Chemical analysis indicates the presence of organic chemicals (primarily PAHs and PCBs) and metals in sediment at concentrations that are likely to be causing the adverse effects observed in the sediment bioassays. The highest concentrations of those chemicals were detected primarily in the central portion of the canal, which coincides with the locations where the most severe effects to the sediment bioassay organisms were also observed.

- PAHs were consistently detected in sediment at the highest concentrations relative to their ecological screening benchmarks and are considered to represent the greatest site-related risk to the benthic community. Other chemicals, most notably PCBs and seven metals (barium, cadmium, copper, lead, mercury, nickel, and silver), were also detected at concentrations above their ecological screening benchmarks and at concentrations above those detected in reference area sediments, and are also considered to represent a potential site-related risk to the benthic community.

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

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

- 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 reference area locations and represent a site-related risk to aquatic herbivores.
- Potential risk to avian omnivores (represented by heron) from exposure to mercury and selenium. However, mercury was the only metal that was frequently detected both in fish and crab tissues at elevated concentrations and that was also detected onsite (in sediments) at a concentration above those detected in reference area locations, and thus represents a site-related risk to avian omnivores.
- There is no potential risk to avian piscivores such as the double-crested cormorant from the ingestion of fish in the canal.

Human Health Risk Assessment

The HHRA was conducted to evaluate the potential human health risks associated with direct contact with surface sediment and surface water in the Gowanus Canal, ingestion of fish and crabs, direct contact with sediment and surface water that overtop the canal during extreme tidal or storm surge conditions, and inhalation of emissions from the canal into the ambient air near the canal. Two scenarios were evaluated: (1) a reasonable maximum exposure (RME), which uses conservative exposure factors to estimate the reasonable maximum exposures anticipated for the canal, and (2) a central tendency exposure (CTE), which describes a more typical or average exposure. Two types of effects were evaluated: noncarcinogenic hazards and carcinogenic risks. Acceptable risk levels are defined in National Contingency Plan (40CFR300.430(e)(2)(I)(A)).

For an adult, an adolescent, and a child using the canal for recreational purposes, the risks associated with exposure to surface water and surface sediment (from exposed and near-shore locations) in the canal and from ambient air at canal level while swimming were evaluated. The HHRA assumed that recreational use/swimming in the canal would occur at frequencies, durations, and exposures that are typical of most water bodies, even though the actual use of the canal is lower given its nature. The total RME noncarcinogenic hazard associated with exposure to all of the media for all recreational users was within USEPA acceptable risk levels. However, exposure to all of the media by recreational adults, adolescents, and children may result in carcinogenic risks above USEPA’s target risk range. These risks are associated primarily with exposure to carcinogenic PAHs in the surface water and the surface sediment. The total noncarcinogenic hazard based on the CTE assumptions was within or below USEPA’s acceptable risk levels; however, carcinogenic risk was above USEPA’s target range.

The risks associated with exposure to ambient air at street level and with surface water and surface sediment from canal overflow were evaluated for residential adults and children and for industrial workers. RME noncarcinogenic hazards and carcinogenic risks associated with exposure to these media by the industrial worker are within acceptable levels. Exposure to all of the media by residential adults and children may result in carcinogenic risks above USEPA’s acceptable risk levels. The RME carcinogenic risk for the adult/child resident is associated with carcinogenic PAHs in sediment (with a smaller contribution from surface water). The total carcinogenic risk evaluated under the CTE assumptions was within or below USEPA's acceptable risk levels.

Risks associated with ingesting fish and crabs from the Gowanus Canal were evaluated for the angler adult, adolescent, and child. The HHRA assumed fishing/crabbing and ingestion of the fish/crab from the canal at typical recreational angler fish/crab consumption rates, which is very conservative given the nature of the canal. The RME and CTE total noncarcinogenic hazards and/or carcinogenic risks for all receptors exceeded USEPA acceptable levels. The noncarcinogenic hazards and carcinogenic risks are associated with PCBs in fish and crab. The average concentrations of PCBs in the canal fish and crab samples were about two times higher than the average PCB concentrations in the reference area samples collected from Gowanus Bay and Upper New York Bay. However, the PCB concentrations in the reference samples would also result in noncarcinogenic hazards and carcinogenic risks above USEPA acceptable levels.

1.4 Conceptual Site Model

The CSM for the Gowanus Canal summarizes and integrates information about historical and ongoing sources of contamination, the nature and extent of contamination (Section 1.3.2) , contaminant fate and transport mechanisms, and risks to humans and wildlife from exposure to contaminated sediments in the Gowanus Canal (Section 1.3.3). Sources of contamination and fate and transport mechanisms are described below. A schematic representation of the CSM for the Gowanus Canal is provided in Figure 1-8. This CSM is used as the basis for developing remedial alternatives for canal sediments.

1.4.1 Sources of Contamination

The Gowanus Canal has been affected by numerous known and potential sources of contamination for a period of about 140 years. The major sources of contamination to the canal are (1) historical industrial activities, (2) upland contaminated sites, (3) CSO and stormwater discharges, and (4) discharges from other pipe outfalls. All of these sources except for historical industrial activities continue to contribute contaminants to the canal. These sources, including an assessment of the potential for ongoing sources to recontaminate canal sediments after a remedy is implemented, are described further below. Active sources should be controlled prior to remediation of Gowanus Canal sediments to prevent recontamination.

Direct Discharges from Historical Industrial Activities

These activities included manufactured-gas production; bulk handling of products such as petroleum, coal, chemical fertilizers, oil, and scrap metal; various manufacturing activities; and other industrial operations. Wastes from many of these operations were discharged directly into the canal. Based on the site history and the poor environmental practices typical of the era, a large quantity of waste was likely released through this pathway. Direct discharges from industrial activities were substantially reduced or controlled over time because of declining industrial activity and the implementation of the Clean Water Act in the early 1970s. Discharges from present-day industrial operations are regulated and permitted under the National Pollutant Discharge Elimination System (NPDES). The higher concentrations of most contaminants in subsurface (buried) soft sediments compared to those in surface sediments may reflect the contribution of historical sources of contamination that are no longer present along the canal as well as historical contributions from CSOs, although some of the historical contamination would have been removed by past dredging events.

Discharges from Upland Contaminated Sites Adjacent to the Canal

Contaminants from upland contaminated sites can be transported into the Gowanus Canal by migration of NAPL through subsurface soils, groundwater discharge of dissolved-phase contaminants, and surface runoff (i.e., overland transport of contaminated soils). The RI sampling results indicate that NAPL contamination is present in native and soft sediment in the canal, primarily in native sediment north of the Gowanus Expressway and soft sediment in the middle reach of the canal. The NAPL has migrated and continues to migrate from the three former MGP sites under and possibly through the bulkheads into the sediments in and beneath the canal. NAPL is present at depths of greater than 6 feet below the contact between the soft and native sediments at many locations in the canal. Therefore, any NAPL remaining in place after a sediment remedy is implemented could act as an ongoing source of contamination to overlying canal sediments. An analysis of the potential for upward migration of NAPL from native to soft sediments indicates that upward migration may be occurring in some areas (Appendix A). Any NAPL seeping into the canal from the shoreline (e.g., seepage through the bulkheads) could also act as on ongoing source of contamination to canal sediments; this pathway will be addressed as part of the upland source control measures.

The RI sampling results indicated that the transport of dissolved-phase contaminants to the canal by groundwater discharge is occurring at some locations. Analytical results for groundwater samples collected during the RI were evaluated to assess the potential for contaminated groundwater discharge to recontaminate canal sediments following a remedial action. The evaluation focused on the constituents that were found to be contributing to unacceptable ecological and human health risks: PAHs, PCBs, and metals (barium, cadmium, copper, lead, mercury, nickel, and silver).

There are no established criteria for evaluating PAH concentrations in groundwater with respect to potential risk from groundwater discharge to surface water bodies. Therefore, a screening approach based on USEPA’s equilibrium sediment benchmark (ESB) guidance for PAH mixtures (USEPA, 2003) was developed to identify and prioritize upland sites along the canal with the potential to recontaminate canal sediment with PAHs by groundwater transport. The full screening analysis is provided in Appendix B and is summarized below.

The screening approach is based on the following assumptions:

- No attenuation, transformation, or binding of PAHs will occur; therefore, PAH concentrations in groundwater equal potential PAH concentrations in sediment pore water.
- The principal form of toxicity elicited by PAHs to benthic invertebrates is narcosis. Narcotic toxicants demonstrate additive toxicity; that is, the effects of narcotic toxicants can be added together to summarize the total amount of toxicity present in a mixture of such chemicals (as occurs in sediments).

The following procedure was used to screen upland sites for potential concern:

- Select final chronic values (FCVs) for the 34 PAHs listed in USEPA's guidance document for PAH mixtures (USEPA, 2003). The FCVs are based on USEPA's National Water Quality Criteria, and are the concentrations of chemicals in water that are considered to be protective of the presence of aquatic life. The document recommends that 34 PAHs be analyzed when assessing the risk represented by PAHs in contaminated sediments. However, the Gowanus Canal groundwater samples were analyzed only for the 16 PAHs that are part of the Target Compound List. If results are available for only a subset of the 34 PAHs (i.e., 13 or 23 commonly quantified PAHs), the benchmark document provides uncertainty factors that can be applied to account for the missing PAHs. An uncertainty factor of 11.5 was selected for this analysis, as detailed in Appendix B.
- Calculate the ratios of the concentrations of 13 individual PAHs in each groundwater sample to the corresponding FCVs.
- Sum the ratios for the 13 individual PAHs into a toxicity unit (TU) for each sample.
- Multiply each TU by 11.5 to account for the PAHs that were not analyzed.
- Rank all sites with TUs greater than 1 from highest to lowest. If the calculated TU is less than 1, then the site is assumed to pose no risk to the sediment from groundwater discharge. Because some attenuation of PAH concentrations is expected to occur as groundwater discharges to the canal, sites with TUs between 1 and 10 were assumed to pose minimal risk to the canal from groundwater discharge.

The TU for each groundwater sample is summarized in Table 1-3. Figures 1-9a and 1-9b show the locations of shallow and intermediate groundwater samples, respectively, with PAH TUs that exceed 10. These figures also show the locations where NAPL was observed in monitoring wells. In shallow wells, TUs were highest (i.e., greater than 100) in four areas: near the Fulton former MGP site, near President Street, immediately downstream of 9th Street, and near Halleck Street. NAPL was observed in wells in three of these four areas. In intermediate wells, TUs of greater than 1,000 were identified near 4th Street and immediately downstream of 9th Street. TUs of greater than 100 were identified in the same areas as the shallow wells, as well as near Carroll Street, the infilled 1st Street basin, the infilled portion of the 4th Street basin, and near the 6th Street basin. These areas may pose a risk of recontamination from ongoing transport of PAHs to the canal by groundwater discharge.

PCBs were not detected in groundwater samples. For metals, the results of the screening evaluation performed for the RI were examined to identify the frequency and magnitude of sample concentrations that were elevated above screening criteria. Metals concentrations were within a factor of 10 times the screening criteria at all locations except one, and locations with concentrations above criteria were generally dispersed across the length of the canal with no indication of significant, pervasive contaminant plumes. Based on these results, ongoing discharge of metals and PCBs to the canal by groundwater transport does not appear to be a concern.

CSO and Stormwater Discharges

The Gowanus Canal served as an open sewer when it was initially constructed in the late 1860s. By the late 1870s, sewers entering the canal carried a combination of household waste, industrial effluent from gas works and other industries, and stormwater runoff (Hunter Research et al., 2004). Prior to the implementation of the Clean Water Act, the contaminant load in sewage and stormwater discharges to the canal was greater than it is under present-day conditions.

New York City has taken various measures over the years to mitigate the impacts of sewage and stormwater discharges, and a variety of additional upgrades and control measures is in progress or planned as part of the LTCP. Today, CSOs occur only during wet weather, discharging a mixture of sanitary sewage and stormwater to the canal. Of the 10 active CSOs, four discharge 95 percent of the total annual wet-weather discharge (RH-034, RH-035, OH-007, and RH-031; Figure 1-4). CSO discharges result in point source loading of high-organic-content solids. Collection system modeling performed for the LTCP indicates that the current annual loading of total suspended solids (TSS) to the canal is approximately 259,000 lbs (approximately 222,000 lbs from CSOs and 37,000 lbs from stormwater discharges) (NYCDEP, 2007). The reconstruction of the Gowanus Wastewater Pump Station is expected to decrease CSO discharges to the canal by approximately 34 percent and reduce the total annual TSS load (CSO and stormwater) by 32 percent, to 177,000 lbs.

Sampling results for wet-weather flow samples collected from the CSO system for the RI indicate that VOCs, SVOCs (primarily PAHs), and metals are discharged to the canal during overflow events. VOCs, SVOCs (primarily PAHs), metals, pesticides, and PCBs were detected in residual sediment collected from the CSO pipes during dry-weather conditions. The CSO wet-weather water-sampling data collected for the RI, in conjunction with information about discharge volumes, were used to estimate contaminant loading from the CSOs under present-day conditions. The estimated ranges of PAH and metal concentrations attributable to the ongoing deposition of CSO solids was determined based on CSO wet-weather water sample data (Table 1-4; details are provided in Appendix B). PCBs were not included because they were detected in only one wet-weather CSO water sample. CSO sediment data were not used in this analysis because the residual sediments in the sewer lines were notably sandier than the surface sediments in the canal and, therefore, are considered to be less representative of the solids discharged to the canal.

The values reported in Table 1-4 represent the estimated range of PAH and metals concentrations on CSO solids discharged from the outfalls that convey 95 percent of annual CSO and stormwater discharge (RH-034, RH-035, OH-007, and RH-031), assuming that all of the contamination is associated with the particulate phase. Because the CSO wet-weather water samples are considered to represent the quality of solids discharged from the CSOs, CSOs are a major source of solids to the canal, and CSO solids settle within the canal, these levels would be expected to persist in canal surface sediments if no CSO reductions are made. It should be noted that the quantity and possibly the quality of CSO solids may differ in the future as a result of the CSO management actions currently being taken by New York City.

Table 1-4 shows the average concentrations of the PAHs and metals in surface sediments in the upper, middle, and lower reaches of the canal. The ranges of PAH concentrations correspond well to the estimated ranges of CSO solids except in the middle reach of the canal, which is more heavily influenced by PAH contamination from the Carroll Gardens/Public Place former MGP site. The ranges of metals concentrations also generally correspond, although the ranges are larger. Given that CSOs are the major source of solids in the canal, these results suggest that contaminant concentrations in surface sediments are influenced by the CSO solids and dominated more so in the upper and lower reaches of the canal than in the middle reach.

Other Pipe Outfalls

Nearly 250 outfall features were identified in the RI, most of which were pipes. Twenty-five of these pipe outfalls were observed to be actively discharging during dry weather. The effluent from 14 of the 25 active outfalls could not be attributed to tidal drainage (i.e., drainage of seawater that entered the pipe at high tide). Samples from 12 of these 14 outfall discharges contained VOCs, SVOCs (primarily PAHs), and metals (two of the discharges were not sampled due to low flow rates). Pesticides and PCBs were not detected. The flow rate from all but one of the active outfalls was very small (< 1 L/min).

A review of NYSDEC and USEPA databases identified five active permitted discharges to the canal. Three of these permitted outfalls were not observed to discharge during the RI. Two of the permitted outfalls could not be clearly identified during the RI because of the large number of outfall features in their vicinity.

Contaminant loading from outfalls other than the CSO outfalls was not estimated because the annual discharge volumes are not known. Discharges from these unpermitted outfalls will be eliminated as part of the remedy for the canal.

Other Sources

Other potentially active sources of contamination to the Gowanus Canal include uncaptured stormwater runoff from adjacent upland sites and streets, and sediments and contaminants from Buttermilk Bay by the flushing tunnel and from Upper New York Bay through tidal flow. However, impacts from these potential sources are expected to be relatively minor compared to the active sources identified above. Uncaptured stormwater runoff drains only 6 percent of the Gowanus Canal watershed, whereas combined sewers and storm sewers drain 94 percent of the watershed (NYCDEP, 2008a). Sediments from Upper New York Bay, as represented by reference area sediment samples collected for the RI, have significantly lower concentrations of PAHs, PCBs, and metals than surface sediments in the canal, as well as a lower TOC content and higher percent fines than the sediments in the canal. If Upper New York Bay was a major source of sediments and contaminants to the canal, then the reference area and canal sediments would show greater similarity.

1.4.2 Contaminant Fate and Transport

A variety of physical and chemical processes influences the fate and transport of contaminants and NAPL in the Gowanus Canal sediments, as described below.

Fate and Transport Processes for Sediment-Associated Contaminants

Many of the contaminants detected in canal sediments (e.g., SVOCs, PCBs, and metals) have a low solubility and an affinity for fine-grained sediment particles and organic matter.

Contaminants with a higher solubility and volatility (i.e., VOCs and some of the low-molecular-weight SVOCs) tend to disperse in the water column. Therefore, the accumulation of soft sediments in the canal over time has resulted in the accumulation of high levels of persistent contaminants. Because of low current velocities and limited tidal exchange with Gowanus Bay, the contaminated sediments have accumulated in the canal rather than being flushed out to the bay. Bathymetric survey data indicate that 1 to 3 feet of sediment was deposited in the upper canal between 3rd Street and Sackett Street between 2003 and 2010 (USEPA, 2011). The upper canal is the reach most affected by the deposition of solids from CSO discharges. Radioisotope analyses of sediment cores from other areas of the canal (i.e., south of 3rd Street) indicated net sediment accumulation rates on the order of 1 to 2 in./yr (GEI, 2007), although most of the cores that were dated showed evidence of disturbances that reduce the accuracy of the age-dating estimates.

Because many of the contaminants that are present at high levels in the Gowanus Canal soft sediments have an affinity for fine-grained sediment particles and organic matter, the fate and transport of these contaminants is related to the fate and transport of the sediments. Sediments deposited in Gowanus Canal may be resuspended by currents, propeller wash, dredging, and other disturbances. The canal is a low-velocity environment, with current velocities generally less than 0.5 ft/s (USACE ERDC, undated). These current speeds are insufficient to substantially erode sediment deposits on the bottom of the canal. Currents generated by the flushing tunnel apparently eroded sediments near the outlet of the tunnel, but the sediments settled out where the current velocities decreased farther down the canal between Sackett and 3rd streets.

Sediments in Gowanus Canal appear to be frequently resuspended and mixed by propeller wash from vessel traffic. The effects of propeller wash are particularly evident in the reach between the Gowanus Expressway and 3rd Street, where minimal sediment accumulation was observed between 2003 and 2010. This reach experiences frequent tug and barge traffic associated with the concrete plant at the end of 5th Street. Evidence of propeller scour was also seen near the southern end of the canal project area in the 2010 bathymetric survey.

Given the low-current velocities in the canal, most of the sediments resuspended by propeller wash likely settle out relatively quickly in the same reach of the canal. However, finer-grained sediment particles that remain suspended in the water column for a longer period of time may be transported out of the canal by tidal currents. The amount of sediment transported out of (or into) the canal in typical weather conditions or during storm events has not been measured or estimated; however, a substantial drop in contaminant concentrations in surface sediments from the middle reach of the canal to the lower reach, and the additional drop from the lower reach of the canal to the Gowanus Bay and Upper New York Bay reference locations (Table 1-5) indicates that much of the sediment-associated contamination remains within the canal.

Groundwater Discharge

As noted in Section 1.4.1, contaminants from upland sites can be transported into the Gowanus Canal in the dissolved phase by groundwater discharge. Figures 1-9a and 1-9b identify areas where transport of PAHs into the canal by groundwater discharge may be occurring. Transport of metals and PCBs to the canal by groundwater discharge does not appear to be a concern, as discussed in Section 1.4.1 and Appendix B.

NAPL Fate and Transport Processes

NAPL in the canal sediments can be transported through the sediments into the water column through several transport mechanisms, including ebullition, seep migration, sheen migration, and groundwater advection.

Ebullition is the production of gas due to anaerobic biological activity in sediment (Viana et al., 2007a). Mineralization of organic matter by bacteria in the sediment generates gases such as methane, nitrogen, and carbon dioxide (Reible, 2004). Ebullition is commonly observed in the soft sediments in the Gowanus Canal, which are rich in organic matter (i.e., average total organic carbon content of 12 percent). The bubbles produced during ebullition tend to accumulate hydrophobic contaminants and colloids, such as NAPL sheen, on their surfaces (Viana et al., 2007b). NAPL can then migrate out of the sediment and upwards through the water column, and be deposited on the water surface as sheen.

A NAPL *seep* is defined as a NAPL discharge when the following occur:

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

NAPL seeps can migrate with groundwater through sediments that are not impacted by NAPL (i.e., NAPL is nonwetting), but migrate more readily through sediments previously impacted with NAPL (NAPL is the wetting phase) (Sale, 2011). When NAPL is nonwetting, water is the wetting phase and the NAPL migrates when the NAPL head exceeds the pore entry pressure of the groundwater. This allows NAPL to migrate to areas previously unaffected by NAPL. When NAPL is the wetting fluid, NAPL discharge is likely continuous because the driving head of NAPL continues to release NAPL along the NAPL-wetted pathway.

An analysis of NAPL impacts at the contact between native and soft sediments in the Gowanus Canal suggests that seep migration is occurring at some locations (Appendix A). The potential for upward NAPL migration in areas where NAPL impacts were observed on both sides of the native-soft sediment contact was investigated further using an equation that balances the resulting forces of the groundwater velocity and the NAPL density (Cohen and Mercer, 1993). The analysis presented in Appendix A indicates that upward groundwater velocities can potentially result in the upward NAPL migration under certain conditions.[5] This is essentially because the upward vertical groundwater velocity appears to be sufficient to overcome the downward density and capillary forces of the NAPL.

NAPL *sheen* is defined as a NAPL discharge when the following occur:

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

[5] The general site conditions were used to grossly estimate the potential for NAPL migration. The actual conditions at specific locations can vary substantially. Additional data collection and evaluation would be necessary to verify NAPL mobility at specific locations.

NAPL sheens migrate by the difference in the surface tensions that result in a positive spreading coefficient as described in Appendix A. In the upland area, NAPL spreads on the groundwater surface in the same way as surface water sheen. In this way, NAPL sheen spontaneously enters water-coated, air-filled pores through capillary forces. These forces overcome gravitational forces and NAPL migrates. However, surface tensions alone are insufficient for the sheen to exceed the pore entry pressure of the groundwater and migrate through nonwetted areas (areas absent of NAPL impacts). Hence, sheen migration occurs only in a previous NAPL-wetted pathway at the interface of groundwater and the vadose zone such as through vadose zone transport from an upland source. Sheens may migrate into the canal where the groundwater surface intersects the canal.

NAPL transport by *groundwater advection* occurs when the groundwater velocity is sufficient to overcome the density and capillary forces required to move the NAPL in the direction of groundwater flow.

SECTION 2

Development and Application of Remediation Goals

This section presents the RAOs, preliminary remediation goals (PRGs), and remediation target areas (RTAs) for the Gowanus Canal. The RAOs are a general description of what the cleanup is expected to accomplish. The RAOs provide the basis for developing numerical remediation goals, which are used to identify the extent of the cleanup (i.e., the RTAs) needed to achieve the RAOs. This section also describes the potential ARARs that must be met by the cleanup.

Remedial actions at CERCLA sites must be protective of human health and the environment. For the Gowanus Canal, numerical remediation goals are based on the site-specific risk assessments rather than ARARs because there are no promulgated federal or New York State sediment cleanup standards. The RAOs are based on the findings of the ERA and HHRA and specify (1) the contaminant of concern, (2) the exposure route(s) and receptor(s), and (3) an acceptable contaminant level (or range of levels) for each exposure route. USEPA's (2005) *Contaminated Sediment Remediation Guidance* states the following:

> When developing RAOs, project managers should evaluate whether the RAO is achievable by remediation of the site or if it requires additional actions outside the control of the project manager . . . the RAOs should reflect objectives that are achievable from the site cleanup.

This FS evaluates remedial alternatives for sediments in the Gowanus Canal. Ongoing discharges to the canal from CSOs and stormwater outfalls are managed by NYCDEP, and migration of contaminants from upland properties to the canal are regulated by NYSDEC. Discharges to the canal through unpermitted outfall structures must also be addressed. Contaminant contributions from these sources must be reduced or eliminated before remediation of Gowanus Canal sediments to prevent recontamination of the canal.

NAPL contamination in native sediment beneath the canal north of the Gowanus Expressway extends beyond the maximum depth of a practical removal remedy for sediments. For example, deep borings installed in the canal adjacent to the Carroll Gardens/Public Place former MGP site indicate that contamination extends to a depth of greater than 50 feet (GEI, 2010). Therefore, the remedy for canal sediments must also prevent recontamination by any deep NAPL that is not removed.

Total suspended solids, grit, and other solids discharged from CSOs that settle in the canal will influence the long-term quality of surface sediment. Long-term contributions of CSO solids should be reduced to the maximum extent practicable to prevent recontamination of the canal.

2.1 Remedial Action Objectives

The RAOs for the Gowanus Canal are as follows:

Ecological

- Reduce to acceptable levels toxicity to benthic organisms in the canal from direct contact with PAHs, PCBs, and metals in sediment
- Reduce to acceptable levels the risk to herbivorous birds from dietary exposure to PAHs

Although the BERA concluded that mercury poses a site-related risk to omnivorous birds, additional analysis of the sediment and tissue data collected for the RI indicates that mercury levels in the Gowanus Canal are similar to those in the Gowanus Bay and Upper New York Bay reference areas (Appendix C). Therefore, an RAO specifically for the protection of omnivorous birds from exposure to mercury was not developed. However, it is expected that the RAO developed for the other contaminants will provide protection from exposure to site-related mercury as well.

Human Health

- Reduce to acceptable levels the risk to human health from the incidental ingestion of and dermal contact with PAHs in sediment and surface water during recreational use of the canal or from exposure to canal overflow
- Reduce the risk to human health from ingestion of PCB-contaminated fish and shellfish collected from the canal

NAPL Mitigation

- Prevent the migration of NAPL into the canal after the remedial action is completed
- Prevent NAPL from serving as a source of contaminants to groundwater discharging to the canal

NAPL mitigation will require a combination of upland source control measures and the use of sediment remediation technologies to prevent recontamination of the canal by NAPL that remains in deep canal sediments after the remedy is implemented. Upland source control measures may also be required to ensure that there is no driving force (pressure head) to cause NAPL seep migration into the canal or sheen migration on the groundwater surface.

2.2 Development of Remediation Goals

Because there are no promulgated standards or criteria that apply to the cleanup of contaminated sediments in New York,[1] remediation goals for sediments in the Gowanus Canal were developed based on the results of the ERA and HHRA. Risk-based PRGs were developed for the contaminants, exposure pathways, and receptors associated with unacceptable risks. Estimated ranges of contaminant concentrations associated with CSO solids were also developed for comparison to the PRGs. In Section 2.4.1, PRGs are used to define the extent of cleanup needed to achieve the RAOs.

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

2.2.1 Risk-Based Preliminary Remediation Goals

The approach used to develop ecological and human health risk-based PRGs and the results of the analysis are summarized below. The detailed analysis is provided in Appendix C.

Ecological

PRGs were developed for the protection of benthic (sediment-dwelling) organisms and herbivorous birds.

Protection of the Benthic Community. PRGs for the protection of benthic organisms were based on the site-specific toxicity test and collocated sediment chemistry data collected for the RI. Concentrations of PAHs, PCBs, and metals (barium, cadmium, copper, lead, mercury, nickel, and silver) were greater than screening values in many samples, and the observed toxicity in laboratory tests could have resulted from the effects of one or a combination of these contaminants. The toxicity test results cannot be used to distinguish which contaminants were causing the effects, although the results for simultaneously extracted metals/acid volatile sulfide analyses presented in the ERA (USEPA, 2011) indicate that the bioavailability of metals is low; thus, it is likely that PAHs caused a significant portion of the observed toxicity in laboratory tests. Therefore, target areas for remediation will be developed based on PRGs for total PAHs and then checked to verify that the potential for adverse effects from exposure to PCBs and metals are also addressed.

PRGs for total PAHs were derived through an analysis of the site-specific toxicity test results and collocated sediment chemistry data to identify the highest total PAH concentration that did not result in unacceptable effects. Sediment toxicity data were available for the following endpoints and test species: (1) survival, growth, and reproduction of the amphipod *Leptocheirus plumulosus*, and (2) survival and growth of the polychaete *Nereis virens*. Two approaches were used to derive PRGs for total PAHs:

- **Graphical**—prepared plots of each toxicity test endpoint versus total PAH concentration in sediment (both the dry weight concentration and TOC-normalized concentration), then identified (1) the lower bound of the range of toxicity test results for the Gowanus Bay and Upper New York Bay reference samples (i.e., the lower bound of the reference envelope), and (2) the level of toxicity associated with a 20 percent reduction relative to control. The lower of these two thresholds was defined as the adverse effects level. The highest no observed adverse effect concentration (NOAEC) was selected as the PRG.
- **Toxicity Response Analysis Program (TRAP)**[2]—used TRAP to estimate the total PAH concentration associated with various percent reductions in response and selected the 20 percent effects concentration (EC_{20}) as the PRG. The EC_{20} is typically considered a chronic response threshold. The TRAP analysis was performed for the amphipod endpoints only because they were more sensitive to chemical contamination than the polychaetes. The 95 percent confidence intervals around the EC_{20} estimates were large, indicating high variability of the dose-response relationships. None of the relationships were statistically significant. Therefore, the TRAP results were used only to verify the PRGs developed using the graphical approach.

2 http://www.epa.gov/med/Prods_Pubs/trap.htm.

The PRGs for total PAHs that address risk to the benthic community through direct contact with sediment are summarized in Table 2-1. These PRGs range from 7.8 to 290 mg/kg. The recommended sediment PRG is 7.8 mg/kg because this value is the no-effect level for the most sensitive toxicity test endpoints (amphipod growth and reproduction).

To evaluate whether the selected PRG for total PAHs would also be protective of the effects of metals and PCBs, total PAH concentrations were plotted against metal and PCB concentrations. In general, samples with elevated PAH concentrations relative to reference locations also had elevated metals and PCB concentrations relative to reference locations (Appendix C). Therefore, remedial actions to address total PAH concentrations above the PRG at most locations should also address potentially toxic concentrations of metals and PCBs.

Protection of Herbivorous Birds. The BERA found unacceptable risks to herbivorous birds through dietary exposure to PAHs. A total PAH PRG for protection of herbivorous birds was derived using the food web model developed for the BERA. The model was used to estimate the total PAH concentration in sediment that would not pose an unacceptable risk to water fowl eating aquatic plants in the Gowanus Canal. The PRG for this endpoint was 230 mg/kg (Table 2-1).

Human Health

Based on the results of the HHRA, risk-based human health PRGs were developed for exposure pathways where individual carcinogenic PAHs contributed a cancer risk greater than 10^{-6} (i.e., one per one million) to a cumulative cancer risk of greater than 10^{-4} (i.e., one per 10,000). PRGs were developed for six carcinogenic PAHs for exposure to nearshore surface sediment and surface water during recreational use of the canal by adults, adolescents, and children. PRGs were calculated based on the site-specific exposure data presented in the HHRA. The ratio between the target risk and the calculated risk was determined for each PAH, and then the ratio was multiplied by the exposure point concentration (EPC) from the HHRA to calculate the PRG (Appendix C). A 10^{-5} target risk level was used for each individual PAH so that the cumulative risk from exposure to all carcinogenic PAHs would not exceed 10^{-4}. The lowest (most protective) PRGs for the recreational use scenario for sediment and surface water are presented in Tables 2-1 and 2-2, respectively.

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

The HHRA results indicated potentially unacceptable risk from the consumption of PCB-contaminated fish and crabs from the Gowanus Canal. Numerical PRGs were not calculated for this exposure scenario because remediation target areas that are developed based on PRGs for PAHs will also address PCBs.

2.2.2 Ongoing Deposition of CSO Solids

As described in Section 1.4.1, the estimated range of PAH concentrations attributable to the ongoing deposition of CSO solids was determined based on CSO wet-weather water sample data collected as part of the RI (Table 1-4). Because the CSO wet-weather water samples collected for the RI are considered to represent the quality of solids discharged from the CSOs, these levels would be expected to persist in canal surface sediments if no CSO improvements were completed. However, the quality of CSO solids may differ in the future as a result of any management actions that are taken. Although CSO discharges are not the only source of solids to the canal, they provide a large contribution.[3]

The risk-based ecological and human health PRGs were compared to the estimated range of concentrations on CSO solids to determine whether RAOs are likely to be achieved under current site conditions. The total PAH concentrations on CSO solids are higher than the most protective ecological PRG, which is based on the protection of the benthic community.

The risk-based human health PRGs for four of the six carcinogenic PAHs are higher than the estimated concentration ranges on CSO solids, and the PRGs for two of the PAHs (benzo(a)pyrene and dibenz(a,h)anthracene) are within the ranges. The cumulative cancer risk from direct exposure to PAHs associated with CSO solids under current conditions is within USEPA's acceptable risk range (Appendix C).

2.3 Potential Applicable or Relevant and Appropriate Requirements (ARARs)

Section 121(d) of CERCLA requires that remedial alternatives attain ARARs unless they are waived in accordance with CERCLA. ARARs are regulations, standards, criteria, or limitations promulgated under federal or more-stringent state laws. An ARAR may be either "applicable" or "relevant and appropriate," but not both. NCP defines applicable, relevant and appropriate, and to-be-considered (TBC) criteria as follows:

- Applicable requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal or state law that directly and fully address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site.
- Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal or state law that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar (relevant) to those encountered at a CERCLA site (relevant) that their use is well suited (appropriate) to the particular site.
- TBC criteria are advisories, criteria, or guidance developed by USEPA, other federal agencies, or states that may be useful in developing CERCLA remedies. They are neither promulgated nor enforceable; however, they may be useful for determining protectiveness or how a remedial action could be performed.

To qualify as a state ARAR under CERCLA and the NCP, a state requirement must be (1) a standard, requirement, criterion, or limitation under a state environmental or facility citing law; (2) promulgated (of general applicability and legally enforceable); (3) substantive (not

[3] The estimated annual load of total suspended solids to the canal from CSO and stormwater discharges is approximately 259,000 lbs (NYCDEP, 2008).

procedural or administrative); (4) more stringent than the federal requirement; (5) identified by the state in a timely manner; and (6) consistently applied.

Another factor in identifying the requirements that must be addressed by remedial alternatives is whether the requirement is substantive or administrative.

"Onsite" CERCLA response actions must comply with the substantive but not the administrative requirements of environmental laws and regulations. Substantive requirements are those pertaining directly to actions or conditions in the environment.

Administrative requirements are mechanisms that facilitate the implementation of the substantive requirements of an environmental law or regulation. In general, administrative requirements prescribe methods and procedures (fees, permitting, inspection, reporting requirements, etc.) by which substantive requirements are made effective for the purposes of a particular environmental or public health program. Offsite actions must comply with all legally applicable requirements, both substantive and administrative.

Specifically, the onsite components of the developed remedial alternatives are evaluated in this FS on the basis of whether they can be designed to meet substantive requirements. For example, onsite noncommercial treatment facilities constructed and operated to dewater or to stabilize sediments prior to their transport to an offsite facility for further treatment or disposal must be designed to comply with effluent limitations. Administrative requirements, such as obtaining a permit, would not be applicable. An offsite commercial facility where the sediments may be transported for offsite stabilization would be required to comply with both the administrative (have the appropriate permits) and substantive requirements. All alternatives (with the exception of the No Action alternative) include at least onsite dewatering; some alternatives include additional elements that would be performed onsite (for example, stabilization) and that also would need to comply with substantive requirements.

ARARs are grouped into three types: chemical-specific, action-specific, and location-specific. Tables 2-3 through 2-5 provide the chemical-specific, action-specific, and location-specific ARARs and TBCs that may apply to remedial actions in the Gowanus Canal.

Chemical-specific ARARs include laws and requirements that define health- or risk-based numerical values or methodologies applied to site-specific conditions that can be used to establish remediation goals. Many potential ARARs associated with specific remedial actions (i.e., discharges) can be characterized as action-specific but include numerical values or methodologies to establish them, so they fit in both the chemical- and action-specific categories. Table 2-3 lists the preliminary chemical-specific ARARs for the Gowanus Canal.

Action-specific ARARs regulate the specific type of action or technology under consideration, including the management of regulated materials. Table 2-4 lists the preliminary action-specific ARARs identified for the Gowanus Canal.

Location-specific ARARs are requirements that relate to the geographical position of the site. State and federal laws and regulations that apply to the protection of wetlands, construction in floodplains, and protection of endangered species are examples of location-specific ARARs. Preliminary location-specific ARARs for the Gowanus Canal are provided in Table 2-5.

2.4 Remediation Target Areas

The following criteria were used to divide the Gowanus Canal into target areas for remediation:

- Comparison of PAH concentrations in surface and subsurface sediment to ecological and human health-based PRGs
- Occurrence and distribution of NAPL in soft and native sediments
- Present day channel depth and depth required for commercial navigation

Each of these criteria is described further in Sections 2.4.1 through 2.4.3, and a description of the RTAs defined by considering all criteria is provided in Section 2.4.4.

2.4.1 Application of Preliminary Remediation Goals

Ecological Protection

Total PAH concentrations in surface and subsurface sediments in the Gowanus Canal were compared with risk-based PRGs to identify target areas for remediation. Surface sediment (the 0-to-6-inch depth interval) represents the biologically available zone and is the layer of sediment that poses the greatest risk to humans and ecological receptors. However, receptors could be exposed to subsurface sediment if the surface sediment was eroded (for example, due to propeller wash) or removed (for example, if soft sediments were partially dredged). Therefore, the PRGs were also compared to the subsurface soft and native sediments.

Total PAH concentrations in surface sediment, soft sediment, and native sediment throughout the Gowanus Canal are shown in Figures 2-1a through 2-1c, respectively. These figures also show the PRGs that are related to the protection of ecological receptors (Table 2-1). The surface sediment plot (Figure 2-1a) also shows the estimated range of PAH concentrations on CSO solids. A logarithmic scale was used to display total PAH concentrations because of the wide range of concentrations measured.

Total PAH concentrations in all of the surface sediment samples exceed the PRG based on the protection of the benthic community, but most are lower than the PRG based on the protection of herbivorous birds (Figure 2-1a). Total PAH concentrations in surface sediment are within the range measured on CSO solids discharged from the four major CSO outfalls except near the Carroll Gardens/Public Place and Metropolitan former MGP sites, where PAH concentrations are substantially higher. PAH concentrations in surface sediment are also relatively higher near and immediately downstream of the Fulton former MGP site.

Total PAH concentrations in almost all of the soft sediment samples upstream of the Gowanus Expressway exceed the most protective ecological PRG, in some cases by more than three orders of magnitude (Figure 2-1b). As with surface sediments, the highest total PAH concentrations are found in the vicinity of the Carroll Gardens/Public Place and Metropolitan former MGP sites. Downstream of the Gowanus Expressway, total PAH concentrations in most of the soft-sediment samples exceed the most protective PRG, but overall concentrations are lower than those upstream of the expressway.

Total PAH concentrations in the majority of native sediment samples north of the Gowanus Expressway exceed the ecological PRGs (Figure 2-1c). Approximately 1,500 feet south of the Gowanus Expressway, total PAH concentrations in most native sediment samples are below the PRGs.

Based on these comparisons, remedial alternatives will be developed and evaluated for the entire sediment column throughout the length of the canal. In native sediment, the vertical extent of NAPL contamination and high PAH concentrations in most areas north of the Gowanus Expressway are greater than the vertical limit of investigation. South of the Gowanus Expressway, the average total PAH concentration in native sediment is substantially lower.

Human Health Protection

As described in Section 2.2.1, the human-health PRGs for six carcinogenic PAHs are based on a cancer risk of 10^{-5}, so that the cumulative risk from exposure to all six PAHs will not exceed 10^{-4}. The following procedure was used to identify specific locations where the cumulative risk from exposure to the six individual PAHs in surface sediments exceeds 10^{-4}:

- Identify the PAH concentration in each sample collected from a location that was determined to be a human health exposure point in the HHRA (USEPA, 2011)
- Calculate the ratio of each PAH concentration to the PRG
- Add the ratios for all PAHs at each sample location
- Identify samples with a sum of greater than 10, which corresponds to a cumulative risk of greater than 10^{-4}

The results of this analysis are provided in Table 2-6. This table shows the ratio of each PAH to the PRG at each sample location, and identifies the sample locations where the sum of the ratios exceeds 10. Based on this analysis, the sediment at the head of the 6th Street basin poses the greatest human health risk.

Human health exposure points within the Gowanus Canal were defined in the HHRA as areas with shallow or exposed sediments. Although most of the subsurface sediments in the canal are too deep to be human health exposure points if the overlying surface sediments were eroded or removed, the subsurface soft sediment data were compared with human-health-based PRGs to provide a general indication of potential risk if they were remobilized and deposited in shallow areas (Appendix C). This analysis indicates that PAH concentrations in subsurface soft sediments in the middle reach of the canal most frequently exceed the human-health-based PRGs.

Human-health-based surface water PRGs were not used directly to identify target areas for remediation. However, the remediation of PAH-contaminated sediments in the canal is expected to reduce PAH concentrations in surface water to acceptable levels.

2.4.2 NAPL Occurrence and Distribution

The occurrence and distribution of NAPL-saturated intervals in soft and native sediments vary by reach in the Gowanus Canal, as follows:

- Between the head of the canal and approximately 4th Street, including the 4th Street basin, soft sediments contain only localized NAPL impacts, and native sediments contain many NAPL-saturated intervals.
- Between approximately 4th Street and 9th Street, including the 6th and 7th Street basins, NAPL saturation is widespread in both soft and native sediments.
- Between approximately 9th Street and the south side of the Gowanus Expressway, including the 11th Street basin, soft sediments have localized NAPL impacts near the Metropolitan former MGP site, and native sediments have many NAPL-saturated intervals.
- South of the Gowanus Expressway, soft sediments contain only localized NAPL impacts near Bryant Street; no NAPL-saturated intervals were identified in native sediments.

2.4.3 Navigational Depth Requirements

The Gowanus Canal can be divided into the following reaches based on its depth and use for commercial navigation:

- Between the head of the canal and 3rd Street (Reach 1): depths of less than -15 feet NAVD88; no commercial navigation
- Between 3rd Street and the Gowanus Expressway/Hamilton Avenue (Reach 2): depths generally between -8 and -16 feet NAVD88; used for commercial navigation but not a federally authorized channel; navigational depth requirement of -16 feet NAVD88 estimated by USACE in a dredging alternatives analysis (USACE, 2009)
- Between the Gowanus Expressway/Hamilton Avenue and Sigourney Street (Reach 3a): depths generally between -15 and -20 feet NAVD88; used for commercial navigation and federally authorized to a depth of -21 feet NAVD88[4]
- Between Sigourney Street and the south end of the study area (Reach 3b): depths of greater than -20 feet NAVD88; used for commercial navigation and federally authorized to a depth of -33 feet NAVD88[5]

The bathymetric map of the lower reach of the canal (Figure 1-5c) shows a steep increase in channel depth at Sigourney Street corresponding to the increase in federally authorized channel depth.

2.4.4 Summary of Remediation Target Areas

The comparison of PAH concentrations in sediment to PRGs shows that the entire soft-sediment column throughout the study area should be addressed. In addition, PAH concentrations in the majority of the native sediment samples collected north of the Gowanus Expressway and many of the native sediment samples collected south of the expressway also exceed PRGs.

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[4] -18 feet MLLW.

[5] -30 feet MLLW.

NAPL distribution in the soft sediments is most pervasive in Reach 2. Soft sediments in Reach 1 and Reach 3 contain localized areas of NAPL contamination.

In native sediment, NAPL is present in Reaches 1 and 2 to at least the maximum depth investigated in the RI (i.e., generally 6 feet below the interface between soft and native sediments, although some cores recovered up to 13 feet of native sediment). Additionally, borings installed by National Grid near the Carroll Gardens/Public Place former MGP site in Reach 2 indicate NAPL contamination to depths of greater than 50 feet. NAPL saturation was not observed in the native sediment in Reach 3.

These data indicate that the vertical extent of contamination exceeds the practical limit of a sediment removal remedy in most areas north of the Gowanus Expressway. Therefore, the remedial alternatives developed in this FS must ensure that deeper NAPL contamination left in place does not cause recontamination of canal surface sediments through seep migration, ebullition, or groundwater advection (including NAPL transport by advection and NAPL solubilization to groundwater).

Navigational depth requirements also were considered. The navigational depth requirement differs within each reach of the canal. These differences may result in different remedial approaches for each reach.

Based on the characteristics identified above, the canal was divided into three RTAs, as shown in Table 2-7 and Figure 2-2. Average concentrations of other constituents of concern in each RTA are shown in Table 2-8.

RTA 1, which corresponds to Reach 1, includes the main channel from the head of the canal to 3rd Street. RTA 1 has the following characteristics:

- Relatively lower soft-sediment PAH concentrations than RTA 2
- Localized NAPL impacts in soft sediment and widespread NAPL impacts in native sediments
- No commercial navigation

RTA 2, which generally corresponds to Reach 2, includes the main channel from 3rd Street to the south side of the Gowanus Expressway, including the 4th, 6th, 7th, and 11th Street basins. RTA 2 has the following characteristics:

- The highest soft-sediment PAH concentrations in the project area
- Widespread NAPL impacts in soft sediments adjacent to the Carroll Gardens/Public Place former MGP site, localized impacts in soft sediments near the Metropolitan former MGP site, and widespread NAPL impacts in native sediments
- Commercial navigation in a channel with no federal authorization

RTA 3, which corresponds to Reach 3, extends from the south side of the Gowanus Expressway to the south end of the project area. RTA 3 has the following characteristics:

- The lowest soft-sediment PAH concentrations relative to the other RTAs
- Minimal NAPL impacts in soft and native sediments

- Commercial navigation in a federally authorized channel.

RTA 3 is further divided into RTAs 3a and 3b on the basis of channel depth, with RTA 3a (corresponding to Reach 3a) extending from the south side of the Gowanus Expressway to Sigourney Street, and RTA 3b (corresponding to Reach 3b) from Sigourney Street to the south end of the study area.

The RTAs identified above are addressed by the remedial alternatives presented in Section 4.

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SECTION 3

Identification and Screening of Remedial Technologies

This section presents the process by which potential remedial technologies for Gowanus Canal sediments are identified and screened. The following three-step process was used:

1. Identify general response actions (GRAs) that can accomplish the RAOs identified in Section 2
2. Establish the process for initial screening of potential remedial technologies and evaluation criteria
3. Identify and screen potential remedial technologies against the evaluation criteria and in consideration of the nature and extent of contamination and other site-specific factors

3.1 General Response Actions

GRAs are broad categories of action that, with the exception of the No Action alternative, can be expected to accomplish the RAOs. GRAs may be used in combination with one another. The No Action alternative is included as it is required by NCP (Title 40 Code of Federal Regulations § 300.430(e)), as a baseline alternative against which all other alternatives are compared.

The GRAs selected to address the RAOs were developed from nine primary remediation strategy categories. Table 3-1 lists the GRAs that are appropriate for consideration at the Gowanus Canal.

3.2 Technology Screening Process and Evaluation Criteria

Technology screening was conducted following the technology screening guidance described in the USEPA *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (USEPA, 1988). In addition, the technologies identified and screened are consistent with the USEPA *Contaminated Sediment Remediation Guidance for Hazardous Waste Sites* (USEPA, 2005). Potential remedial technologies and process options were screened according to the following three established criteria:

- Technical effectiveness
- Implementability
- Cost

3.2.1 Technical Effectiveness

The technical effectiveness of a technology/process option was evaluated based on its ability to meet the RAOs under the conditions and limitations present at the site. The technical effectiveness criterion was used to determine which remedial technologies would be effective based on the nature and extent of contamination, site characteristics, and other engineering considerations. The NCP defines effectiveness as the "degree to which an alternative reduces toxicity, mobility, or volume through treatment, minimizes residual risk, affords long-term protection, complies with ARARs, minimizes short-term impacts, and how quickly it achieves protection." Remedial technologies that are not likely to be effective for addressing sediment contamination within the Gowanus Canal are screened out and not retained for further evaluation.

3.2.2 Implementability

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

3.2.3 Cost

The primary purpose of the cost-screening criterion is to allow for a comparison of rough costs associated with the technologies/process options. The cost criterion addresses costs to implement the technology/process option and long-term costs to operate and maintain the remedy. At this stage of the process, the cost criterion is qualitative and used for rough comparative purposes only.

Each technology was evaluated on a scale of 1 to 4 for each of the established screening criteria, with 1 being the lowest ranking and 4 being the highest ranking. The qualitative definitions for each screening criteria are presented in Table 3-2. The ranking numbers are qualitative only and are not used as the basis of screening (i.e., whether a technology/process option is retained or not).

3.3 Identification of Remedial Technologies and Initial Screening

This section presents an overview of the remedial technologies and process options that were identified to address the impacted sediment at the Gowanus Canal Superfund Site. GRAs may be addressed by several types of remedial technologies and process options. Remedial technologies (e.g., capping, disposal) are general categories of technologies and process options (e.g., reactive cap, landfill) are specific processes within a remedial technology category. The identification of remedial technologies and process options and the initial screening process are intended to evaluate the various technologies identified against the established criteria (effectiveness, implementability, and cost) and eliminate technologies and process options that are inappropriate or infeasible for addressing RAOs established for the site. Remedial technologies/process options that are retained after screening are then combined into potential remedial alternatives for the site. Table 3-3 presents the descriptions of the remedial technologies and process options that were identified and the initial screening evaluation as they apply to sediment within the Gowanus Canal.

3.4 Results of Technology Screening Using Established Criteria

The initial screening process evaluated the remedial technologies and process options for effectiveness, implementability, and cost. Remedial technologies and process options that would not effectively address sediment contamination within the Gowanus Canal were eliminated. Table 3-3 screens technologies and process options. Table 3-4 summarizes the results of the screening and the technologies and representative process options that were retained and carried forward for the development of remedial alternatives in Section 4. Note that often there are multiple process options within a remedial technology type that could be applied within the canal. In many cases, one representative process option was carried forward for use in developing remedial alternatives and estimating the associated costs in the FS. During remedial design, other process options may be used in addition to or instead of the representative process options listed in this FS. The process options incorporated into the remedial design will achieve the established RAOs and support the long-term effectiveness of the selected remedy.

As described in USEPA *Contaminated Sediment Remediation Guidance for Hazardous Waste Sites* (USEPA, 2005*)*, three potential remedy approaches should be evaluated at every sediment site: dredging, in situ capping, and monitored natural recovery (MNR). Dredging and in situ capping were retained in the technology-screening process for the Gowanus Canal, but MNR was not, because site conditions in the Gowanus Canal are not conducive to MNR. Some of the site conditions that are conducive to MNR are as follows (USEPA, 2005):

- Anticipated land uses or new structures are not incompatible with natural recovery
- Natural recovery processes have a reasonable degree of certainty to continue at rates that will contain, destroy, or reduce the bioavailability or toxicity of contaminants within an acceptable timeframe
- Sediment bed is reasonably stable and likely to remain so
- Sediment is resistant to resuspension (e.g., sediment is cohesive or well-armored)
- Contaminant concentrations in biota and in the biologically active zone of sediment are moving towards risk-based goals on their own
- Contaminant concentrations are low and cover diffuse areas

The canal is used for navigation in RTA 2 and RTA 3. Therefore, future dredging may be required, which would expose higher contaminant concentrations in subsurface sediments. Furthermore, contaminant concentrations in CSO solids are expected to control the long-term quality of the surface sediment and inhibit any measureable recovery that might occur in surface sediments that currently have relatively lower contaminant concentrations. If discharges of CSO solids were reduced or eliminated, then the timeframe needed to reduce surface sediment concentrations to acceptable levels could be unacceptably long. Additionally, sediments in RTA 2 and RTA 3 are resuspended by propeller wash, and the stability of the sediment bed in RTA 1 could be affected by increased current velocities resulting from flushing tunnel upgrades. These factors collectively would reduce the effectiveness of MNR as an approach for achieving RAOs in an acceptable timeframe.

SECTION 4

Development, Screening, and Analysis of Remedial Alternatives

The purpose of this section is to develop, screen, and evaluate remedial alternatives that will address the RAOs for the Gowanus Canal. The remedial alternatives were developed by assembling the remedial technologies and process options retained in Section 3. This section defines the criteria to be used in screening and evaluating alternatives; describes the alternatives; and screens them on the basis of effectiveness, implementability, and cost. The alternatives that are retained following the screening are then described in more detail and analyzed individually and comparatively using the established evaluation criteria.

4.1 Evaluation Process and Criteria

The NCP defines nine criteria—classified as threshold, balancing, or modifying—to be used for the evaluation and analysis of remedial alternatives. The definitions of these criteria from the USEPA RI/FS guidance (USEPA, 1988) are presented below. The alternatives were also qualitatively evaluated with respect to sustainability and green remediation metrics.

Potential alternatives were first screened with respect to effectiveness, implementability, and cost to reduce the number of alternatives to be analyzed in detail. For the alternatives that were retained, the detailed analysis was performed using a two-step process. During the first step, each alternative was evaluated individually against the NCP criteria and the sustainability/green remediation metrics. In the second step, a comparative analysis was performed using the same criteria to identify key differences between alternatives. The detailed analysis presents the significant components of each alternative, the assumptions used, and the uncertainties associated with the assessment.

4.1.1 NCP Threshold Criteria

To be eligible for selection, an alternative must meet the threshold criteria described below, or in the case of compliance with ARARs, a waiver, if necessary, must be justified.

Overall Protection of Human Health and the Environment

This criterion evaluates whether an alternative can protect human health and the environment. This criterion draws on the analyses performed for other evaluation criteria, particularly long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs. Evaluation of overall protection of human health and the environment offered by each alternative focuses on the following:

- Determining whether an alternative achieves adequate protection
- Considering how site risks associated with each exposure pathway are either eliminated, reduced, or controlled through treatment, engineering, or institutional controls

- Determining if an alternative will result in any unacceptable short-term or cross-media effects

Compliance with ARARs

This evaluation criterion is used to determine whether an alternative meets the substantive portions of the federal and state ARARs defined in Section 2 and in Tables 2-3, 2-4, and 2-5. It must be noted that under CERCLA, permits are not required for actions conducted onsite; however, the substantive requirements of the associated ARARs must be met.

CERCLA authorizes the waiver of an ARAR with respect to a remedial alternative if any of the following bases exist (USEPA, 1988):

- The alternative is an interim measure that will become part of a total remedial action that will attain the ARAR
- Compliance with the requirement will result in greater risk to human health and the environment than other alternatives
- Compliance with the requirement is technically impracticable from an engineering perspective
- The alternative will attain a standard of performance that is equivalent to that required under the otherwise applicable standard, requirement, or limitation through use of another method
- With respect to a state requirement, the state has not consistently applied, or demonstrated the intention to consistently apply, the promulgated requirement in similar circumstances at other remedial actions within the state
- For Superfund-financed response actions only, an alternative that attains the ARAR will not provide a balance between the need for protection of human health and the environment at the site and the availability of Fund monies to respond to other sites.

4.1.2 NCP Balancing Criteria

Alternatives meeting the threshold criteria are further evaluated using the following five primary balancing criteria.

Long-Term Effectiveness and Permanence

The assessment against this criterion evaluates the long-term effectiveness of the alternatives in maintaining consistent protection of human health and the environment after the RAOs have been met. A key component of this evaluation is to consider the extent and effectiveness of controls that may be required to manage risk posed by treatment residuals and/or untreated waste. The long-term effectiveness of an alternative is assessed by considering the following two factors:

- **Magnitude of residual risk** assesses the residual risk remaining from untreated waste or treatment residuals at the conclusion of the remedial activities.

- **Adequacy and reliability of controls** evaluates the capability and suitability of controls, if any, that are used to manage treatment residuals or untreated wastes that remain at the site.

Reduction of Toxicity, Mobility, or Volume Through Treatment

This evaluation criterion addresses the statutory preference for selecting remedial actions that employ treatment technologies resulting in the permanent and significant reductions of toxicity, mobility, or volume of the hazardous substances as their principal element. This preference is satisfied when treatment is used to reduce the principal threats at a site through destruction of toxic contaminants, irreversible reduction in contaminant mobility, or reduction of total volume of contaminated media. The following six factors are considered when evaluating alternatives against this criterion:

- The treatment processes the remedy will employ and the materials they will treat
- The amount of hazardous materials that will be destroyed or treated (including how the principal threat(s) will be addressed)
- The degree of expected reduction in toxicity, mobility, or volume measured as a percentage of reduction (order of magnitude)
- The degree to which the treatment is irreversible
- The type and quantity of treatment residuals remaining following treatment
- Whether the alternative satisfies the statutory preference for treatment as a principal element

Of particular importance in evaluating this criterion is the assessment of whether treatment is used to reduce principal threats, including the extent to which toxicity, mobility, or volume is reduced either alone or in combination.

Short-Term Effectiveness

This criterion assesses the effects of the alternative during its construction and implementation until the RAOs are met. Alternatives are evaluated with respect to their effects on human health and the environment during their implementation. The following factors are considered when evaluating alternatives against this criterion:

- **Protection of the community during remedial actions** addresses any risk resulting from the remedy implementation. Examples include dust from excavations, transportation of hazardous materials, and air-quality impacts.
- **Protection of workers during remedial actions** assesses threats potentially posed to workers and the effectiveness and reliability of protective measures that would need to be taken.
- **Environmental impacts** considers the environmental impacts potentially resulting from the construction and implementation of the alternative and assesses the reliability of available mitigation measures for preventing or reducing those impacts.

- **Time until RAOs are achieved** includes an estimate of the time required to achieve protection for either the entire site or individual elements associated with specific site areas or threats.

Implementability

The implementability criterion assesses the technical and administrative feasibility of implementing an alternative and the availability of various services and materials required during the remedy implementation. The following factors are considered when evaluating alternatives against this criterion:

- **Technical feasibility** includes the following**:**
  - **Construction and operation** relates to the technical difficulties and unknowns associated with a technology.
  - **Reliability of technology** focuses on the likelihood that technical problems associated with the implementation will result in schedule delays.
  - **Ease of undertaking additional remedial action** includes a discussion of what, if any, future remedial actions may need to be performed and how difficult it would be to implement those actions.
  - **Monitoring considerations** addresses the ability to monitor the effectiveness of the remedy and includes an evaluation of exposure risk should monitoring be insufficient to detect a failure.
- **Administrative feasibility** assesses the activities required to coordinate with other offices and agencies (e.g., access, right-of-way).
- **Availability of services and materials** includes an evaluation of the availability of appropriate offsite treatment, storage capacity, and disposal services; necessary equipment and specialists; services and materials (including the potential for competitive bidding); and the availability of prospective technologies.

Cost

This criterion includes all the engineering, construction, and operations and maintenance (O&M) costs incurred over the life of the project. The evaluation of cost includes three principal components:

- **Capital costs** includes direct (construction) and indirect (nonconstruction and overhead) costs. Equipment, labor, and materials required for the installation of the remedy are considered direct costs. Indirect costs consist of those expenses related to the engineering, financial, and other services that are necessary to complete the remedy installation but are not part of the actual installation or construction activities.
- **Annual O&M costs** refers to postconstruction expenditures required to ensure continued effectiveness of the remedial action. Components of annual O&M costs include auxiliary materials, monitoring expenses, equipment or material replacement, and 5-year review reporting.

- **Present worth analysis** is a method of evaluating expenditures such as construction and O&M that occur over different lengths of time. This allows costs for remedial alternatives to be compared by discounting all costs to the year that the alternative is implemented. The present worth of a project represents the amount of money, which if invested in the initial year of the remedy and disbursed as needed, would be sufficient to cover all costs associated with the remedial action.

The level of detail required to analyze each alternative with respect to the cost criteria depends on the nature and complexity of the site, the types of technologies and alternatives being considered, and other project-specific considerations. The analysis is conducted in sufficient detail to understand the significant aspects of each alternative and to identify the uncertainties associated with the evaluation.

The cost estimates presented for each alternative have been developed for the purpose of comparing the alternatives. The final costs of the selected remedy will depend on actual labor and material costs, competitive market conditions, final project scope, the implementation schedule, and other variables. The cost estimates are order-of-magnitude estimates with an intended accuracy range of plus 50 to minus 30 percent. The range applies only to the alternatives as they are described in this report and does not account for changes in the scope of the alternatives. Selection of specific technologies or processes to configure remedial alternatives is not intended to limit flexibility during remedial design but to provide a basis for preparing cost estimates. The specific details of the selected remedial alternative and the corresponding cost estimate need to be refined during the final remedial design.

4.1.3 NCP Modifying Criteria

The two modifying criteria are state acceptance and community acceptance. The evaluation of these criteria is typically not completed until state and public comments are received on the Proposed Plan.

4.1.4 Sustainability

The USEPA Office of Solid Waste and Emergency Response (OSWER), as well as USEPA Region 2, have a goal to implement sustainable and/or green practices as part of remedial actions, where practicable. The OSWER Technology Primer titled *Green Remediation: Incorporating Sustainable Environmental Practices into Remediation of Contaminated Sites* (USEPA, 2008) cites the following six core elements of green remediation:

- Energy requirements of the treatment system
- Air emissions
- Water requirements and impacts on water resources
- Land and ecosystem impacts
- Material consumption and waste generation
- Long-term stewardship actions

Similarly, USEPA Region 2 has implemented a "Clean & Green" Policy that establishes a preference for the following (USEPA, 2010):

- One hundred percent use of renewable energy, and energy conservation and efficiency approaches, including EnergyStar equipment
- Cleaner fuels and clean diesel technologies and strategies
- Water conservation and efficiency approaches, including WaterSense products
- Sustainable site design
- Industrial material reuse or recycling within regulatory requirements
- Recycling applications for materials generated at or removed from the site
- Environmentally preferable purchasing
- Greenhouse gas emission reduction technologies

The disposal options considered in this FS are evaluated qualitatively against a number of sustainability metrics that include these principal elements. The intent of this evaluation is to highlight differences among the disposal options with respect to sustainability and green practices or elements.

4.2 Summary of Alternatives

Six remedial alternatives were developed for the Gowanus Canal using various combinations of the remedial technologies that were retained in the screening evaluation in Section 3. A combined approach will be necessary to achieve the RAOs for the canal. USEPA's *Contaminated Sediment Remediation Guidance for Hazardous Waste Sites* (USEPA, 2005) identifies NCP remedy expectations and their potential application to contaminated sediments. These factors, summarized below, were considered in the development of remedial alternatives for the canal:

- **Use treatment to address principal threats wherever practicable**. In situ and ex situ treatment options were incorporated into the alternatives for the canal.
- **Use engineering controls such as containment for waste that poses a relatively low long-term threat or where treatment is impractical**. Capping is incorporated into the remedial alternatives for the canal to address contaminated sediments that cannot be removed or effectively treated.
- **Use a combination of methods, as appropriate, to achieve protection of human health and the environment**. The remedial alternatives for the canal are various combinations of dredging, capping, treatment, disposal, and beneficial-use options.
- **Use institutional controls as needed to supplement engineering controls to prevent or limit exposure**. Institutional controls will be incorporated into the remedy for the canal as needed to assist in maintaining the long-term integrity of the cap and for controlling long-term exposure from treated materials that are beneficially used onsite.
- **Consider using innovative technologies when they offer the potential for comparable or superior treatment performance or implementability**. Innovative in situ and ex situ treatment technologies have been incorporated into the alternatives; in particular, in situ

stabilization (ISS) has been evaluated as a potential measure for reducing the mobility of NAPL that cannot be practicably removed from the canal.

- **Prevent further migration of groundwater plumes and exposure to contaminants in groundwater**. The alternatives for the canal sediments include a source control component that will address ongoing migration of NAPL and dissolved-phase contaminants in groundwater into the canal.

Each of the alternatives (except No Action) has dredging and capping components. Capping is a component of all alternatives because NAPL-contaminated sediments are present to depths that exceed the practicable depth of removal. However, a capping-only alternative is not included for the following reasons: (1) a cap in the upper reach of the canal (RTA 1) would further restrict the water depth in the canal and result in a relatively large area of exposed sediment at low tide; (2) a cap in the middle reach of the canal (RTA 2) would compress soft sediments and mobilize the NAPL within them; and (3) a capping-only remedy would be incompatible with the continued use of the canal for commercial navigation.

The sediments dredged under any of the alternatives could be treated and/or disposed of using a variety of methods; treated sediments may be beneficially used. The dredging and capping alternatives are combined with one or more of the treatment/disposal options to create a complete remedial alternative.

In order for any of the proposed remedial alternatives to be effective, upland sources of contamination—including discharges from CSOs, from the former MGP sites and other contaminated sites along the canal, and from the unpermitted pipes along the canal—must be controlled. These upland source controls need to be coordinated and implemented in concert with the selected sediment remedy to prevent recontamination of the canal following remedy implementation. All of the alternatives in this FS rely upon the successful implementation of these controls; therefore, they are included as the first component of all the alternatives. The source control measures that will be developed are included by reference in this FS.

The following dredging and capping alternatives were developed for the Gowanus Canal:

- Alternative 1: No Action
- Alternative 2
  - Dredge soft sediment to a specified elevation
  - Cap with isolation layer and armor layer
- Alternative 3
  - Dredge soft sediment to a specified elevation
  - Cap with treatment layer, isolation layer, and armor layer
- Alternative 4
  - Dredge entire soft sediment column
  - Cap with isolation layer and armor layer
- Alternative 5
  - Dredge entire soft sediment column
  - Cap with treatment layer, isolation layer, and armor layer

- Alternative 6
  - Dredge entire soft sediment column
  - Solidify top 3–5 feet of native sediment in targeted areas
  - Cap with isolation layer and armor layer
- Alternative 7
  - Dredge entire soft sediment column
  - Solidify top 3–5 feet of native sediment in targeted areas
  - Cap with treatment layer, isolation layer, and armor layer

The following treatment and disposal options for dredged sediments were identified:

- Option A: Offsite thermal desorption and beneficial use
- Option B: Offsite disposal (landfill)
- Option C: Offsite cogeneration and beneficial use
- Option D: Offsite stabilization and offsite beneficial use
- Option E: Onsite stabilization and onsite beneficial use
- Option F: Offsite stabilization and placement in onsite constructed CDF
- Option G: Onsite stabilization and placement in onsite constructed CDF

The dredging-and-capping alternatives and treatment/disposal options are briefly described in Sections 4.2.1 and 4.2.2, respectively. The dredging-and-capping alternatives and treatment/disposal options are screened separately in Section 4.3. The alternatives and treatment/disposal options that were retained for detailed evaluation after the screening step are detailed in Section 4.4.

4.2.1 Dredging-and-Capping Alternatives

Table 4-1 presents the major components of each alternative. Alternatives 2 through 7 include the following common elements, which are detailed in Section 4.4:

- Predesign investigation
- Upland source control
- Preconstruction and bulkhead stabilization and repair
- Dredging
- Sediment dewatering and stabilization
- Cap placement
- Dredge cell dewatering and water treatment

Alternative 1

Per the NCP requirement, the No Action alternative is carried through the entire FS process as the baseline condition against which the performance of the remaining alternatives is evaluated.

Alternative 2

In Alternative 2, the soft sediment in RTAs 1 and 3 would be removed to a specified elevation, and all of the soft sediment would be removed from RTA 2. Partial removal of soft sediment in RTA 2 was not considered because of the high degree of NAPL contamination in these sediments. The upper canal (RTA 1) is no longer used for commercial navigation; however, this reach of the canal must have depth sufficient to operate the flushing tunnel, and vessels will need to navigate this reach of the canal to perform cap monitoring and maintenance as well as sewer system and flushing tunnel maintenance. The final elevation was determined on the basis of the two following objectives: (1) ensure that the final sediment surface remains submerged throughout the tidal cycle and (2) minimize remedy implementation challenges (e.g., allow sufficient water depth for construction work throughout the tidal cycle). In RTA 2, a navigation depth of -16 feet NAVD was assumed (see Section 2.4.3). Therefore, all of the soft sediment and some native sediment would be removed to accommodate the cap thickness and allow for continued commercial vessel use in this reach. The removal elevations in RTA 3 were determined on the basis of the conceptual cap thickness and the federally authorized navigation depths.

Final Target Elevations, Cap Thickness, and Dredge Elevations: Alternative 2

	RTA 1	RTA 2	RTA 3a	RTA 3b
Final target elevation (NAVD88)	-7	-16	-21	-33
Buffer thickness (ft)	2	2	2	2
Cap surface elevation (NAVD88)	-9	-18	-23	-35
Cap thickness (ft)	2.5	2.5	2.5	2.5
Target dredge elevation (NAVD88)	-11.5	-20.5	-25.5	-37.5

The conceptual cap for this alternative is 2.5 feet thick, consisting of the following layers, from top to bottom:

- Armor layer: 1.5 feet of stone with a median diameter of 0.75 feet. Approximately 0.5 feet of sand will be placed on top of the armor layer to fill in the voids between the stones in order to facilitate benthic recolonization.
- Isolation layer: 0.5 feet of gravel and 0.5 feet of sand.

Alternative 3

Alternative 3 is the same as Alternative 2, except that the conceptual cap design includes an oleophilic clay treatment layer in addition to the isolation and armor layers. The treatment layer will mitigate the impacts of ebullition and upward migration of NAPL and dissolved-phase contaminants in groundwater.

Final Target Elevations, Cap Thickness, and Dredge Elevations: Alternative 3

	RTA 1	RTA 2	RTA 3a	RTA 3b
Final target elevation (NAVD88)	-7	-16	-21	-33
Buffer thickness (ft)	2	2	2	2
Cap surface elevation (NAVD88)	-9	-18	-23	-35
Cap thickness (ft)	3.5	3.5	3.0	3.0
Target dredge elevation (NAVD88)	-12.5	-21.5	-26.0	-38.0

The target dredge elevations for this alternative are slightly deeper in RTAs 1 and 3 because the cap is thicker.

The conceptual cap for this alternative is 3.5 feet thick in RTA 1 and RTA 2 and 3 feet thick in RTA 3. The cap consists of the following layers (from top to bottom):

- Armor layer: 1.5 feet of stone with a median diameter of 0.75 feet. Approximately 0.5 feet of sand will be placed on top of the armor layer to fill in the voids between the stones in order to facilitate benthic recolonization.
- Isolation layer: 0.5 feet of gravel and 0.5 feet of sand.
- Treatment layer (oleophilic clay): 1 foot in RTA 1 and RTA 2, and 0.5 feet in RTA 3.

Alternative 4

In Alternative 4, all of the soft sediment within the canal would be removed, and a cap would be placed on top of the native sediment. The conceptual cap for this alternative is the same as the cap described for Alternative 2, one consisting of an armor layer and an isolation layer. The native sediment surface elevation is variable within the canal; therefore there is not a single specific removal elevation in RTAs 1 or 3 under this alternative. In RTA 1, the native surface elevation ranges from -11.8 to -25.6 feet NAVD88. In RTA 3, the native surface elevation—and therefore the target dredge elevation—ranges from -18.9 to -44.2 feet NAVD88. The removal of all the soft sediment in RTA 1 and RTA 3 will allow for the placement of the cap and at the same time meet navigational needs. The target dredge elevation for RTA 2 is the same as that listed for Alternative 2.

Alternative 5

In Alternative 5, all of the soft sediment within the canal would be removed, and a cap would be placed on top of the native sediment surface. The conceptual cap for this alternative is the same as the cap described for Alternative 3, one consisting of an armor layer, an isolation layer, and an oleophilic clay treatment layer. The removal elevations correspond to the native sediment surface elevation, and are summarized for RTAs 1 and 3 under Alternative 4. The removal of all the soft sediment in RTA 1 and RTA 3 will allow for the placement of the cap and at the same time meet navigational needs. The target dredge elevation for RTA 2 under Alternative 5 is the same as what is listed for Alternative 3.

Alternative 6

In Alternative 6, all of the soft sediment within the canal would be removed, and ISS would be applied to targeted areas of native sediment to immobilize NAPL with upward migration potential. ISS would be performed to a depth of 3 to 5 feet and would consist of incorporating pozzolanic additives into the native sediment to solidify the material. ISS would be applied to areas where data indicate the potential for active upward NAPL migration from the native sediment. The stabilization material would be delivered to the in situ sediment from a barge using large augers without dewatering the canal. The area being stabilized would be surrounded by temporary sheet piling to contain the contaminants that would be released when the augers are in use.

The conceptual cap for this alternative is the same as the cap described for Alternative 2, one consisting of an armor layer and an isolation layer. The removal elevations correspond to the native sediment surface elevation and are summarized for RTAs 1 and 3 under Alternative 4. The target dredge elevation for RTA 2 under Alternative 6 is the same as what is listed for Alternative 2.

Alternative 7

Alternative 7 is the same as Alternative 6, except that the conceptual cap for this alternative is the same as the cap described for Alternative 3, one consisting of an armor layer, an isolation layer, and an oleophilic clay treatment layer. The removal elevations correspond to the native sediment surface elevation, and are summarized for RTAs 1 and 3 under Alternative 4. The target dredge elevation for RTA 2 under Alternative 7 is the same as what is listed for Alternative 3.

4.2.2 Treatment and Disposal Options

Each treatment and disposal option considered for the canal sediments is briefly described below. The options that are retained after the screening step are described in greater detail in Section 4.4.

Option A: Offsite Thermal Desorption and Beneficial Use

Option A consists of transporting dredged and dewatered sediment by barge to an offsite commercial facility for stabilization followed by transport of the stabilized sediment to another offsite facility for thermal desorption treatment. The treatment residuals would be destroyed in an afterburner, and treated sediment would be transported for use as daily cover at a landfill or for another beneficial use at an offsite location. It is assumed that transport following stabilization would occur by truck.

Option B: Offsite Disposal (Landfill)

Option B consists of transporting dredged and dewatered sediment by barge to an offsite commercial facility for stabilization followed by transport of stabilized sediment to an offsite landfill. It is assumed that transport to the offsite disposal facility would occur by truck. Disposal at a RCRA Subtitle D landfill is assumed for the stabilized sediment.

Option C: Offsite Cogeneration and Beneficial Use

Option C consists of transporting dredged and dewatered sediment by barge to an offsite commercial facility for stabilization followed by transport of stabilized sediment to an offsite cogeneration electrical plant. The stabilized sediment would be mixed with coal and then burned to generate electricity. Treatment would include thermal destruction (i.e., burning) of the organic contaminants through heating of the sediments at high temperatures (greater than 1,400°C). The treated sediment would then be transported for use as daily cover at a landfill or for another beneficial use at an offsite location. It is assumed that transport following stabilization would occur by truck.

Option D: Offsite Stabilization and Beneficial Use

Option D consists of transporting dredged and dewatered sediment by barge to an offsite commercial facility for stabilization followed by transport of stabilized sediment to an offsite location for beneficial use. The degree of stabilization necessary for direct offsite beneficial use without further treatment will be more substantial than under Options A through C, where the stabilization process would be utilized to prepare sediments for offsite transport via truck to be followed by treatment before final disposition. A specific beneficial use has not been determined in this FS, but potential uses of the stabilized sediment include fill and daily landfill cover.

Option E: Onsite Stabilization and Beneficial Use

Option E includes stabilizing dredged sediment onsite and beneficially using the treated sediment in areas adjacent to the canal. As with Option D, the degree of stabilization necessary for direct onsite beneficial use without further treatment will need to be more substantial than the stabilization under Options A through C, where the stabilization process would be utilized to prepare sediments for offsite transport by truck to be followed by treatment before final disposition. A specific beneficial use has not been determined in this FS, but potential uses include fill or creation of concrete blocks. Additional physical and chemical testing and cost analyses would be required to evaluate potential beneficial uses.

Option F: Offsite Stabilization and Disposal in Onsite-Constructed CDF

Option F consists of transporting dredged and dewatered sediment by barge to an offsite commercial facility for stabilization followed by transport by barge of the stabilized material back to the site for placement into a constructed onsite CDF. The CDF would be constructed by installing a single-sheet pile wall on the sides adjacent to land and a installing a double-sheet pile wall on the side of the CDF adjacent to water. The void in the double sheet pile wall would be filled with bentonite-augmented soil or a similar low-permeability material. This FS assumes that three sides of the CDF will be adjacent to land and one side will be adjacent to water. Under this option, enough stabilization agents would be added to the dewatered sediment such that a relatively impermeable monolithic mass would result. The material would be transferred into the constructed CDF before the material has completely hardened and would be placed using standard material-handling equipment. The final design of the CDF would depend on location of the CDF and the characteristics of the stabilized sediment. Testing would need to be performed before this design could be developed.

Option G: Onsite Stabilization and Disposal in Onsite-Constructed CDF

Option G consists of stabilizing dredged sediment onsite and then transferring the sediment into a constructed onsite CDF. The description of the CDF is provided in the description of disposal Option F.

4.3 Alternative Screening

The dredging-and-capping alternatives and treatment/disposal options were each screened on the basis of effectiveness, implementability, and cost to reduce the number of alternatives and options carried forward for detailed evaluation. Because the base components of Alternatives 2 through 7 are very similar, the implementability of the dredging-and-capping alternatives is not expected differ markedly among alternatives. The relative costs of the dredging-and-capping alternatives and the treatment/disposal options are discussed in the following sections.

4.3.1 Dredging and Capping Alternative Screening

The screening analysis for the dredging-and capping-alternatives is presented in Table 4-2. Alternatives 2 and 3 include only partial removal of the soft sediment column. Capping extremely soft, fine-grained sediments with high water content poses technical challenges due to the sediments' low bearing capacity (USACE, 2000; Reible, 2005). The physical characteristics of the soft sediments in the canal suggest that they may have insufficient load-bearing capacity to support a cap or could be destabilized by the uneven placement of cap material. Capping over these could destabilize any NAPL present in the soft sediments (Reible, 2005). Given these considerations, this FS assumes the removal of all the soft sediment, and the alternatives that require removal of only a portion of the soft sediments were screened out.

Alternatives 2, 4, and 6 include installation of a two-layer cap, with isolation and armor layers. These alternatives were not retained because an armored sand cap is not sufficient to control the long-term flux of NAPL and dissolved-phase contaminants. NAPL mitigation is a major concern in RTA 1 and RTA 2. Although little NAPL is present in RTA 3, groundwater upwelling through PAH-contaminated sediments in some portions of RTA 3 may pose a concern. Therefore, a thinner oleophilic clay treatment layer was included for RTA 3 in this FS. Conceptual cap designs will be refined during remedial design.

The relative cost rankings for the dredging-and-capping alternatives are influenced by the volume of sediment removed, the presence or absence of an oleophilic clay treatment layer in the cap, and inclusion or exclusion of ISS. The approximate dredging, capping, and ISS costs of Alternatives 2 through 7 range from $152 million for Alternative 2 to $191 million for Alternative 7. These cost estimates do not include disposal costs. The difference between the highest and lowest cost is 23 percent.

Based on this screening evaluation, Alternatives 1, 5, and 7 were retained for further development and detailed evaluation.

4.3.2 Treatment and Disposal Option Screening

The screening analysis for the treatment/disposal options is presented in Table 4-3. This evaluation was specific to each RTA because the differences in the degree of NAPL impacts and contamination levels influence the expected effectiveness of some of the options.

Options D and E (offsite and onsite stabilization and beneficial use, respectively) were not retained for RTA 2. The soft sediments within RTA 2 have pervasive NAPL impacts that would inhibit successful stabilization of the dredged sediment for beneficial use.

Options F and G (offsite or onsite stabilization and placement in a constructed CDF, respectively) were not retained for further evaluation for RTA 1 or RTA 2 because of the higher levels of contamination encountered and the space constraints on constructing a CDF with sufficient capacity to accommodate the dredged sediments from all RTAs. Therefore, this FS assumes that the CDF would be used to contain the least contaminated sediments from the canal (i.e., those from RTA 3). However, this does not preclude the use of this option for sediments from RTA 1 or RTA 2 in the selected remedy, if areas of lower contamination are identified during the design and if additional CDF capacity becomes available.

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

As described in Sections 4.4 and 4.7, additional evaluation of the selected treatment and disposal option(s) will be required during remedial design.

4.4 Detailed Description of Retained Alternatives

The descriptions of the remedial alternatives provided herein are conceptual and have been developed to a level of detail sufficient for the purposes of evaluating the alternatives against the NCP criteria and developing cost estimates with an expected accuracy of plus 50 to minus 30 percent. The selected alternative will be further developed during the remedial design process, and the specific methodologies and construction sequences utilized may change on the basis of additional information that is gathered as part of predesign investigations.

The following three alternatives are evaluated in the detailed analysis:

- Alternative 1: No Action, retained as a the baseline condition per NCP requirements
- Alternative 5: Dredge entire soft sediment column and cap with treatment layer, sand-and-gravel isolation layer, and armor layer
- Alternative 7: Dredge entire soft sediment column, solidify top 3–5 feet of native sediment in targeted areas, and cap with treatment layer, sand-and-gravel isolation layer, and armor layer

Seven treatment and disposal options are evaluated as part of Alternatives 5 and 7:

- Option A: Offsite thermal desorption and beneficial use
- Option B: Offsite disposal (landfill)
- Option C: Offsite cogeneration and beneficial use
- Option D: Offsite stabilization and beneficial use
- Option E: Onsite stabilization and beneficial use
- Option F: Offsite stabilization and placement in onsite constructed CDF
- Option G: Onsite stabilization and placement in onsite constructed CDF

Alternatives 5 and 7 include bulkhead stabilization throughout the entire canal and the removal of some native sediment in RTA 2 to accommodate a cap and maintain the depths required for navigation. As described in Section 4.2, it is anticipated that the remedial action in the canal will be performed using a phased approach, with the upper and middle reaches of the canal (RTA 1 and RTA 2) being remediated first.

In order for any of the remedial alternatives to be effective, upland sources of contamination—such as discharges from CSOs, from the former MGP sites and other contaminated sites along the canal, and from the unpermitted pipes along the canal—must be controlled in parallel with or prior to the implementation of the selected sediment remedy. These upland source controls need to be coordinated and implemented in concert with the selected sediment remedy to prevent recontamination of the canal following remedy implementation. All of the alternatives in this FS rely upon the successful implementation of these controls; therefore, they are included as the first component of all alternatives. The source control measures that will be developed are included by reference in this FS.

Emerging sediment remediation technologies may be evaluated during the remedial design and may be incorporated into the selected remedy, if determined to be effective and implementable during bench testing or pilot studies.

Table 4-1 presents the major components of each alternative. The following section provides a more detailed description of each alternative and the disposal options, including the assumptions regarding technologies and materials used, volume of sediment removed, quantities of material needed for the capping and/or treatment, proximity of treatment and disposal facilities, and the conceptualized construction sequence and construction duration. The alternative descriptions and construction sequences are generally applicable to all the RTAs in the canal; differences among the RTAs, such as sediment volumes removed, capping requirements, and conceptual cap design parameters are noted in the text and in the associated tables containing the detailed components and construction sequence.

4.4.1 Alternative 1: No Action

Per the NCP requirement, the No Action alternative is carried through the entire FS process as the baseline condition against which the performance of the remaining alternatives is evaluated. This alternative would not include any active remediation of the Gowanus Canal but could include performing 5-year reviews. Additional monitoring and implementation of institutional controls are not included components of this alternative.

4.4.2 Alternatives 5 and 7

This section presents a conceptual construction sequence and the assumptions used as the basis of estimate for the primary components of Alternatives 5 and 7. Figures 4-1a and 4-1b present process diagrams depicting the primary components, including the treatment and disposal options. In general, the only difference between the alternatives is Alternative 7's inclusion of ISS in RTAs 1 and 2. Alternative 7 is also retained for RTA 3 should predesign investigations determine that there are areas with NAPL in RTA 3 that could benefit from ISS application. Based on the above, the detailed components and construction sequencing for both Alternatives 5 and 7 are presented only once, in Table 4-4. The assumptions related to quantities, production rates, and materials used are specified in this table, and differences between the two alternatives are identified. The quantities of sediment removed in each RTA are summarized in Table 4-5. Sections 4.2.3 through 4.2.5 provide details specific to each alternative.

Predesign Investigation

A predesign investigation is anticipated to be needed to collect specific information to support the design of the selected remedy.

Upland Source Control

Source control measures will be needed to ensure that the sediment remedy achieves the RAOs and is sustainable. Source control is the first component of all alternatives except No Action. Source control measures are in the process of being developed, and therefore the costs are not available for inclusion in this FS. The source control measures are included by reference in this FS.

Potential source control measures include sealing unpermitted pipe outfalls to the canal, controlling discharges of suspended solids in CSOs, and controlling the discharge of NAPL and contaminated groundwater to the canal from upland sources. The existing pipe outfalls will need to be reviewed to identify those that are not permitted to discharge to the canal. Pipe outfalls that are not permitted will need to be sealed to eliminate these sources of contamination to the canal. Examples of methods that can be used to control discharge of PAH- and metal-containing CSO solids include constructing deep tunnels, retention tanks to temporarily store discharges during storms, green infrastructure, and sewer separation. Approximately 95 percent of the CSO discharges occur from outfalls RH-034 at the head of the canal, RH-035 at Bond Street, OH-007 at 2nd Avenue, and RH-031 at Creamer Street.

Preconstruction and Bulkhead Stabilization /Repair

Preconstruction activities would include setting up staging areas (e.g., clearing an area, constructing security fencing, and setting up job-site trailers and utility services) and evaluating and stabilizing the bulkheads. Specifically, the existing bulkheads along the canal are degraded in many areas and, in order to prevent their collapse, these bulkheads should be reinforced, stabilized, or replaced. Additional structural surveys of the bulkheads will need to be performed during the remedial design to determine the specific conditions and corresponding appropriate actions to stabilize the bulkheads. The remedial design will also need to consider the effects on the bulkhead stabilization of any upland NAPL source control measures that are proposed or implemented by third parties. The upland controls may include the installation of collection trenches or barrier walls near the shorelines. Table 4-4 provides details regarding the assumptions used in this FS on how the bulkheads will be addressed and the percentage of the canal shoreline that is assumed to require bulkhead reinforcement or rebuilding. It is anticipated that the removal action in the canal will occur using a phased approach, and that the upper and middle reaches of the canal (RTA 1 and RTA 2) will be remediated first.

It is assumed for the FS that any reinforcing or stabilizing structures installed to address bulkhead stability would be permanent. Targeted debris removal required for the bulkhead stabilization or reinforcement would be performed by the subcontractor selected to perform this component of the work. This debris removal is not the same as the debris removal required prior to dredging. A small amount of residual sediment may be left between the existing bulkhead structures and the new or reinforcing structures. Any gaps between the existing bulkheads and the new or reinforcing structures would be filled with sand, gravel, or other freely draining material. Residual sediment remaining between the new and old bulkhead structures would be isolated from contact with ecological receptors and humans.

Dredging

Enclosed cells for dredging would be created by driving temporary sheet piling into the native sediment in RTA 1 and RTA 2. These cells would serve to contain potential releases of contaminants that occur during sediment removal, which could include NAPL, suspended solids, and dissolved organics. The dredge cells would be placed along one-half of the width of the canal at a given time to allow tidal exchange throughout the reach and to allow flushing tunnel flow to flow past. It is assumed that while work is taking place in one cell, construction would be occurring to create the next cell, so that dredge cell construction does not delay dredging activities.

Dredge cells would not be constructed in RTA 3. The soft sediment in RTA 3 does not generally exhibit significant NAPL saturation, and the potential for NAPL releases during dredging is much lower. Additionally, the construction of dredge cells in RTA 3 would interfere with navigation in the lower canal. Turbidity and sheens in this area would be controlled with silt curtains and oil booms.

Debris removal would be performed using an excavator positioned on a barge. Larger debris might require removal using a crane and clamshell bucket. The debris would be removed after each dredge cell is constructed so that sheens and turbidity releases can be controlled. Upon removal, the debris would be decontaminated, sorted, and recycled or disposed of as appropriate. This process and the associated waste streams will be determined during remedial design.

Sediment removal would be performed using mechanical dredges outfitted with standard clamshell buckets in RTA 1 and RTA 2 and with environmental buckets in RTA 3. Standard clamshell buckets are assumed for RTAs 1 and 2 because dredging would be performed within enclosed dredge cells that would prevent sheens and turbidity from spreading beyond the immediate work area. Dredge cells would not be constructed in RTA 3; therefore an environmental bucket is assumed for dredging in this reach. The dredges would be positioned on barges to allow for easier movement within the canal and to minimize effects to the upland businesses and residents. Dredged sediment would be loaded onto material barges and moved to an onsite staging area for dewatering. The clamshell and environmental buckets are expected to be able to remove the gravel present throughout RTA 2 and in portions of RTA 3a.

Dewatering/Stabilization

Dredged sediment would undergo passive dewatering at an onsite staging area. The dredged material would be allowed to sit in scows for a period of time so that the solids would settle to the bottom of the barge. The overlying water would be pumped off into holding tanks, treated in an onsite temporary water treatment system, and discharged back to the canal.

The dewatered sediment would then be transported by barge to a treatment facility for stabilization. For the purposes of the FS, it was assumed that an existing, offsite treatment facility would be used for disposal options A, B, C, D, and F. An offsite facility was assumed for these options because (1) there is currently an existing facility within the greater New York region that can accept material transported by barge, and (2) existing offsite facilities could readily handle the predicted daily volumes of dredged materials. Disposal options E and G consider the use of an onsite stabilization facility.

The materials and reagent quantities required for the stabilization are dependent upon the final disposal method selected and will be determined during design but are expected to be portland cement, blast furnace slag, or a combination of the two. After stabilization, the material would be further treated and/or disposed using one of the following options: offsite thermal treatment, offsite landfill, offsite cogeneration, onsite or offsite beneficial use, or an onsite CDF. The degree of stabilization needed would depend on the disposition of the stabilized material (i.e., preparing the sediments for transport is expected to require less stabilization than to prepare them for placement in a CDF or for beneficial use). Table 4-4 details the assumptions for the reagents and quantities required for sediment stabilization for each disposal option.

In Situ Stabilization

ISS is the only component that is different between Alternatives 5 and 7. In Alternative 7, ISS would be used in the native sediment in targeted areas of RTAs 1 and 2 to further reduce or prevent NAPL migration. Appendix A presents an analysis of NAPL impacts on both sides of the native sediment–soft sediment interface at sampling locations throughout the canal. These NAPL impacts are considered indicative of the potential for active upward NAPL migration from the native sediment to the soft sediment. The degree of migration is considered greater in cases where NAPL-saturated sediments occur on both sides of the interface. The locations where the application of ISS is proposed are those areas that exhibit NAPL saturation on either side of the native sediment–soft sediment interface. Other site-specific characteristics were also taken into account. Figure 4-2 illustrates the areas where ISS is included in this FS:

- RTA 1: The ISS area includes the entire width of canal from approximately 100 feet from the head of the canal (Douglass Street) to the southern boundary of the Fulton former MGP site (Sackett Street). This distance is approximately 600 feet. Although NAPL-saturated soft sediments were not found at the native sediment-soft sediment interface in this reach, soft sediment impacts may have been affected by dredging and possibly flushing tunnel operations.
- RTA 2: NAPL saturations across the native sediment-soft sediment interface were identified in the main channel of the canal from the 7th Street turning basin to the southern boundary of the Metropolitan former MPG site. This distance is approximately 1,400 feet. The ISS footprint also includes the area from the northern boundary of the Carroll Gardens/Public Place former MPG site to the 7th Street turning basin (approximately 500 feet).
- 4th Street Turning Basin: The ISS footprint for this turning basin includes the eastern end of the basin. This distance is approximately 250 feet. This turning basin is approximately 100 feet wide in this area.
- 6th Street Turning Basin: NAPL saturations on either side of the native sediment-soft sediment interface were noted in the western third of this basin. The proposed ISS footprint includes a distance of approximately 250 feet from the confluence with the canal. This turning basin is approximately 100 feet wide.
- 7th Street Turning Basin: NAPL saturations on either side of the native sediment-soft sediment interface were noted in the western two-thirds of this basin. The proposed ISS footprint includes a distance of approximately 300 feet from the confluence with the canal. This turning basin is approximately 100 feet wide.

ISS is currently not proposed for RTA 3. Based on the available data, the NAPL impacts in the southern portion of the project area are much less significant and less pervasive than those observed in the upper reaches of the canal. Alternative 7 may be applied in RTA 3 if, during predesign, areas that would benefit from ISS application are identified. Because these areas have not been identified at the time of preparation of this FS, no costs for this option have been included.

The FS assumes that the in situ delivery of stabilization material to the native sediment would be performed from a barge using large augers to a depth of approximately 5 feet below the native sediment surface and that delivery would be performed without dewatering the canal. If Alternative 7 is the selected remedy for any of the RTAs within the canal, the remedial design should include further evaluation of the areas where ISS should be applied, the delivery method to be used, and bench testing and pilot testing to determine the appropriate reagent mix.

Cap Placement

Upon completion of the sediment removal in Alternative 5 or upon completion of ISS in Alternative 7, a cap would be placed over the remaining sediment. The purpose of the cap is to prevent direct human or ecological exposure to the contaminated sediments and to prevent the migration of NAPL in the underlying sediment to the overlying water column. The conceptual cap designs are based on the extent of NAPL saturation expected to remain in the underlying sediment following dredging and thus the design varies by RTA. Appendix A provides a detailed discussion of possible cap designs for the different RTAs within the canal based on the expected presence of NAPL. A brief description is provided below.

Dredging activities are expected to release some NAPL to the water column. Control measures to avoid placing capping materials through a NAPL-affected water column will be defined in the remedial design. Examples of these types of mitigation measures may include allowing the NAPL to settle out of the water column for a period of time before placing the isolation (clay) layer, or placing a portion of the isolation layer and treating a volume of water from the dredge cell and then placing the remaining portion of the clay layer.

The conceptual cap design consists of a three-layer cap comprising a treatment layer, a sand-and-gravel isolation layer, and an armoring layer. The sand-and-gravel layer will provide a transition in particle size from the granular clay treatment layer to cobble-sized armor stone and will protect the clay layer from bioturbation. Appendix D provides the assumptions and calculations used to determine the shear stresses and water velocities associated with propeller wash, as well as the calculations to determine the median particle size and thickness required for the armor layer of the cap. For the purposes of this FS, it is assumed that the same armor layer will be used throughout the canal; however, further evaluation during design may indicate that different materials or thicknesses may be appropriate in RTAs 1 and 3 based on navigational or other considerations. Sand will be placed on top of the armor layer to fill some of the voids between the stones in order to facilitate benthic colonization. Epibenthic fauna such as crabs and mussels could colonize areas with relatively larger stone sizes, and benthic infauna could colonize areas with finer-grained particles that fill in the gaps between the cobbles. However, if not controlled, soft sediment from the ongoing CSO outfalls will be deposited and will accumulate on top of the cap over time.

The treatment layer of the conceptual cap design is assumed to be composed of oleophilic clay, which is a surface-modified clay that is effective for adsorbing insoluble and partially insoluble compounds. Oleophilic clay is hydrophobic and permeable and would allow ebullition bubbles to pass through the cap, preventing cap uplifting, while adsorbing the

NAPL, and thus preventing transport of the NAPL into the water column. The oleophilic clay is also designed to retain high permeability upon organic adsorption.

Two different oleophilic clay materials are possible: granular oleophilic clay emplaced much like a sand layer, and reactive core mats consisting of a thin layer of oleophilic clay material sandwiched between two permeable geotextile layers made of biodegradation-resistant synthetic fibers. The advantage of granular oleophilic clay is that it can be emplaced to any specified thickness to meet site-specific adsorptive capacity requirements. The disadvantage of granular oleophilic clay, like sand caps, is that improper emplacement over soft sediments can cause resuspension of the soft sediment layer, leading to settling of contamination both in and on top of the cap layer. Specific construction quality control measures are needed for proper placement. For the conceptual cap designs presented in this FS, granular oleophilic clay is assumed for the treatment layer. Appendix A provides additional discussion on the rationale for the selection of the treatment layer material.

Based on the evaluations performed in Appendix D, a 1.5-foot-thick armor layer with a median stone size of approximately 0.75 feet would be required in RTA 2. For purposes of this FS, this armor size and thickness have been assumed for all RTAs. It is possible that a smaller armor size would be protective in RTAs 1 and 3; however, further analysis for the current and predicted vessel use, as well as potential habitat requirements, is required to refine the cap design. The cap designs will be finalized during the remedial design.

Dredge Cell Dewatering and Water Treatment

After the sediment is removed, ISS has been performed (if Alternative 7 is implemented),and the cap has been placed, the water in the cell would be tested, and, if needed, pumped through the onsite water treatment processes and discharged back to the canal. Water from the canal outside of the dredge cell would be allowed to flow into the cell as pumping occurs in order to minimize the differential pressure against the sheet piling. For the purposes of cost estimating for this FS, it is assumed that the water treated in each cell will be approximately two cell volumes at mean high tide. The site for the temporary water treatment plant will be determined during the remedial design.

Treatment and Disposal Options

The following section describes the seven treatment and disposal or beneficial-use options that are included for Alternatives 5 and 7. As noted in the screening analysis (Section 4.3), some of the treatment and disposal options are not applicable to all RTAs. The seven treatment and disposal options are:

- Option A: Offsite thermal desorption and beneficial use (RTAs 1, 2, and 3)
- Option B: Offsite disposal (landfill; RTAs 1, 2, and 3)
- Option C: Offsite cogeneration and beneficial use (RTAs 1, 2, and 3)
- Option D: Offsite stabilization and offsite beneficial use (RTAs 1 and 3)
- Option E: Onsite stabilization and onsite beneficial use (RTAs 1 and 3)
- Option F: Offsite stabilization and placement in onsite constructed CDF (RTA 3)
- Option G: Onsite stabilization and placement in onsite constructed CDF (RTA 3)

Table 4-4 provides additional details with respect to the construction sequence, assumed construction specifications, volumes of sediment treated, stabilization reagents used and the associated mix percentages, and expected production rates. Table 4-5 summarizes the sediment volumes to be treated and disposed for each RTA.

Additional treatability testing and sampling is needed for all disposal options. Further testing of stabilized sediment will be required to confirm that dredged sediment can be accepted by thermal desorption (Option A) and cogeneration (Option C) facilities. Selection of Option B (offsite landfill) will require testing of stabilized dredged sediment to confirm that it will meet acceptance criteria. Options D, E, F, and G will require further evaluations to determine the appropriate reagents and dosing required for stabilization and to assess the leachability of the stabilized material. Options D and E will further require a beneficial use to be identified and a determination as to whether the stabilized sediment will meet the associated beneficial-use requirements. Options F and G will require the identification of a suitable area of sufficient size within the project area to construct a CDF.

Option A: Thermal Desorption and Offsite Beneficial Use. Option A consists of transporting dewatered, dredged sediment that has been stabilized to the degree required to pass the paint filter test at the offsite dredge material processing facility to an offsite thermal desorption facility for thermal treatment. The treatment residuals would be destroyed in an afterburner. Thermally-treated sediment would be transported for use as daily cover at a landfill or other beneficial use. It is assumed that transport to the offsite thermal desorption facility and from the facility to the location of its beneficial use would occur by truck.

A preliminary evaluation of the soft-sediment data collected during the RI was performed with respect to the acceptance criteria at the thermal treatment plant operated by Clean Earth of Southeast Pennsylvania (CESP) in Morrisville, Pennsylvania. The data represent sediment prior to the addition of any stabilization amendments. A summary of the comparison of the acceptance criteria and the untreated soft sediment data is presented in the inset at right. The total PCB and lead concentrations present in the sediment may preclude this treatment option for some areas of the canal.

Comparison of Gowanus Canal Soft Sediment to CESP Acceptance Criteria

Parameter	CESP Criterion (mg/kg)	Canal Sediment Exceedances
Arsenic	<53	2/376
Lead	<450[a]	246/376
TPH	45,000	1/382[b]
Total PCBs	<4	102/381

[a] Dependent upon back-end facility.
[b] Total PAH used as a proxy for screening; exceedances are presented in number of exceedances / number of samples analyzed.

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

Option C: Cogeneration and Offsite Beneficial Use. Option C consists of transporting dredged, dewatered sediment that has been stabilized to the degree required to pass the paint filter test at the offsite dredge-material-processing facility to an offsite cogeneration electrical plant. The stabilized sediment would be mixed with coal and then burned to generate electricity, which would then be distributed to the receiving electrical grid. Treatment would include thermal destruction (i.e., burning) of the organic contaminants through burning of the sediments at high temperatures (greater than 1,400°C). The treated sediment would then be transported for use as daily cover at a landfill or other beneficial use. It is assumed that transport from the offsite dredge-material-processing facility to the cogeneration plant and from the cogeneration plant to the location where the treated sediment would be beneficially used would occur by truck.

This disposal option is considered for sediment originating from all three RTAs. Additional bench-scale testing is required to determine whether the sediment in all areas of the canal would provide sufficient energy value (in British Thermal Units, or BTUs) to make cogeneration a feasible treatment/disposal option for the entire canal and to determine which areas of the canal contain sediment with the greatest BTU value.

The Piney Creek Power Plant, a cogeneration facility in Clarion, Pennsylvania, was contacted to determine if treatment through cogeneration was possible for sediments from the canal. Based on discussions with facility personnel, this facility would be able to accept dewatered canal sediments for burning. Canal coal tar waste classified as MGP waste is exempt from toxicity characteristic leaching procedure (TCLP) testing in Pennsylvania and will require only pH, reactivity, and ignitability testing to confirm the waste is nonhazardous prior to shipment. TCLP and reactivity, pH, and ignitability data collected during the RI on selected composite samples of entire sediment cores indicate that untreated sediment (i.e., not stabilized or solidified) is not considered a characteristic hazardous waste as defined by the Resource Conservation and Recovery Act (RCRA). Bench testing would be required to determine the amount of stabilization materials needed to reduce the moisture content of the material to approximately 20 percent (the desired limit for the receiving facilities).

Option D: Offsite Stabilization and Offsite Beneficial Use. Option D is applicable to RTAs 1 and 3 and consists of transporting dewatered sediment to an offsite facility via barge, where the sediment will be stabilized. The treated material would then be transported via truck or rail (assumed to be by truck in this FS) to the offsite beneficial use location. A beneficial use would need to be identified and further evaluations would be required to determine the amounts and types of solidifying agents that should be added to the sediment to result in the desired physical and chemical properties. Tests to assess the leachability of NAPL and other contaminants, as well as the material strength, would need to be performed on the stabilized material in order to determine whether it would meet the beneficial use requirements.

The fines content (i.e., clays and silts), organic carbon content, NAPL impacts, and other contaminants in the sediment will influence the possible beneficial use options. The average total organic carbon content for RTAs 1, 2, 3a, and 3b are approximately 14,000 mg/kg, 26,000 mg/kg, 27,000 mg/kg, and 6,800 mg/kg, respectively. RTA 2 exhibits the greatest degree of NAPL impacts and RTA 3 exhibits the least. It is the NAPL impacts in RTA 2 that preclude the application of this option to sediment from RTA 2.

Potential beneficial use options include the stabilized sediment's use as fill or landfill daily cover, or its incorporation into construction materials such as concrete. For the purposes of this FS, it is assumed that the sediment would be stabilized and used as fill material in a controlled location (e.g., landfill cover). Table 4-4 provides additional assumptions related to the reagent types, dosages, transport distances, and other parameters used as the basis of the cost estimate.

Option E: Onsite Stabilization and Onsite Beneficial Use. Option E is also applicable only to RTAs 1 and 3 and includes stabilizing dewatered sediment onsite and beneficially using the material onsite or within the area immediately adjacent to the project area. Characteristics of the sediments and the rationale for excluding sediment from RTA 2 were described under Option D. Sediments would need to be stabilized to a degree consistent with their beneficial use including considerations on the leachability of contaminants.

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

A temporary onsite stabilization facility would need to be constructed and a location for this facility would need to be identified. Table 4-4 includes the specifications for this facility that were used to develop the cost estimate. Final disposition of the stabilized sediment is assumed to be a net zero cost following onsite stabilization.

Option F: Offsite Stabilization, Transport of Treated Material Back to Site, Placement in Onsite Constructed CDF. Option F is considered only for RTA 3 sediments because the space requirements to construct a CDF that could contain the contaminated sediments from all three RTAs would be significant. The remedy can be designed so that the sediments placed in the CDF are those with fewer NAPL impacts and less contamination and the sediments sent for offsite disposal or treatment are those with greater NAPL impacts and contamination. However, the selected remedy may utilize this disposal option for sediment from other reaches of the canal, especially those from RTA 1 if areas of lower contamination are identified during design and additional CDF capacity becomes available.

This option consists of transporting the stabilized sediment from the offsite treatment facility back to the site by barge, and then transferring the sediment into an onsite constructed CDF. The containment facility would be constructed by installing single sheet pile wall on the sides adjacent to land and a installing a double sheet pile wall on the side of the CDF that was adjacent to water. The void in the double sheet pile wall would be filled with bentonite-augmented soil or a similar low-permeability material. This FS assumes that three sides of the CDF will be adjacent to land and one side will be adjacent to water. Under this option, enough stabilization agents (e.g., portland cement and/or blast furnace slag) would be added to the dewatered sediment such that a monolithic mass would result. The material would be transferred into the constructed CDF before it was completely hardened and would be placed using standard material-handling equipment.

Once the treated sediment has hardened, leaching is expected to be negligible, so no leachate collection system is assumed for this alternative. Upon placement of the sediment, the CDF would be capped. This FS assumes that the top layer of the cap will be asphalt, allowing use of the surface. Surveys would be required on a regular basis to monitor the long-term integrity of the cap. Cap maintenance would include placement of additional clean materials to replace damaged areas of the cap.

Bench-scale testing is recommended to determine the amounts of stabilizing/solidifying agents that should be added to the sediment to result in the desired consistency. Tests to assess the leachability of NAPL and other contaminants would also be performed on the stabilized material in order to refine the CDF design.

For the purposes of this FS, it has been assumed that a CDF able to accommodate the entire volume of sediment removed from RTA 3 could be constructed. The volume of in situ sediment in RTA 3 has been estimated at 281,000 cubic yards (Table 4-5), and an expansion factor of approximately 1.15 has been estimated for stabilized material for this disposal option, resulting in a CDF capacity of approximately 323,000 cubic yards. If the CDF is constructed such that the thickness of stabilized sediment is 20 feet, the area required for the CDF would be approximately 436,000 ft^2, or 10 acres.

Option G: Onsite Stabilization and Disposal in Onsite Constructed CDF. The description of disposal under Option F is applicable to Option G, with the exception that the stabilization will be performed onsite and transport of sediment to and from an offsite stabilization facility would not be needed. For the purposes of this FS, it is assumed that an onsite temporary stabilization facility would be constructed near or adjacent to the CDF location. The proposed onsite stabilization facility is described in Table 4-4.

Short-Term Monitoring

Short-term monitoring would be required during the construction phase to protect human health and the environment. Monitoring requirements could include turbidity and water quality monitoring, dust and air quality monitoring, and noise monitoring. The monitoring requirements will be defined during the remedial design.

Institutional Controls

Institutional controls limiting the size of vessels using the canal, the speeds at which vessels can use the canal, and limitations on anchoring or mooring would be needed to minimize damage to areas where a cap was placed. If disposal Option E is utilized, institutional controls to limit construction activities and exposure to the stabilized, beneficially used sediment would be required. If disposal Option F or G is utilized, institutional controls to limit access and future use of the CDF site would be required.

Long-Term Monitoring and Maintenance

Surveys would need to be performed on a regular basis to monitor the long-term integrity of the capped areas and to assess the potential for recontamination. Annual surveys may be appropriate in some areas (e.g., near-CSO discharge points and in areas with higher vessel traffic or higher potential for scour) to confirm layer thickness. At defined intervals, surveys on a defined grid would need to be conducted across the entire RTA to assess layer thickness, cap performance, and integrity. Cap performance metrics may include assessment of cap adsorptive capacity and monitoring for sheens on the water surface. Surveys after severe storm events may also be needed to assess cap integrity. Cap maintenance could include placement of additional clean materials and/or increased armoring to supplement or replace damaged areas of the cap. Cap repairs would be performed as needed. A long-term monitoring plan developed as part of the remedial design would describe the performance metrics to be used and the appropriate monitoring and repair requirements. Table 4-4 lists the assumptions used to develop the long-term monitoring and maintenance costs.

4.5 Detailed Analysis of Alternatives

Detailed analyses of Alternatives 1, 5, and 7 and the associated disposal options were performed for each RTA. Tables 4-6a through 4-6c present the detailed analysis of the alternatives against the NCP criteria defined in Section 4.1. These tables provide only the present-worth costs for comparison purposes. Table 4-7 presents the capital costs, periodic operations and maintenance costs, and present-worth costs for each alternative and the associated disposal options. Appendix F contains the detailed cost estimates.

A semiquantitative evaluation of the disposal options relative to the sustainability metrics is presented in Table 4-8. Because the only substantive difference between Alternatives 5 and 7 is the inclusion of targeted ISS, the goal of this evaluation was to identify differences between the disposal options. This evaluation focused on the metrics that are the most significant for the alternatives evaluated.

4.6 Comparative Analysis

The comparative analysis was also performed by RTA, and Tables 4-9a, 4-9b, and 4-9c present the results of the comparative analysis for RTAs 1, 2, and 3, respectively. The following sections explain the relative ranking of alternatives for each of the seven NCP criteria and discuss the comparative sustainability considerations among the disposal options. The subcriteria within each of the seven NCP criteria were considered during the detailed and comparative evaluation; however, the following discussion focuses on the ranking of the alternatives with respect to the primary criteria. This narrative is relevant to all three RTAs with respect to the alternatives' dredging, capping, and ISS components. The discussion of the disposal options herein is RTA specific because only a subset of the disposal options considered were retained for evaluation in RTAs 1 and 2.

4.6.1 Overall Protection of Human Health and the Environment

Alternative 1, No Action, would not provide overall protection of human health and the environment. This alternative would not achieve the RAOs for the canal. Contaminated sediments would remain onsite and exposed. Exposure to these sediments would continue to pose human health and ecological risks. NAPL migration from the sediment to the surface water would continue, and the potential for direct contact with NAPL would remain.

Alternatives 5 and 7 are expected to be protective of human health and the environment. These alternatives would meet the RAOs by removing contaminated soft sediment and placing a cap to reduce and control the long-term risks associated with the native sediment. Placing a cap over contaminated native sediment remaining in the canal would prevent exposure to human and ecological receptors, thereby reducing and controlling toxicity to benthic organisms and eliminating the risks to herbivorous birds. The cap would also prevent direct contact with NAPL and prevent NAPL migration to the surface water of the canal. The implementation of ISS in targeted areas as part of Alternative 7 would be expected to provide additional protectiveness against NAPL migration from the native sediment.

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

4.6.2 Compliance with ARARs

Because no action is taken under it, Alternative 1 would not trigger the chemical-, action-, or location-specific ARARs.

Alternatives 5 and 7 can be designed to comply with the substantive components of the ARARs.

4.6.3 Long-Term Effectiveness and Permanence

Alternative 1 would not result in any significant change in risk associated with contaminated sediment or NAPL. This alternative receives a low ranking for this criterion.

Alternatives 5 and 7 would result in significant, permanent reduction of the risks associated with canal sediments and would meet the RAOs. Both alternatives would provide long-term protection of human health and the environment. The risks associated with contaminated sediment and NAPL in the canal would be reduced over the implementation period of the alternatives as the sediments are removed from the canal.

The cap layout described in this FS would provide long-term control of the risks associated with the native sediment in the canal, provided that appropriate long-term cap monitoring and maintenance plans are implemented. Adsorptive caps to control NAPL migration can be designed for a set life expectancy where the NAPL migration rate is known. At the McCormick & Baxter Superfund site in Portland, Oregon, the NAPL discharge rate to the cap was estimated and a design life of over 100 years established (Blischke and Olsta, 2009). NAPL discharge rates at the Gowanus Canal should be determined prior to cap design to establish the appropriate adsorptive cap thickness requirements.

Alternatives 5 and 7 are considered to have a high degree of effectiveness because all the soft sediment would be removed, and risks associated with the native sediment would be controlled by the cap. The application of ISS to targeted areas of native sediment in Alternative 7 is expected to further reduce the NAPL mobility from the native sediment; however, treatability and pilot testing will need to be performed to determine the effectiveness and implementability of ISS within the canal.

The seven disposal options were also ranked with respect to long-term effectiveness and permanence. Options A, B, and C rank high with respect to this criterion because the material will be transferred offsite and treated or contained in a managed landfill, alleviating the associated risk.

Options D and E (stabilization and beneficial use) are considered to have low to moderate long-term effectiveness. The effectiveness would depend on the actual beneficial use. Use as an offsite landfill cover, as is assumed for Option D, would be effective and permanent since the material is used in a controlled, monitored environment. Use as onsite fill could potentially be effective and permanent but would require testing to ensure that appropriate treatment is applied and would require a suitable, controlled, end-use location to be identified. Long-term monitoring would also be needed to assure that performance criteria continue to be achieved. Permanent institutional controls would be needed to ensure that long-term potential human and ecological direct contact exposures are appropriately limited. The institutional controls would need to restrict digging or construction activities within the fill material and may need to be applied to one or more properties, depending on where the material is used. Depending on the number of properties and where on the properties the fill is placed, more effort and coordination may be needed to ensure successful implementation and enforcement of these controls. Institutional controls would require sustained application and monitoring to assure their success.

Options F and G (stabilization and placement into a constructed CDF) are considered to have a moderate to high ranking for this criterion because the sediment will remain onsite but will be contained in an engineered CDF. Under Options F and G, the sediment would be permanently stabilized into a relatively impermeable monolithic mass, which is the primary mechanism for reducing or controlling long-term risk. The CDF could be designed to provide additional protection of human health and the environment through additional containment. As previously noted, the remedy can be designed so that the sediments placed in the CDF are those with fewer NAPL impacts. Long-term monitoring, periodic repair, and maintenance would be needed to assure that the CDF continues to function effectively. Institutional controls, which would be relatively straightforward to implement and maintain, would be required to assure that the CDF would remain undisturbed.

4.6.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Alternative 1 does not include a treatment component and therefore is ranked low for this criterion.

The granular oleophilic clay layer included in the cap layouts under Alternatives 5 and 7 will reduce the mobility of NAPL and is considered a treatment technology. The overall reduction of NAPL mobility expected to be achieved by this oleophilic clay layer is high. Alternative 7 is considered to have a higher ranking because the capping component is the same as that included in Alternative 5, but its effectiveness is supplemented by ISS. The application of ISS to targeted areas of native sediment in Alternative 7 is expected to further reduce the NAPL mobility from the native sediment; however, treatability and pilot testing will need to be performed to determine the effectiveness and implementability of ISS within the canal.

The reduction of toxicity, mobility, or volume of the dredged sediment is dependent upon the disposal option selected; therefore, the four disposal options are also evaluated and ranked. Thermal treatment (Option A) and cogeneration (Option C) are both ranked high. Both treatment options would significantly reduce or eliminate the toxicity, mobility, and volume associated with the dredged sediment, and both options would satisfy the statutory preference for treatment as a principal element of the alternative. Disposal Options B (offsite landfill disposal), D and E (stabilization and beneficial use), and F and G (stabilization and placement into a constructed CDF) are all ranked as moderate for this criterion. Stabilization of the sediment would reduce contaminant mobility, but toxicity and volume would not be affected.

Thermal treatment (Option A) and thermal destruction through cogeneration (Option C) are irreversible. The stabilization components of Options F and G are considered irreversible since the treated sediment would be placed in a controlled and monitored disposal facility. The irreversibility of stabilization for Options D and E (beneficial use) will be dependent upon the conditions where the material is placed and the degree of stabilization performed. Additional testing will be required to determine if an irreversible stabilization process can be developed on the basis of beneficial use.

4.6.5 Short-Term Effectiveness

The short-term effectiveness of Alternative 1, No Action, is considered to be high because no construction activities would occur.

The preconstruction site work, sediment removal, and capping components of Alternatives 5 and 7 are considered to have moderate short-term effectiveness due to the construction duration and the associated potential risks and environmental impacts described in Tables 4-6a through 4-6c.

The short-term effectiveness of the disposal options is evaluated based on the potential short-term impacts to the site associated with transportation and the transportation distance required. The short-term effectiveness is considered moderate to high for all seven disposal options evaluated (Tables 4-9a through 4-9c).

The transportation distance of dredged material to the final treatment or disposal facility is an important consideration for short-term effectiveness. Options E (onsite stabilization and onsite beneficial use) and G (onsite stabilization and disposal in onsite CDF) do not require the dredged sediment to be transported offsite, although stabilization reagents (e.g., cement and blast furnace slag) would need to be transported to the onsite facility. Of the remaining disposal options, Option F (offsite stabilization and disposal in onsite CDF) offers the shortest transport distance for the dredged sediment (approximately 60 nautical miles round trip), all of it by barge. Disposal Option A (thermal treatment) consists of approximately 30 nautical miles of barge transport from the site to the offsite-dredge-material-processing facility and from there approximately 60 miles of transport by truck to the thermal treatment facility used as the example facility in this FS. The transport distance for Option B (offsite landfill) is estimated to be approximately 30 nautical miles by barge to the processing facility and then approximately 110 miles by truck to a disposal facility. Option C (cogeneration) is estimated to include approximately 30 nautical miles of transport to the processing facility and approximately 350 miles by truck to the cogeneration plant used as the example facility in this FS. The offsite beneficial use for sediment under Option D has been assumed to be landfill cover; thus, for purposes of this FS, it has been assumed that the material will need to be transported approximately 110 miles by truck from the offsite stabilization facility to the disposal facility.

4.6.6 Implementability

Alternative 1 is considered to be readily implementable (high ranking) because no remedial actions would be performed; however, this alternative would not be administratively feasible because it would not meet any of the RAOs for the site.

The dredging and capping components of Alternatives 5 and 7 are considered moderately implementable. Both alternatives will require significant coordination among USEPA, USACE, NYSDEC, New York City, potentially responsible parties, and property owners and tenants along the canal from the start of the design through completion of construction. The specific characteristics of the canal (e.g., debris, degraded bulkheads, space limitations, and the surrounding lively metropolitan residential and commercial community) and the large volumes of capping materials required will pose challenges to the remedy implementation. The amount of material required for the cap construction may require using several vendors, advanced planning, and stockpiling material in advance of the construction to assure that enough material is available during the implementation period. It is anticipated that appropriate planning and engineering measures can address these issues. Alternative 5 is considered to have moderate overall implementability. Because there are more uncertainties associated with the ISS component of Alternative 7 and additional treatability and pilot testing are required to determine the overall feasibility and effectiveness of this technology, Alternative 7 is considered to have low to moderate implementability.

The implementability of the different disposal options is more variable:

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

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

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

The implementation of Options D and E (stabilization and beneficial use) will require identifying an offsite or onsite beneficial use of the stabilized material as well as defining the performance standards for the end-use requirements. The stabilized material will need to meet the chemical and physical performance standards (e.g., short- and long-term leachability and strength characteristics) in order for this alternative to be implemented. Additionally, onsite use of the stabilized material will require stakeholder acceptance and the sustained application of institutional controls. Due to these unknowns and challenges, these two disposal options are considered to have moderate implementability. The offsite beneficial-use option has a slightly higher ranking due to the possibility of more beneficial-use applications. The onsite beneficial-use option also is ranked slightly lower due to the potential difficulties associated with effective sustained implementation of institutional controls described in Section 4.6.3.

Implementation of disposal Options F and G (stabilization and onsite CDF) is dependent on the identification of a suitable location and acceptance from stakeholders. This option may be difficult to implement due to administrative considerations. This option received a moderate ranking.

4.6.7 Cost

A summary of the estimated cost for each alternative and the associated disposal options within RTAs 1, 2, and 3 is provided in Table 4-7. Appendix F presents the detailed cost estimates and associated assumptions. The detailed components presented in Table 4-4 provide the basis of the cost estimate. Source control measures will be needed to ensure that the sediment remedy achieves the RAOs and is sustainable. Source control is the first component of all alternatives except No Action. Source control measures are in the process of being developed; therefore, the associated costs are not included in this FS. The source control measures that will be developed are included by reference in this FS.

4.6.8 Sustainability

The sustainability evaluation of the seven disposal options is presented in Table 4-8. This evaluation is qualitative and was performed by considering four areas of potential sustainability impacts that are considered to be the most significant. The evaluation did not focus on water requirements or impacts on water resources because that was not considered to be a significant criterion for the evaluation of the disposal options. The four criteria evaluated were also assigned a ranking of relative importance (a "1" ranking was the most significant and "4" the least significant). The ranking assigned is as follows:

1. Energy consumption/fossil fuel depletion
2. Waste reduction, reuse, recycling
3. Greenhouse gas and other air emissions
4. Transportation impacts

The overall ranking of the sustainability impacts for each disposal option is as follows:

- Option A (offsite thermal desorption and beneficial use): high
- Option B (offsite land fill disposal): moderate to high
- Option C (offsite cogeneration and beneficial use): moderate
- Option D (offsite stabilization and offsite beneficial use): moderate

- Option E (onsite stabilization and onsite beneficial use): low
- Option F (offsite stabilization and disposal in onsite constructed CDF): low
- Option G (onsite stabilization and disposal in onsite constructed CDF): low

4.7 Remedial Design Considerations

The evaluations performed in this FS have identified a number of elements that may require further consideration during the remedial design. The surveys, evaluations, and analyses listed below are not prescriptive or inclusive, but simply summarize possible data collection activities identified during the development and analysis of alternatives.

The remedial design will need to include development of a groundwater model to determine whether proposed upland source control measures such as slurry walls or barrier walls and the potential ISS of the native sediment will alter the groundwater flow patterns within and around the canal such that the remedy is affected. Additional data collection and evaluation to determine NAPL seepage rates will be required in order to determine the final cap designs. Hydrodynamic modeling may also be required to support the final cap designs.

The design should also incorporate technologies that could increase the overall protection and permanence of the remedy but had not yet been proven or established at the time this FS was written. ISS is a developing technology that will require further evaluation if included in the selected remedy. Pilot studies and treatability testing will be required to determine the stabilization reagents and dosage required as well as an effective and implementable delivery mechanism.

The remedial design may also include additional evaluation and analysis of the sustainability impacts of the selected alternative and consider potential ways to reduce the overall environmental footprint of the remedy. Although the sustainability evaluation herein focused on the disposal options, all components of the alternative should be evaluated with respect to increasing the overall sustainability. Examples include considering approaches to minimize energy and fuel use by reducing transportation distances and utilizing the most efficient form of transportation possible for both supplies (e.g., capping materials) and dredged material, reducing the amount of material requiring disposal, and maximizing the beneficial use of treated material.

In addition to determining NAPL seepage rates, other data collection activities and surveys performed during the remedial design may include a bulkhead stability evaluation, a bathymetry- and sediment-probing survey to refine volumes and establish baseline conditions prior to remedial action, and sediment chemistry surveys to establish baseline, or preremedy, conditions.

Additional bench-scale testing will be needed to support all the treatment and disposal options considered in order to determine the stabilization materials that would be needed and their quantities. These evaluations will also need to confirm that the stabilized materials meet the acceptance criteria of the treatment or disposal facilities or will meet specified performance criteria for beneficial-use options. A beneficial use for stabilized sediment would need to be identified for Options D and E, and the associated performance criteria for the end purpose would need to be determined; corresponding appropriate institutional controls would need to be identified and sustained long term. The sediment samples used for these evaluations would need to be collected following a sampling scheme that results in composite samples representative of the approximate sampling frequency required by the receiving facilities (e.g., one sample per 4 to 5 tons of material).

SECTION 5

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Appendix A
Non-Aqueous-Phase Liquid (NAPL) Technical Evaluation

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Non-Aqueous-Phase Liquid (NAPL) Technical Evaluation, Gowanus Canal

1. Introduction

The remedial investigation (RI) conducted at the Gowanus Canal found that non-aqueous-phase liquid (NAPL) contamination is pervasive in the native sediments and the overlying soft sediments in select reaches of the canal (USEPA, 2011). The predominant source of the NAPL appears to be releases of coal tar waste from the three former manufactured-gas plant (MGP) sites (Fulton, Carroll Gardens/Public Place, and Metropolitan). Long-term remedy effectiveness will be limited unless the potential remedial alternatives being considered in the Gowanus Canal feasibility study (FS) include mechanisms to mitigate the potential for NAPL remaining in place after the sediment remedy is implemented to recontaminate the canal. Note that measures to directly address the offsite upland NAPL sources will be addressed separately and are not considered here.

2. Objectives

The objectives of this evaluation are as follows:

- Document site conditions related to NAPL nature and extent throughout the Gowanus Canal
- Develop a NAPL conceptual site model (CSM) that describes the NAPL sources and NAPL fate and transport mechanisms in the canal
- Develop NAPL mitigation objectives for the FS
- Identify and evaluate potential NAPL response actions and NAPL remediation technologies
- Present conceptual cap designs that would be effective in mitigating further NAPL impacts to Gowanus Canal sediments

The conceptual capping designs are one component of the remedial alternatives developed and evaluated in Section 4 of the FS report.

3. NAPL Remediation Target Areas

As described in Section 2.4 of the FS report, the Gowanus Canal has been divided into four remediation target areas (RTAs) (1, 2, 3a, and 3b) based upon the degree of NAPL contamination in sediments, the navigational requirements for specific sections of the canal, and a comparison of chemical concentrations in soft and native sediments to risk-based preliminary remediation goals. The RTAs are shown in Figure 1.

A coordinate system for the Gowanus Canal has been established to allow spatial reference to the site based on the distance from the head of the canal. A coordinate station of 0+00 has been assigned to the head of the canal, and a coordinate station of 80+00 to the south end of the canal representing the 8,000-foot canal length. The turning basins are referenced using 0+00 at the intersection with the main canal. Figure 2 shows the canal stationing.

The average sediment profiles for each RTA are shown in Figure 3. The turning basin profiles are not shown. The distinguishing characteristics of each RTA are described below.

3.1 Remediation Target Area 1—Upper Canal, from Head of Canal to 3rd Street (STA 0+00 to 23+00)

General characteristics include:

- 0-to-16-foot water depth
- Approximately 100 feet wide
- Approximately 2,300 feet long
- No commercial navigation and limited recreational navigation
- Moderate soft sediment contamination compared to the other reaches
- Significant native sediment contamination
- Fulton former MGP site near upper end of the reach

As described further in Section 4, the upper canal soft sediments showed fewer NAPL impacts than the middle canal soft sediments. Only a few samples in the vicinity of the flushing tunnel had NAPL in the soft sediments. However, nearly all the native sediments in the uppermost portion of the upper canal showed NAPL impacts, with native sediment samples all along the reach containing free product.

3.2 Remediation Target Area 2—Middle Canal, Between 3rd and Creamer Streets (STA 23+00 to 56+25), Including 4th, 6th, 7th, and 11th Street Turning Basins

The 4th, 6th, 7th, and 11th Street turning basins are included in RTA 2 because they are assumed to have the same navigational use requirements as the main canal in this reach, and to simplify the conceptual cap design for the entire RTA. The same alternatives were developed for the entire RTA, including the turning basins, as described in Section 4. General characteristics of the main canal in this RTA include:

- 8-to-20-foot-water depth
- Approximately 100 feet wide
- Approximately 3,325 feet long
- Light commercial and recreational navigation
- Highest level of soft and native sediment contamination compared to the other reaches
- Carroll Gardens/Public Place former MGP site near the midpoint of the reach
- Metropolitan former MGP site near the lower end of the reach

As described further in Section 4, the soft sediments in the middle canal are impacted by NAPL or contain free product, particularly in the areas directly in front of the two former MGP sites located along this reach. The NAPL impacts near the Carroll Gardens/Public Place former MGP site appear to be more significant than the impacts near the Metropolitan former MGP site. Additional pockets of NAPL impacts and free product also exist in areas between the two former MGP sites. The native sediment in this reach is very heavily contaminated, with nearly all samples containing free product.

4th Street turning basin; extends approximately 770 feet from main canal:

General characteristics include:

- 4-to-5-foot water depth
- Approximately 100 feet wide
- Approximately 775 feet long

As described further in Section 4, nearly half of the total length of sampled soft sediments in the 4th Street Basin are impacted by NAPL or contain free product. The native sediment in this basin is even more heavily impacted, with portions of every recovered native sediment sample showing NAPL impacts or free product. At the east end of the basin, both soft and native sediments are saturated with NAPL.

6th Street turning basin; extends approximately 800 feet beyond main canal:

General characteristics include:

- 6-to-9-foot water depth
- Approximately 120 feet wide
- Approximately 800 feet long

As described further in Section 4, soft sediments in the basin are generally not impacted by NAPL, except near the contact with the native sediment at the west end of the basin. The native sediments in this basin, however, are highly impacted, with native sediment showing NAPL impacts at every sample location.

7th Street turning basin; extends approximately 500 feet beyond main canal:

General characteristics include:

- 6-to-8-foot water depth
- Approximately 100 feet wide
- Approximately 550 feet long

As described further in Section 4, areas of saturation were seen in cores from two of three sampling locations in this basin. Soft sediments are saturated with NAPL near the contact with the native sediment in the western half of this basin.

11th Street turning basin:

General characteristics include:

- 2-to-8-foot water depth
- Approximately 75 feet wide
- Approximately 150 feet long

Because of the relatively insignificant size of the 11th Street turning basin, its NAPL impacts are discussed as part of the main channel.

3.3 Remediation Target Area 3a—Lower Canal, Creamer Street to Sigourney Street (STA 56+25 to 62+25)

General characteristics include:

- 12-to-30-foot water depth
- Approximately 75 to 225 feet wide
- Approximately 600 feet long
- Significant commercial and recreational navigation
- Relatively lower sediment contamination compared to the other reaches

As described further in Section 4, NAPL impacts in soft sediment are limited in the lower canal. Only a few samples scattered along the length of this reach had visual evidence of NAPL impacts. The native sediments showed some NAPL impacts, but none showed evidence of free product.

3.4 Remediation Target Area 3b—Lower Canal, Sigourney Street to Redhook Channel (STA 62+25 to 80+00)

General characteristics include:

- 28- to 34-foot water depth
- Approximately 225 to 600 feet wide
- Approximately 1,775 feet long
- Significant commercial and recreational navigation
- Relatively lower sediment contamination compared to other reaches

As described further in Section 4, NAPL impacts in soft sediment are relatively infrequent in the lower canal. The native sediments showed some NAPL impacts, but none showed evidence of free product.

4. NAPL Nature and Extent

This section documents the results of laboratory analyses that were performed to determine selected NAPL physical characteristics. Additionally, the results of sediment coring performed as part of the RI are used to describe the extent of NAPL impacts within the canal.

4.1 NAPL Characteristics

National Grid conducted a groundwater/NAPL sampling event at the Carroll Gardens/ Public Place former MGP site on May 19, 2011. National Grid collected both a groundwater sample and a NAPL sample from wells RW-5D and RW-4 located in the upland area of the site, between stations 36+00 and 40+00.

The laboratory test results for the NAPL samples are summarized in Table 1. Documentation of the sampling procedure and the laboratory analytical data are included as Attachment A.

The results indicate that the NAPL is heavier than water and should migrate as a dense non-aqueous-phase liquid (DNAPL) rather than as a light non-aqueous-phase liquid (LNAPL) in the subsurface. The NAPL viscosity is similar to a 30-weight motor oil.

TABLE 1
NAPL and Groundwater Physical Characteristics—May 19, 2011, Sampling Event
NAPL Technical Evaluation

Parameter	Units	RW-4	RW-5D
Density	g/cm^3		
NAPL		1.10	1.04
Water		1.00	1.03
Viscosity	cP		
NAPL		81.3	119
Water		1.18	1.17
Interfacial Tension	dynes/cm		
Water–air		53.2	60.1
Water–NAPL		14.3	27.1
NAPL–air		33.7	33.3

g/cm^3 = grams per cubic centimeter.
cP = centipoises.
dynes/cm = dynes per centimeter.

Interfacial tensions between NAPL and water, NAPL and air, and water and air reflect the surface tension of the three fluids. Surface tension is a property of the surface of a liquid that allows it to resist an external force. It is revealed, for example, in the floatation of some objects on the surface of water, even though they are denser than water.

Surface tensions are used to calculate a spreading coefficient that estimates the spontaneous spreading of oil (NAPL) on a liquid substrate (groundwater) with ambient gas (air) by the following equation:

$$S = \gamma_{gw} - \gamma_{go} - \gamma_{ow}$$

where

S = surface tension (dynes/cm)
γ_{gw} = interfacial tension between groundwater and air (dynes/cm)
γ_{go} = interfacial tension between groundwater and NAPL (dynes/cm)
γ_{ow} = interfacial tension between NAPL and air (dynes/cm)

When surface tension is greater than zero ($S > 0$), spontaneous spreading occurs. Given the values in Table 1, surface tension typical of the NAPL found at the Carroll Gardens/Public Place former MGP site is on average slightly greater than zero, indicating that NAPL at the site will tend to spontaneously spread on the groundwater surface. This property may contribute to the migration of NAPL sheen in the subsurface from the upland property to the water in the canal, as described in more detail below.

4.2 NAPL Sediment Impacts

NAPL was commonly observed in sediment cores collected from the canal and in soil borings advanced at upland locations adjacent to the canal. NAPL is described on the basis of field observations using the following three categories: (1) no visual evidence of NAPL; (2) presence of nonsaturated NAPL (i.e., coatings, stains, sheens, or blebs); and (3) NAPL saturation (i.e., free oil flowing from the sample). Samples were not collected from the sediment cores and submitted to a laboratory for the quantification of NAPL saturation.

Figures 4-5a through 4-5f of the RI show the spatial distribution of sediment cores collected in the soft and native sediment layers throughout the canal along with a summary of the NAPL distribution in each layer.

4.2.1 Soft-Sediment Impacts

Figures 4a and 4b are pie charts displaying the proportion of NAPL impacts (as a percentage of total recovered core length) in soft sediment for each RTA.

Remediation Target Area 1. RTA 1 was fairly unimpacted, with 4 percent of the total collected soft sediment core length in this section being NAPL saturated. Another 11 percent of collected soft sediment was visually impacted with NAPL, but the remaining 85 percent of soft sediment had no visual NAPL impacts. The Fulton Avenue former MGP site is located near the upper end of RTA 1.

Remediation Target Area 2. RTA 2 had the greatest NAPL impacts in soft sediments, with 43 percent of the total collected soft sediment showing NAPL impacts. Approximately 21 percent of the total collected core in RTA 2 was saturated with NAPL, while the other 22 percent had visual NAPL impacts. Approximately 57 percent of the soft sediment collected in this reach had no visual NAPL impacts.

The 4th Street turning basin had soft sediment impacts closely related to those seen in the middle reach of the canal. Like RTA 2, approximately 62 percent of the soft sediments in the turning basin were not impacted by NAPL. Approximately 13 percent of the total core length was impacted by sheens, coatings, staining, or blebs, and 25 percent of the total core length was NAPL saturated.

The soft sediment in the 6th and 7th Street turning basins had NAPL impacts more similar to those seen in RTA 1, with approximately 85 percent of the total core length not impacted by NAPL in each basin. Approximately 14 percent of the recovered soft sediment from either of these turning basins was saturated with NAPL, and none was impacted by sheens, coating, staining, or blebs.

As previously noted, the Carroll Gardens/Public Place former MGP site is near the midpoint of RTA 2, and the Metropolitan former MGP site is near the end of RTA 2.

Remediation Target Areas 3a and 3b. The soft sediment in RTA 3a had the least NAPL impacts of any area of the canal. Less than 1 percent of the total soft sediment core collected in this reach had visible NAPL impacts and none of the soft sediment collected in this reach was saturated with NAPL.

In RTA 3b, 15 percent of the total soft sediment collected was saturated, and another 3 percent had visible NAPL impacts. The NAPL-saturated soft sediment is found on the west side of the canal at the east end of Bryant Street. However, RTA 3b overall is relatively unimpacted, with 82 percent of the total collected soft sediment showing no NAPL impacts.

4.2.2 Native Sediment Impacts

Figures 5a and 5b are pie charts displaying the proportion of NAPL impacts (as a percentage of total recovered core length) for various RTAs in the native sediment. The degree of NAPL contamination in the native sediments is much greater than in the soft sediments, as evidenced by the presence of NAPL-saturated native sediments throughout most of RTAs 1 and 2. NAPL impacts in native sediment were less pervasive in RTAs 3a and 3b.

Remediation Target Area 1. In most areas of RTA 1, NAPL was found in native sediment at the vertical limit of the investigation, typically 6 feet below the soft sediment–native sediment interface. The greatest thickness of NAPL-contaminated native sediment was recovered between Carroll Street and 3rd Street (Figure 4-6b of the RI report). Approximately 47 percent of the total collected core length was impacted by coating, staining, or blebs, and 32 percent was saturated with NAPL.

Remediation Target Area 2. In most areas of RTA 2, NAPL was found in native sediment at the vertical limit of the investigation, typically 6 feet below the soft sediment–native sediment interface. The greatest thickness of NAPL-contaminated native sediment was recovered between 5th Street and Huntington Street (Figure 4-6c of the RI report). Approximately 45 percent of the total collected native sediment was impacted by coating, staining, or blebs, and 34 percent was saturated with NAPL.

The native sediment in the 4th Street turning basin had greater NAPL impacts overall than the soft sediment, but the percentage that was saturated with NAPL was lower. Approximately 44 percent of the total native core length recovered was impacted by coating, staining, or blebs, while 15 percent was saturated with NAPL.

The native sediments in the 6th Street turning basin were also more impacted than the soft sediments, with 55 percent impacted by staining, blebs, or coating, and another 25 percent saturated with NAPL.

The native sediments in the 7th Street turning basin were only slightly more impacted than the soft sediments, and the percentage of total recovered sediment saturated with NAPL was nearly unchanged, at around 17 percent of the total collected length. However, the percent of the recovered native sediment that was impacted with coating, staining, or blebs was nearly 9 percent in the native sediments.

Remediation Target Areas 3a and 3b. In RTAs 3a and 3b, NAPL occurrence in the native sediments was markedly lower. None of the native sediments below Creamer Street were saturated with NAPL, while about 27 percent of the total recovered core had observable coating, staining, or blebs.

4.2.3 Sediment Interface Impacts

The presence of NAPL saturation on either side of the native sediment–soft sediment interface is considered to indicate the potential for active upward NAPL migration from the native sediment to the soft sediment. The degree of migration is considered greater in cases where there are NAPL-saturated sediments on both sides of the interface. An analysis was performed on all sampling locations where sediment was recovered from immediately above and below the native sediment–soft sediment interface to identify areas where upward migration of NAPL may be occurring. Figure 6a depicts the relative impacts at the interface in the main canal relative to distance from the head of the canal. Due to the close proximity of many sample locations in the main canal, some of the locations with fewer NAPL impacts are not shown in the figure. Figures 6b through 6d depict the relative impacts at the interface relative to distance in the turning basins from the main canal.

Remediation Target Area 1. In RTA 1, one of the 17 locations where interface samples were collected showed NAPL saturation on either side of the sediment interface, GC-SD152 was located in front of the Fulton former MGP site. Soft sediment impacts near the Fulton former MPG site may have been affected by previous dredging in this area or by flushing tunnel operations, which could affect the NAPL distribution at the soft sediment–native sediment interface.

Remediation Target Area 2. In RTA 2, 7 of the 15 locations where interface samples were collected showed NAPL saturation on either side of the interface. All of these locations were either in front of or immediately adjacent to the Carroll Gardens/Public Place or Metropolitan former MGP sites.

In the 4th Street and 7th Street turning basins, NAPL saturation on either side of the interface was observed in one of the two sample locations in each basin, indicating that NAPL may be mobile in those areas.

In the 6th Street turning basin, saturation on either side of the interface was observed in one of the two sample locations in that basin, indicating that NAPL may be mobile in that area.

Remediation Target Areas 3a and 3b. In RTA 3a, none of the four locations where interface samples were collected showed NAPL saturation on either side of the interface, indicating that NAPL is likely not migrating from native to soft sediment. In RTA 3b, one of the five locations where interface samples were collected showed NAPL impacts immediately to either side of the interface (GC-SD76C).

The potential for upward NAPL migration in areas where NAPL impacts were observed on both sides of the native sediment–soft sediment interface was investigated further using an equation that balances the resulting forces of the groundwater velocity and the NAPL density (Cohen and Mercer, 1993). The analysis presented in Attachment B indicates that the observed upward groundwater velocities presented in Section 5.2 of this report can potentially result in the upward NAPL migration under certain conditions.[1] This is essentially because the upward vertical groundwater velocity appears to be sufficient to overcome the downward force of gravity on the NAPL.

5. Conceptual Site Model

An overall CSM for the Gowanus Canal is presented in Section 1.4 of the FS report. The CSM summarizes and integrates information about historical and ongoing sources of contamination, nature and extent of contamination, contaminant fate and transport mechanisms, and risks to humans and wildlife from exposure to contaminated sediments in the canal. This CSM is being used to develop and evaluate potential remedial alternatives for the canal.

This section focuses on the aspects of the CSM related to NAPL sources and NAPL fate and transport processes in and near the canal. The CSM is presented in Figure 7, and

[1] The general site conditions were used to grossly estimate the potential for NAPL migration. The actual conditions at specific locations can vary substantially. Additional pre-design data collection and evaluation would be necessary to verify NAPL mobility at specific locations.

descriptions of NAPL-related components of the CSM are presented in the following sections.

5.1 Upland Hydrogeology

Hydrogeologic conditions in the vicinity of the Gowanus Canal influence the fate and transport of NAPL. Two groundwater aquifers are present beneath the Carroll Gardens/Public Place former MGP site: a shallow, unconfined aquifer (Upper Glacial Aquifer) and a confined/semiconfined aquifer (Jameco Aquifer) (GEI, 2005). During the Carroll Gardens/Public Place RI, the Upper Glacial Aquifer was subdivided into shallow and intermediate groundwater zones to evaluate the relationships between potentially different flow regimes within the aquifer. Tidal influence has been observed in both groundwater zones beneath the site.

The shallow groundwater zone resides in fill, alluvial deposits, and glacial outwash deposits (GEI, 2005). The shallow zone ranges from the water table to the approximate elevation of the bottom of the Gowanus Canal (-11 feet North American Vertical Datum 1988 [NAVD88]). Groundwater generally flows toward the Gowanus Canal within the shallow zone with some variations onsite. The average hydraulic gradient of the shallow groundwater aquifer range from 0.015 foot/foot to 0.078 foot/foot, and was generally consistent between the high and low tides. Tidal effects were noted within the shallow groundwater zone. The hydraulic conductivity in the shallow zone averages 1.51 feet /day, with average linear velocities ranging from 5.51 feet/year to 143 feet/year depending on upland site location.

The intermediate groundwater zone resides in glacial outwash deposits. Monitoring well screen intervals within this zone ranged from –27 to –66 feet NAVD88. Groundwater in the intermediate groundwater zone of the Upper Glacial Aquifer flows generally toward the canal during both high and low tide conditions. The average hydraulic gradient of the intermediate groundwater zone is 0.001 foot/foot. The hydraulic conductivity of the intermediate groundwater zone was calculated at 0.965 feet/day, with average linear velocities ranging from 1.17 to 3.52 feet/year.

The deep groundwater zone resides within glacial outwash deposits. Monitoring well screen intervals within this zone ranged from –101 to –120 feet NAVD88. Groundwater in the deep groundwater zone of the Upper Glacial Aquifer flows generally to the west-southwest during both high and low tide conditions. This is consistent with the regional groundwater discharge direction, which is southwesterly toward Upper New York Harbor. The average hydraulic gradient of the deep groundwater aquifer range from 0.0014 foot/foot to 0.004 foot/foot, and was generally consistent between the high and low tides. Tidal effects were noted within the deep groundwater zone of the glacial aquifer.

The Jameco Aquifer underlies the Upper Glacial Aquifer, and regionally, the Gardiner's Clay serves as a confining unit between these two aquifers. At the Carroll Gardens/Public Place site, however, the Gardiner's Clay is not consistently present, suggesting hydraulic connection between the Jameco Aquifer and the overlying upper deep groundwater zone (GEI, 2005).

5.2 Groundwater/Surface Water Pathway

Groundwater-monitoring wells located in the immediate area of the canal are installed at depths of about -15 feet NAVD88 (shallow well) and about -35 to -45 feet NAVD88 (intermediate well). The shallow wells intersect the water table, typically screening the fill and alluvial/marsh deposits. Intermediate-well screen zones are in the glacial deposits. The first-encountered groundwater occurs in the fill deposits.

Water level measurements from the shallow wells indicate that, in general, the water level elevations in wells closer to the canal are lower than in wells further away from the canal. Thus, shallow groundwater flows toward the canal, at both high and low tide. Water level measurements from the intermediate wells indicate that groundwater elevations are relatively consistent during the high and low tides, except in the wells closest to Gowanus Bay. In these wells, the intermediate groundwater elevations during high tide were about 0.5 to 1 foot higher on average than during low tide. These data indicate that there is a tidal influence on the intermediate groundwater elevations, which would affect the intermediate groundwater flow conditions (USEPA, 2011).

Vertical groundwater gradients adjacent to the canal trend upward, suggesting flow toward the canal as a hydrologic discharge zone. Vertical gradients near the canal ranged from 0.005 to 0.06 foot/foot. Vertical gradients measured in upland wells (i.e., greater than 150 feet from the canal) are typically downward, suggesting a typical recharge area. One well cluster approximately 150 feet from the canal exhibited an upward vertical gradient ranging from 0.06 to 0.28 foot/foot (USEPA, 2011).

The Gowanus Canal exhibits a uniform chemical signature along its entire length suggesting minimal influence by groundwater flow contribution. Water chemistry exhibits similar signatures between the canal and adjacent upland shallow wells, suggesting infiltration of surface water into the fill/alluvium. Groundwater flow volumes into the canal appear insufficient to alter the basic chemical signature (USEPA, 2011).

5.3 Upland NAPL Fate and Transport

Where found at the Carroll Gardens/Public Place former MGP site, the majority of NAPL was observed in the intermediate subsurface soils and groundwater-monitoring wells at elevations beneath the bottom of the Gowanus Canal. Information provided by National Grid on DNAPL recovery in the upland area of the Carroll Gardens/Public Place former MGP site between stations 30+00 and 45+00 is presented in Figure 8. This figure presents the NAPL recovery information for the period between December 2010 and May 2011 based on the depth interval where NAPL was recovered. This figure shows that, although the majority of the DNAPL recovery occurs in the deep recovery wells below elevations where NAPL migration could affect the canal, NAPL is also recovered from the intermediate and shallow recovery wells, where NAPL migration could affect the canal.

It appears that releases of NAPL tar from the Carroll Gardens/Public Place former MGP site generally migrated downward through the permeable fill and sandy alluvial/marsh deposits. In general, NAPL migration continued downward in the MGP areas where releases occurred until it encountered the glacial till, clay lenses, and to a lesser degree subtle permeability changes in the sandy alluvial/marsh deposits. The NAPL then migrated laterally south and southeast along the top of the glacial till and clay lenses. Where the glacial till and clay lenses are absent, the tar continued to migrate downward until the volume of tar was insufficient to maintain a NAPL pressure head capable of overcoming the capillary pressures and surface tension forces, thus leading to the stagnation of the NAPL front (GEI, 2005). The NAPL release mechanisms observed at the Carroll Gardens/Public Place former MGP site are likely similar at the Fulton and Metropolitan former MGP sites along the Gowanus Canal, although data to support this are not currently available.

5.4 Discharges to Gowanus Canal

The Gowanus Canal has been affected by numerous known and potential sources of contamination for a period of about 140 years, including the following:

- Direct discharges of waste from historical industrial activities
- Discharges of sewage and stormwater from combined sewer overflows (CSOs)
- Ongoing direct discharges from pipe outfalls
- Discharge of upwelling groundwater through NAPL-impacted soils or sediments, thereby transporting dissolved-phase contaminants into the canal
- Discharges from contaminated upland sites—contaminants from the former MGP sites and other upland sites appear to have been transported to the canal via direct spills, surface runoff (i.e., overland transport of contaminated soils), seepage through the bulkheads, migration of NAPL through subsurface soils into canal sediments and surface water, and groundwater discharge of dissolved-phase contaminants to the canal.

Groundwater discharges into the canal, although flow reversals occur at some locations and tidal stages. Groundwater contamination was found on some of the properties abutting the canal; therefore, the transport of dissolved-phase contaminants to the canal via groundwater discharge is expected to occur at certain locations, as discussed in Section 1.4.1 of the FS report. Transmissivity values range from 7 to 29,000 ft^2/day in the shallow zone and from 27 to 47,000 ft^2/day in the intermediate zone, indicating that most material is transmissive (USEPA, 2011).

Groundwater discharging through NAPL-impacted zones allows partitioning of NAPL constituents to the groundwater. These constituents can either discharge to surface water, or partition back to the sediments outside of the NAPL-impacted zone.

5.5 NAPL Transport from Canal Sediments

NAPL in the Gowanus Canal sediments can be transported into the water column through several transport mechanisms, including ebullition and seep migration. In addition, NAPL could migrate from the sediments into the water column if the sediment column was compressed during capping.

5.5.1 Ebullition

Ebullition is the production of gas due to anaerobic biological activity in sediment (Viana et al., 2007a). Mineralization of organic matter by bacteria in the sediment generates gases such as methane, nitrogen, carbon dioxide, and other gases (Reible, 2004). Gas ebullition acts as a NAPL transport mechanism. The bubbles produced during ebullition tend to accumulate hydrophobic contaminants and colloids, such as NAPL sheen, on their surfaces (Viana et al., 2007b). This NAPL can then travel out of the sediment and be deposited on the water surface as a sheen as the gas bubbles migrate upwards through the water column. The soft sediments in the Gowanus Canal are rich in organic matter, with an average total organic carbon content of 12 percent. Gas bubbles generated by the degradation of natural organic matter (and the NAPL itself) can rise through NAPL-impacted sediments and cause NAPL to be transported to the surface water.

5.5.2 Seep Migration (Advection)

A NAPL seep is defined as a NAPL discharge where:

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

NAPL seeps can more readily migrate through sediments previously impacted with NAPL (NAPL is the wetting phase) (Sale, 2011). When NAPL is nonwetting, water is the wetting phase, and the NAPL migrates when the NAPL head exceeds the pore entry pressure of the groundwater. This allows NAPL to migrate to areas previously unaffected by NAPL. When NAPL is the wetting fluid, NAPL discharge is likely continuous since the driving head of NAPL continues to release NAPL along the NAPL-wetted pathway.

5.5.3 Sheen Migration

NAPL sheen is defined as a NAPL discharge where:

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

NAPL sheens migrate by the difference in the surface tensions that result in a positive spreading coefficient as described in Section 4.2 (Sale, 2011). In subsurface soils, NAPL spreads on the groundwater surface in the same manner as a surface water sheen. In this way, NAPL sheen spontaneously enters water-coated, air-filled pores through capillary forces. These forces overcome gravitational forces and NAPL migrates. However, surface tensions alone are insufficient to exceed the pore entry pressure of the groundwater and migrate through nonwetted areas (areas absent of NAPL impacts). Hence, sheen migration occurs only in a previous NAPL-wetted pathway at the interface of groundwater and the vadose zone such as through vadose zone transport from an upland source.

5.5.4 NAPL Migration with Groundwater Advection

NAPL can migrate with groundwater through sediments that are not impacted by NAPL if the groundwater vertical gradient provides a force greater than the gravity force of the NAPL and the capillary forces and if NAPL is moving through media where the water is the wetting fluid.

5.5.5 NAPL Migration from Capping

Sediments contaminated with NAPL are often extremely soft and have very little shear strength or bearing capacity (Ma et al., 2010). The load placed on NAPL-saturated sediments by a sediment cap can cause sufficient consolidation of the underlying sediments to express pore water into the cap (Reible, 2004). NAPL can be mobilized into the cap along with the pore water (Azcue et al., 2000).

Additionally, the low bearing strength of the contaminated sediments could cause the underlying sediment to billow up during emplacement of the cap materials, causing intermixing of the contaminated sediments and cap materials (Ma et al., 2010). This leads to a reduced thickness of the uncontaminated cap isolation zone between contaminated sediments and the overlying water column. However, this intermixing has been observed to be dependent on both the degree of NAPL saturation and the characteristics of the underlying contaminated sediment. In addition to intermixing, the low bearing strength of the sediments can lead to a contaminated sediments layer on top of the cap material. Laboratory column tests simulating sand cap emplacement showed that some contaminated sediment was resuspended into the water column during cap emplacement, and these suspended contaminated sediments later settled into a thin layer on top of the cap. This resuspension effect can be minimized through careful cap emplacement techniques.

5.5.6 NAPL as a Source for Dissolved Phase Transport

Groundwater under the canal flowing through NAPL-impacted sediment will result in the dissolution of NAPL components into the groundwater (USEPA, 2009). The rate of dissolution would depend on multiple factors, including groundwater flow velocity, presence of co-solvents in the NAPL, and the solubility and fractions of the components composing the NAPL. The migration of the resulting dissolved phase contaminants from the underlying sediments into the canal surface water would be controlled by advection, dispersion, sorption, and degradation processes. The upward vertical groundwater gradients observed near the canal (Section 5.2) indicate that dissolved phase contaminants resulting from the NAPL source zone could potentially migrate upward into the canal under certain conditions.

6. NAPL Mitigation Objectives

Based on the analysis of NAPL occurrence in Gowanus Canal sediments and NAPL fate and transport processes, the following NAPL mitigation objectives were developed for the FS:

1. Prevent direct human or ecological contact with NAPL-contaminated sediments
2. Prevent the migration of NAPL into the canal after the remedial action is completed
3. Prevent NAPL from serving as a source of contaminants to groundwater discharging to the canal

Because NAPL in the native sediments in portions of the canal extends to a greater depth than the practical limit of a potential remedy, the selected remedy for canal sediments will need to prevent the recontamination of the canal by NAPL after the remedy is completed.

7. NAPL Response Actions

As described in Section 2.4 of the FS report, response actions are required to address chemical contamination in canal sediments. These response actions also need to address the

NAPL mitigation objectives identified above. Table 2 summarizes the NAPL mitigation objectives that need to be achieved within each RTA based on the NAPL impacts within each reach (see Figures 4 through 6).

Achieving the NAPL mitigation objectives will require a combination of upland source control measures and the use of sediment remediation technologies to prevent recontamination of the canal by NAPL that remains in deep canal sediments after the remedy is implemented. Upland source control measures would be required to ensure that there is no driving force (pressure head) to cause NAPL seep migration into the canal or through the bulkheads. Sediment remediation technologies for NAPL-impacted sediments are described in Section 8.

TABLE 2
NAPL Mitigation Objectives by Remediation Target Area
NAPL Technical Evaluation

	Remediation Target Area			
NAPL Mitigation Objective	**1—Upper Canal**	**2—Middle Canal**	**3a—Lower Canal (Creamer to Sigourney)**	**3b—Lower Canal (Sigourney to Redhook)**
Prevent Direct Contact	●	●	○	○
Prevent NAPL Migration				
Seeps (Advection)	●	●	—	○
Sheen Migration [a]	—	—	—	—
Ebullition	●	●	○	○
Prevent NAPL Source to Groundwater	●	●	●	●

[a] Not a concern for the saturated sediments beneath the canal.
— Indicates that the pathway is incomplete for the RTA.
● Indicates that the pathway is complete within significant portion of RTA.
○ Indicates that the pathway may be complete for a limited or insignificant portion of the RTA.

8. NAPL-Impacted Sediment Remediation Technology Evaluation

Available sediment treatment and capping technologies were evaluated for the Gowanus Canal. To date, capping technologies have proven to be the most effective method for controlling the migration of NAPL into water bodies. However, several other technologies that are in the early stages of development may prove to be effective for treating or immobilizing NAPL in sediments, and their use in combination with capping may ensure the long-term sustainability of the remedy for the Gowanus Canal. These technologies could be incorporated into the remedy for Gowanus Canal sediments following further testing on their applicability within the canal. The technologies applicable to Gowanus Canal sediments are described below and summarized in Section 3 of the FS report.

8.1 In Situ Stabilization/Solidification

In situ stabilization/solidification (ISS) is a technology based on the use of augers to mix a slurry of pozzolanic additives into soils or sediments to stabilize them in situ. ISS of soils can be performed utilizing various techniques, including single-auger mixing, patented rake injectors, high-speed rotating mixing devices, and excavators. The characteristics of each project are reviewed to determine the most effective method of ISS application (CETCO, 2008). ISS results in a stabilized mass with greater strength, lower permeability, and reduced contaminant mobility.

ISS of aquatic sediments is in the early stages of development. A demonstration project was performed on soft silty sediments in the Passaic River, New Jersey, using Cement Deep Soil Mixing (CDSM) technology (Maher et al., 2005). The sediments were not highly contaminated, and they did not contain NAPL. Sediments were mixed with varying percentages of cement and engineering properties were evaluated in situ. In addition, laboratory tests were performed to evaluate contaminant mobility. Test results indicated that the shear strength of the stabilized sediments was significantly increased, and the moisture content was decreased by 40 percent. The laboratory studies showed that ISS resulted in the immobilization of polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), and dioxins.

One of the benefits of ISS when applied to NAPL-impacted soils or sediments is that it would disperse the soil pore NAPL phase due to the blending of soil, water, NAPL, and the ISS reagent into a uniform low permeability solid-phase consistency. Much of the pore space that was originally present in the sediments and partially filled with NAPL would be filled with the ISS reagent. The contaminants would be homogenized and the stabilized mass would have lower average contaminant concentrations, much lower than the minimum required to form a separate NAPL phase. Elimination of NAPL-saturated zones would also reduce the driving force for contaminant solubilization into groundwater that would then discharge to the canal (EPRI, 2009).

Although ISS has not been tested on NAPL-impacted sediments, the 40 percent reduction in moisture content observed in the Passaic River demonstration project indicates a reduction in the total porosity which would reduce NAPL saturations. In addition, ISS has been used to immobilize DNAPL in soils below the water table. Additional laboratory and field testing is needed to evaluate ISS as a promising technology for controlling NAPL in saturated sediments.

ISS is considered a potentially effective technology for the Gowanus Canal sediments based on the following considerations:

- NAPL saturation heterogeneities would be homogenized. Higher-permeability sediments can have higher NAPL saturations, which result in preferential migration pathways, and these preferential pathways would be eliminated.
- NAPL saturations potentially can be lowered to residual levels by ISS, preventing further NAPL migration.

- Hydraulic conductivity of the ISS-treated sediments would be greatly reduced, resulting in reduced upward groundwater velocities that can cause NAPL migration (ITRC, 2009).
- ISS has been pilot tested on soft sediments using CDSM (Maher, 2005).

Factors that would need to be addressed include an increase in sediment volume after ISS and management of turbidity and NAPL generated by the mixing process.

A suitability assessment of ISS would begin with bench-scale treatability testing to determine whether it can be implemented cost-effectively to achieve the site-specific remedial objectives. Site-specific conditions such as NAPL saturations and distributions, heterogeneity of geologic strata, water content of sediment, and proposed end use of the canal could affect the feasibility of the technology. Bench- and field-scale treatability studies would be required to assess whether ISS would be effective in Gowanus Canal sediments.

8.2 Isolation Cap

Isolation caps are designed to form an isolation layer that physically separates the contaminated underlying sediment layer from the overlying water column. Sand caps have been the most commonly applied type of isolation for contaminated sediments (EPRI, 2006). Sand caps have several drawbacks in a NAPL application. In areas with ebullition, the gases can carry NAPL sheen on the bubble surfaces through the nonreactive sand layer and into the water column. Emplacement of a sand cap over soft sediment can lead to disturbances of the soft sediment column and cause contaminated sediments to billow up into the water column, settling both within the sand cap layer and on top of the capping layer, thus decreasing the isolating effect of the sand cap. Additionally, soft sediments with low shear strength are generally compressible and may not be able to support the weight of an overlying cap. However, at some sites, rotary spreaders have been used to effectively place sand layers on top of soft sediments with minimal disturbance to the underlying sediment.

8.3 Ebullition Gas Collection Cap

Ebullition collection caps are a recently developed technology designed to collect gases formed during ebullition and direct the gases to a collection point where they are vented (McLinn et al., 2011). The sediment bottom is excavated to form an upwards slope towards the collection/venting area. The gases flow up to the impermeable layer, are transported up the slope of the layer surface, and are vented in an open "chimney" area at the bank. In these systems a potential exists for gas to accumulate under the impermeable cap layer and cause uplifting of the cap or scouring of the underlying sediment layer. An evaluation of the navigational requirements of the Gowanus Canal showed that the slope required for channeling ebullition gases to the bulkhead for venting would not be feasible.

8.4 Adsorptive Cap

Adsorptive caps are constructed of materials that adsorb and retain contaminants that are carried by upward advective or diffusive flow, actively preventing transport of contaminants from sediment into the overlying water column, while allowing gas to pass through. These caps can be made of a wide variety of materials depending on the targeted compounds, and can prevent transport of contaminants through adsorption, sequestration, or complexation mechanisms. At the same time, the high hydraulic conductivity of the adsorptive caps allows water and gases produced by ebullition to pass through the cap materials.

Oleophilic clay adsorptive caps were evaluated for this project. Oleophilic clay is a surface-modified clay that is effective for adsorbing insoluble and partially insoluble compounds (Olsta et al., 2006). The surface cation on bentonite or hectorite clay is replaced with an organic molecule, generally quaternary amines based upon tallow, to produce the oleophilic clay (Olsta et al., 2010). The resulting clay is hydrophobic and permeable. This would allow ebullition bubbles to pass through the reactive cap, preventing cap uplifting, while adsorbing the NAPL, thus preventing transport of the NAPL into the water column. The oleophilic clay is also designed to retain high permeability upon organic adsorption.

Two different oleophilic clay materials were considered. The first, granular oleophilic clay, is emplaced much like a sand layer. The second, reactive core matting, consists of a thin layer of oleophilic clay material sandwiched between two permeable geotextile layers made of biodegradation-resistant synthetic fibers (Olsta et al., 2006).

The advantage of granular oleophilic clay is that it can be emplaced to any specified thickness, or mixed with other inert materials, to meet site-specific adsorptive capacity requirements. The disadvantage of granular oleophilic clay, like sand caps, is that emplacement over soft sediments can cause resuspension of the soft sediment layer, leading to settling of contamination both in and atop the cap layer. Specific construction quality control measures are needed for proper placement.

Adsorptive caps to control NAPL migration can be designed for a set life expectancy where the NAPL migration rate is known. For the McCormick & Baxter site in Portland, Oregon, the NAPL discharge rate to the cap was estimated and a design life of over 100 years established (Blischke and Olsta, 2009). The NAPL discharge rate was lower than can be expected at the Gowanus Canal based on the fact that groundwater advection was downward (Gowanus is upward) and the NAPL gradient was relatively flat (Gowanus has NAPL sitting in the alluvium above the elevation of the bottom of the canal). However, oleophilic clays become more impermeable once impacted with NAPL, reducing the penetration of NAPL into the adsorptive cap. NAPL discharge rates should be determined prior to cap design to establish the appropriate adsorptive cap thickness requirements for a given site.

The advantage of oleophilic clay reactive core mats is that they can be installed over soft sediments with minimal resuspension, helping to isolate the contamination beneath the sediment mat. The typical thickness of the reactive mats is approximately 1 cm. Adsorptive mats were not considered for the conceptual cap designs for the Gowanus Canal because excessive layers of mats would be required to achieve the desired adsorptive capacity.

8.5 Reactive Caps

Reactive caps are caps in which contaminants are removed or destroyed, in contrast to adsorptive caps, which only retain contaminants. Several ongoing research projects are evaluating different methods to enhance contaminant destruction within the cap layers. These include the use of oxygen release compounds to promote aerobic degradation (Abdallah et al., 2009) and the use of electrochemical reactions to encourage degradation of PAHs and other hydrocarbons (Yan et al., 2011). Carbon cloth electrodes were placed in a laboratory microcosm containing PAH-contaminated sediments and a thin sand cap. A low voltage (2 to 4 volts) was applied to sustain an oxidative environment at the cap–sediment interface to create conditions that promote contaminant degradation. This work has been completed only on a laboratory scale.

No technologies have been identified that provide for the destruction of NAPL within a cap. In situ thermal and in situ oxidation technologies are typically used to destroy NAPL-impacted soils, but they are not easily implemented and have not been successfully applied in an aquatic environment.

8.6 Impermeable Caps

Impermeable caps place low-permeability material on the sediment surface to block NAPL and groundwater migration upward into overlying sediment.

AquaBlok is a proprietary clay polymer composite developed by AquaBlok, Ltd. of Toledo, Ohio, that is an alternative to traditional sediment-capping materials such as sand. It is designed to swell and form a continuous and highly impermeable isolation barrier between contaminated sediments and the overlying water column. AquaBlok is generally marketed as a nonspecific capping material that could encapsulate any class or type of contaminant as well as theoretically any range of contaminant concentration (USEPA, 2007).

Impermeable caps have also been designed with openings where groundwater discharges to surface water (Mueller et al., 2007). The opening acts like a "gate" in a funnel and gate system where adsorptive or reactive materials can be placed to "treat" the NAPL or groundwater discharging from the gate.

Low-permeability capping would not be suitable for treating NAPL-impacted sediments. Methane gases may be generated beneath the cap, causing its potential uplift and deformation without special design considerations. However, it could be implemented to reduce permeability and reduce groundwater discharge to the canal.

9. Sediment Cap Conceptual Designs

Separate conceptual cap designs were developed for each RTA in the canal. Each conceptual design was developed to address the NAPL mitigation objectives identified in Table 2. The conceptual designs are based on the use of an adsorptive cap for NAPL mitigation because it has the highest stage of development and has been implemented in full-scale sediment remediation projects. Additionally, the conceptual cap design for each RTA incorporates the navigational expectations that have been identified for each reach of the canal and describes how these expectations will be achieved.

It is important to note that the designs presented here are conceptual and based on the remedial technologies and representative process options retained in Section 3. Additional data collection and/or treatability testing would be required prior to remedial design to finalize the process options that would be used and to determine the final cap configuration that would be used to address the RAOs. If new capping process options are available at the time of the design, they may be incorporated into the remedy if shown to improve the overall effectiveness or long-term permanence of the alternative. If changes to cap layer thicknesses are made during the technical design of the sediment caps, the target dredge depths presented here would need to be adjusted accordingly to ensure all navigational and NAPL mitigation objectives can be still achieved. It is also important to note that the conceptual designs presented here address only NAPL already present in canal sediments; NAPL entering the canal by seepage through the bulkheads or through any other pathway from upland sites is not addressed by these conceptual designs.

9.1 Remediation Target Area 1—Upper Canal

9.1.1 Cap Design 1a—Removal of All Soft Sediment

All soft sediment will be removed from RTA 1. Removing all soft sediment will accomplish the following objectives:

- Maintain consistency with current goals of the New York City Department of Environmental Protection (NYCDEP) with respect to CSO abatement. Eliminating exposed sediment will mitigate odors observed at low tide, improve aesthetics, and provide improved benthic habitat.
- Improve cap structural stability and minimize re-entrainment of contaminants in the cap materials (EPRI, 2006).
- Allow for a total cap thickness of 3.5 feet to be placed.
- Allow for a final average elevation of approximately -14.5 feet NAVD88 after the cap is installed.

Conceptual Cap Design 1a for RTA 1 is shown in Figure 9. Key design elements include the following:

- **Cap treatment layer (1 foot).** Consists of granular oleophilic clay material to adsorb NAPL that is transported from the underlying sediment by seep migration and/or ebullition. This isolation layer is permeable enough to allow passage of ebullition bubbles produced from within the underlying contaminated native sediment while removing NAPL. The thickness and reactive contents of the isolation layer were selected to be consistent with the design of the sediment cap at McCormick & Baxter in Portland, Oregon. Disturbance of contaminated native sediments during emplacement of the granular oleophilic clay material is not expected to be an issue.
- **Cap isolation layer (1 foot).** Consists of 6 inches of sand covered with 6 inches of gravel to act as an additional isolation barrier between contaminated sediments and the canal. Also acts as a protective layer to prevent damage to the treatment layer below from the armoring layer above.
- **Cap armor layer (1.5 feet).** Consists of coarse gravel and cobbles to act as a protective layer to prevent damage to the active layer from potential scouring from small watercraft and flushing tunnel currents, and bioturbation from burrowing organisms. The cap armor layer will also provide a demarcation of the cap surface in the event that future dredging is required to remove future accumulated sediment deposits. The armor layer will contain a range of particle sizes to facilitate its colonization by benthic and epibenthic fauna. Epibenthic fauna (crabs, mussels, etc.) can colonize areas with

relatively larger stone size, while benthic infauna can colonize the finer-grained particles that fill in the gaps between cobbles.

9.1.2 Cap Design 1b—Removal of All Soft Sediment and ISS of Native Sediment

This cap design is similar to Cap Design 1a except that the native sediments are treated with ISS to a depth 5 feet below the sediment surface prior to cap placement. Conceptual Cap Design 1b for RTA 1 is shown in Figure 10.

ISS could be incorporated into the cap design in areas of native sediment with NAPL impacts. Bench-scale and pilot testing are needed to determine the reagents and application details for this technology.

9.2 Remediation Target Area 2—Middle Canal

9.2.1 Cap Design 2a—Removal of All Soft Sediment

All soft sediment will be removed from RTA 2. Select areas of native sediment also will be removed to allow for a final maximum elevation of -18 feet NAVD88 after the cap is installed. This targeted elevation is driven by navigational considerations. This approach will accomplish the following objectives:

- Improve cap structural stability and minimize re-entrainment of contaminants in the cap materials (EPRI, 2006). This reach of the canal has the greatest occurrence of NAPL saturated soft sediments.
- Maintain consistency with expected navigational requirement of -16 feet NAVD88 within this reach of the canal (USACE, 2007 and 2009).
- Allow for a total cap thickness of up to 3.5 feet to be placed.
- Allow for the accumulation of 2 feet of future sediment deposits before the canal depth becomes less than -16 feet NAVD88 and requires subsequent sediment dredging for navigational purposes.
- Meet the grade at RTA 1 through a 100- to 200-foot transition zone. The vertical profile of the transition zone will be finalized during the remedial design based on the selected remedies for the RTAs.
- The 4th, 6th, 7th and 11th Street turning basins will be dredged to the grade in the main section of the canal.

Sediments would need to be removed to an elevation of -21.5 feet NAVD88 to achieve this design. The conceptual cap design 2b for RTA 2 is shown in Figure 11. Key design elements include the following:

- **Cap treatment layer (1.0 foot).** Consists of granular oleophilic clay material to adsorb NAPL that is transported from the underlying native sediment through seep migration and/or ebullition. This isolation layer is permeable enough to allow passage of ebullition bubbles produced from within the underlying contaminated native sediment while removing NAPL. The thickness and reactive contents of the isolation layer were selected to be consistent with the design of the sediment cap at McCormick & Baxter in

Portland, Oregon. As described in Section 9.1.1, disturbance of contaminated native sediments during the emplacement of the granular oleophilic clay material is not expected to be an issue.

- **Cap isolation layer (1.0 foot).** Consists of 6 inches of sand covered with 6 inches of gravel to act as an additional isolation layer to prevent contaminated sediment from migrating into the canal. Also acts as a protective layer to prevent damage to the treatment layer below from the armoring layer above.
- **Cap armor layer (1.5 feet).** Consists of coarse gravel and cobbles to act as a protective layer to prevent damage to the active layer from potential scouring from small watercraft and bioturbation from burrowing organisms. The cap armor layer will also provide a demarcation of the cap surface in the event that future dredging is required for navigational purposes to remove future accumulated sediment deposits. As described previously (Section 9.1.1), the armor layer will contain a range of particle sizes to facilitate its colonization by benthic and epibenthic fauna.

9.2.2 Cap Design 2b—Removal of All Soft Sediment and ISS of Native Sediment

This cap design is similar to Cap Design 2a except the native sediments are treated with ISS to a 5-foot depth prior to cap placement. Conceptual Cap Design 2b for RTA 2 is shown in Figure 12.

ISS could be incorporated into the cap design in areas of native sediment with NAPL impacts. Bench-scale and pilot testing are needed to determine the reagents and application details for this technology.

9.3 Remedial Target Area 3a—Lower Canal (Creamer Street to Sigourney Street)

9.3.1 Cap Design 3a—Removal of All Soft Sediment

All soft sediment will be removed from RTA3a. The removal of all soft sediment in RTA 3a will result in an average final elevation of -26 feet NAVD88 after the cap is installed. This will accomplish the following objectives:

- Improve cap structural stability and minimize re-entrainment of contaminants in the cap materials (EPRI, 2006). All soft sediment will be removed.
- Exceed federally authorized navigation depth (18 feet below MLLW).
- Allow for a total cap thickness of up to 3 feet to be placed.
- Meet the grade of RTA 2 at Creamer Street through a 100- to 200-foot transition zone.

Conceptual Cap Design 3a for the lower canal is shown in Figure 13. Key design elements include the following:

- **Cap treatment layer (0.5 foot).** Consists of granular oleophilic clay material to adsorb dissolved contaminants in pore water that is transported from the underlying groundwater. This isolation layer is permeable enough to allow passage of ebullition bubbles produced from within the underlying contaminated native sediment while removing dissolved contaminants. Because NAPL-saturated sediment was not found at its interface with native sediment, the layer used in RTA 3a (0.5 foot) is thinner than that in RTAs 1 and 2 (1.0 foot). This isolation layer is expected to be sufficient to address chemical contamination in the sediments in RTA 3a. As noted, disturbance of contaminated native sediments during emplacement of the granular oleophilic clay material is not expected to be an issue.

- **Cap isolation layer (1 foot).** Consists of 6 inches of sand covered with 6 inches of gravel to act as an isolation barrier between contaminated sediments and the canal. Also acts as a protective layer to prevent damage to the treatment layer below from the armoring layer above.
- **Cap armor layer (1.5 feet).** Consists of coarse gravel and cobbles to act as a protective layer to prevent damage to the isolation layer from potential scouring from watercraft and bioturbation from burrowing organisms. The cap armor layer will also provide a demarcation of the cap surface in the event that future dredging is required for navigational purposes to remove future accumulated sediment deposits. As described previously (Section 9.1.1), the armor layer will contain a range of particle sizes to facilitate colonization of the armor layer by benthic and epibenthic fauna.

9.4 Remedial Target Area 3b—Lower Canal (Sigourney Street to Redhook Channel)

9.4.1 Cap Design 3b—Removal of All Soft Sediment

All soft sediment will be removed from RTA3b. The removal of all soft sediment in RTA 3b will result in an average final elevation of -39 feet NAVD88 after the cap is installed. This will accomplish the following objectives:

- Improve cap structural stability and minimize re-entrainment of contaminants in the cap materials (EPRI, 2006). All soft sediment will be removed.
- Exceed federally authorized navigation depth (30 feet below MLLW[2]).
- Allow for a total cap thickness of up to 3 feet to be placed.
- Meet the grade of RTA 3a at Sigourney Street through a 100- to 200-foot transition zone.

Conceptual Cap Design 3b for this section of the lower canal is shown in Figure 14. Key design elements include the following:

- **Cap treatment layer (0.5 foot).** Consists of granular oleophilic clay material to adsorb dissolved contaminants in pore water that is transported from the underlying groundwater. This isolation layer is permeable enough to allow passage of ebullition bubbles produced from within the underlying contaminated native sediment while removing dissolved contaminants. Because NAPL-saturated sediment was not found at its interface with native sediment, the layer used in RTA 3b (0.5 foot) is thinner than that in RTAs 1 and 2 (1.0 foot). This isolation layer is expected to be sufficient to address chemical contamination in the sediments in RTA 3b. As previously noted, disturbance

[2] The federally authorized depth of -30 feet MLLW corresponds to an elevation of -33 feet NAVD88.

of contaminated native sediments during emplacement of the granular oleophilic clay material is not expected to be an issue.

- **Cap isolation layer (1 foot).** Consists of 6 inches of sand covered with 6 inches of gravel to act as an isolation barrier between contaminated sediments and the canal. It also acts as a protective layer to prevent damage to the treatment layer below from the armoring layer above.

- **Cap armor layer (1.5 feet).** Consists of coarse gravel and cobbles to act as a protective layer to prevent damage to the isolation layer from potential scouring from watercraft and bioturbation from burrowing organisms. The cap armor layer will also provide a demarcation of the cap surface in the event that future dredging is required for navigational purposes to remove future accumulated sediment deposits. As described previously (Section 9.1.1), the armor layer will contain a range of particle sizes to facilitate colonization of the armor layer by benthic and epibenthic fauna.

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Figures

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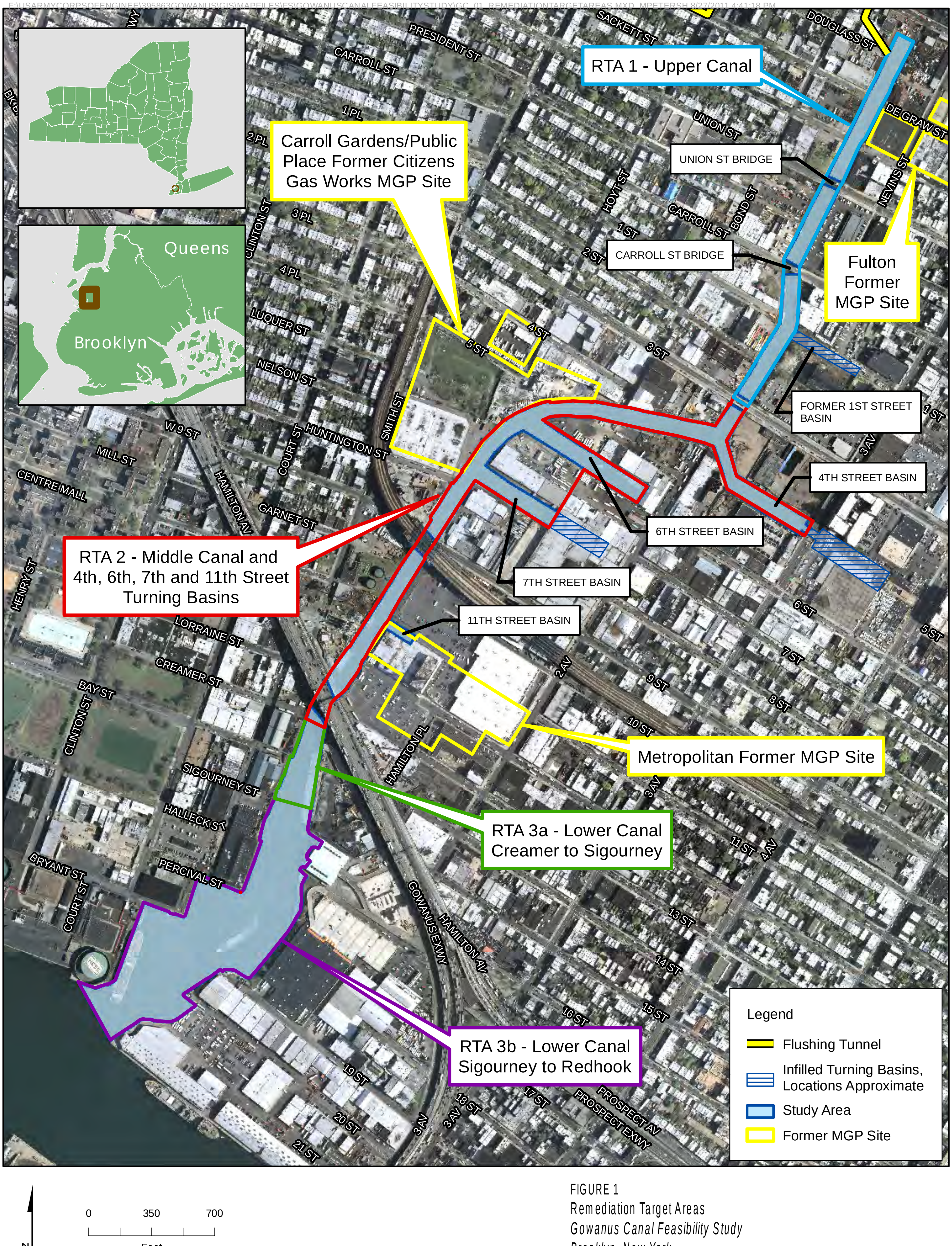

FIGURE 1
Remediation Target Areas
Gowanus Canal Feasibility Study
Brooklyn, New York

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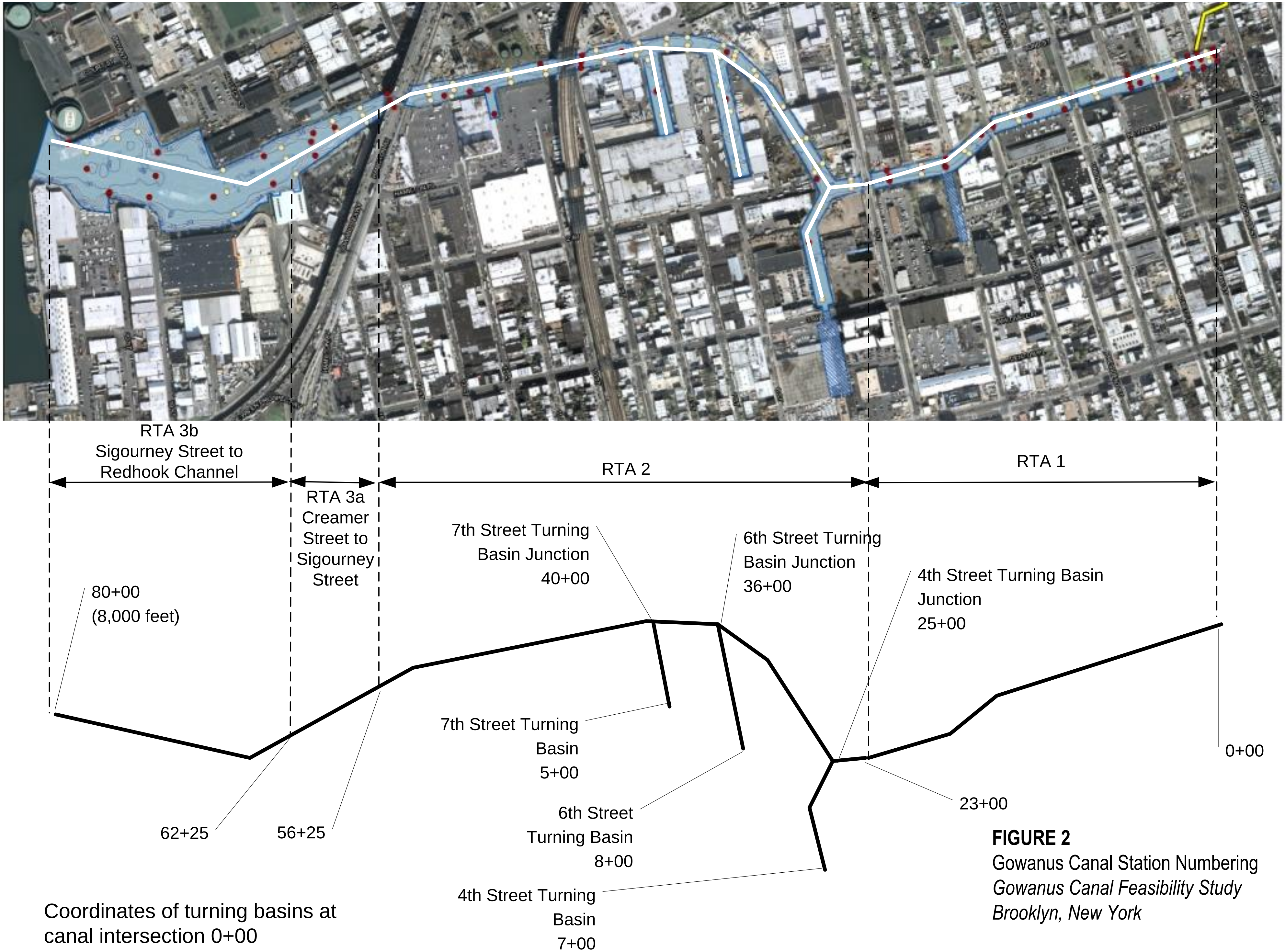

FIGURE 2
Gowanus Canal Station Numbering
Gowanus Canal Feasibility Study
Brooklyn, New York

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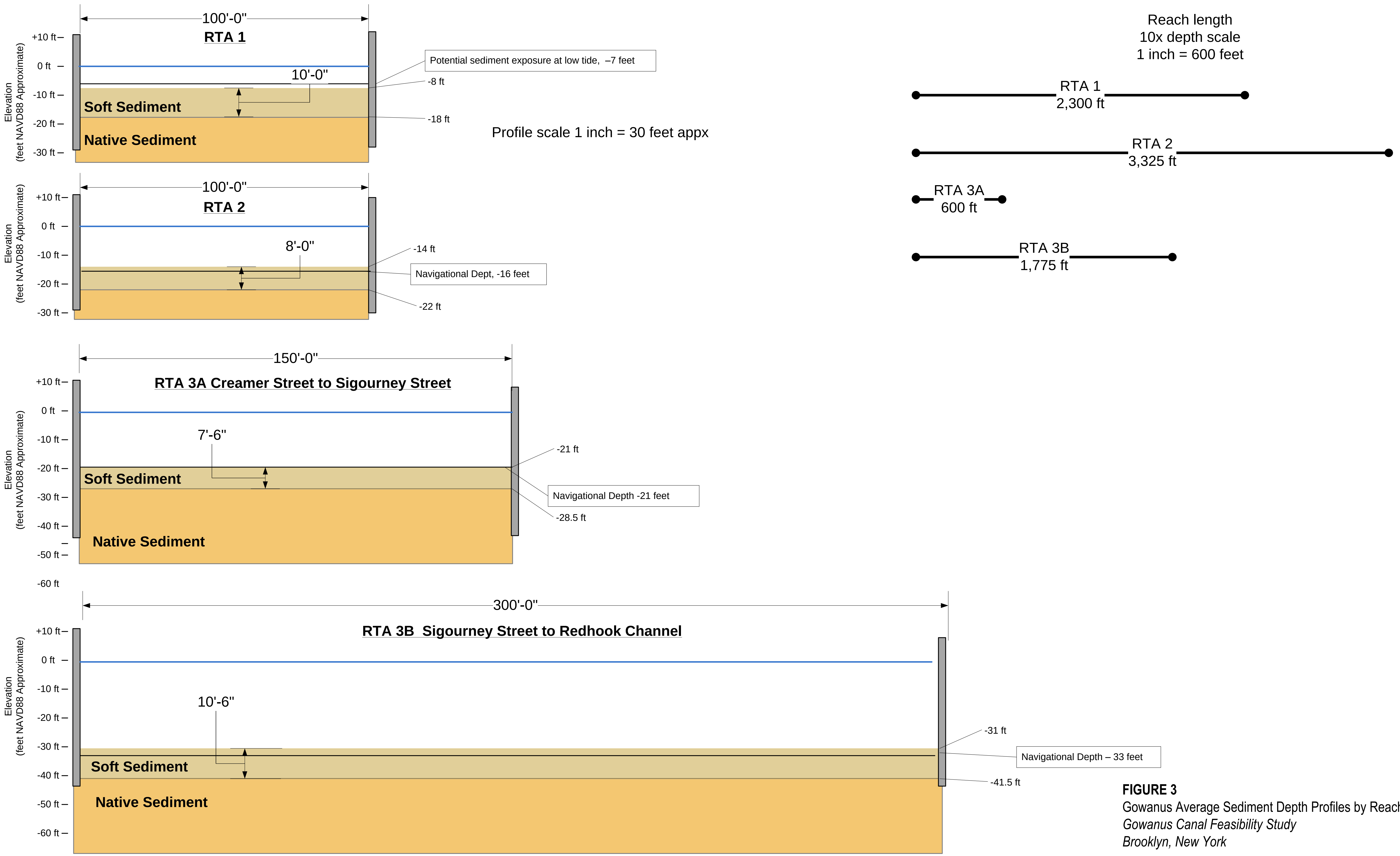

FIGURE 3
Gowanus Average Sediment Depth Profiles by Reach
Gowanus Canal Feasibility Study
Brooklyn, New York

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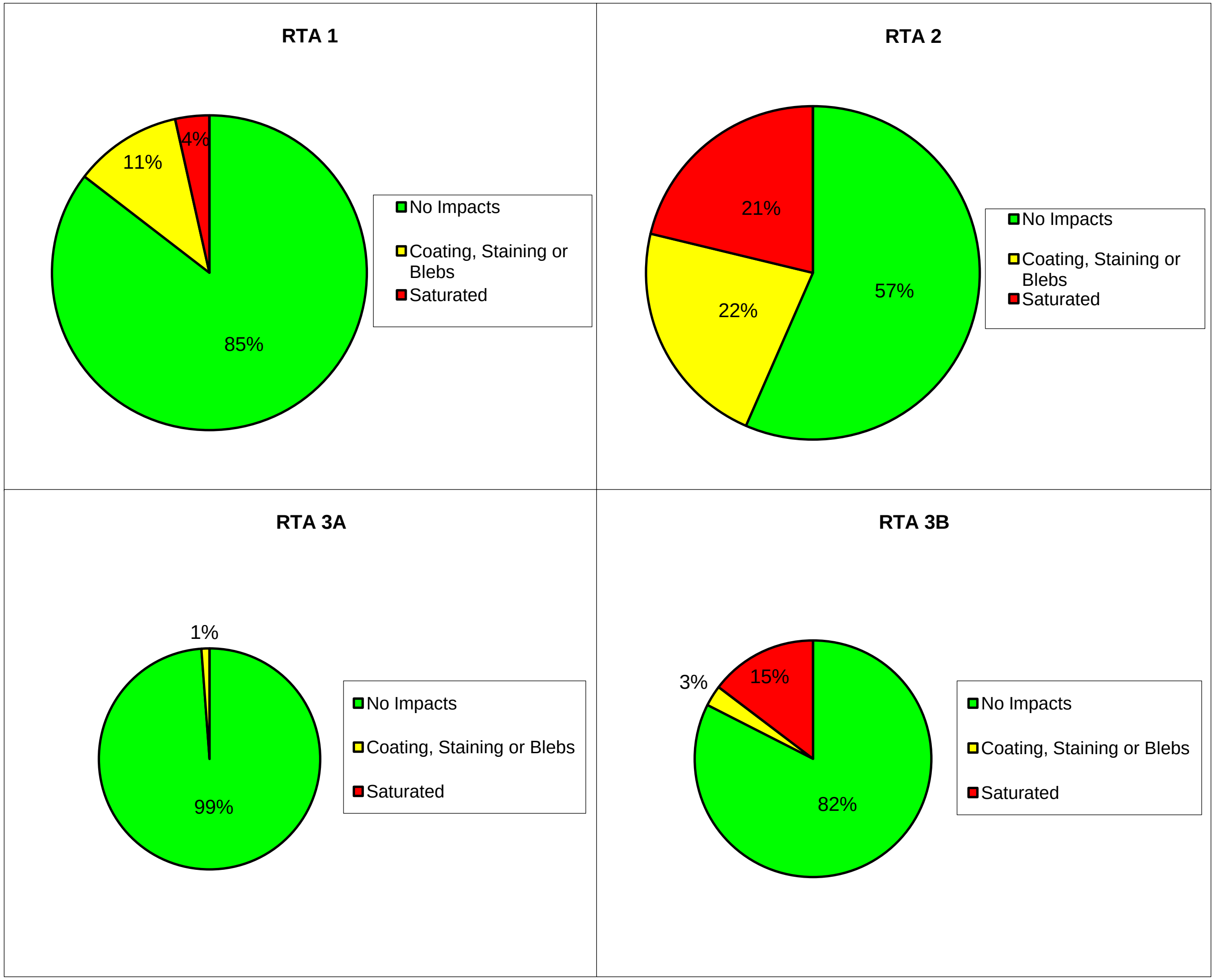

FIGURE 4a
Main Canal Soft Sediment NAPL Impacts
Gowanus Canal Feasibility Study
Brooklyn, New York

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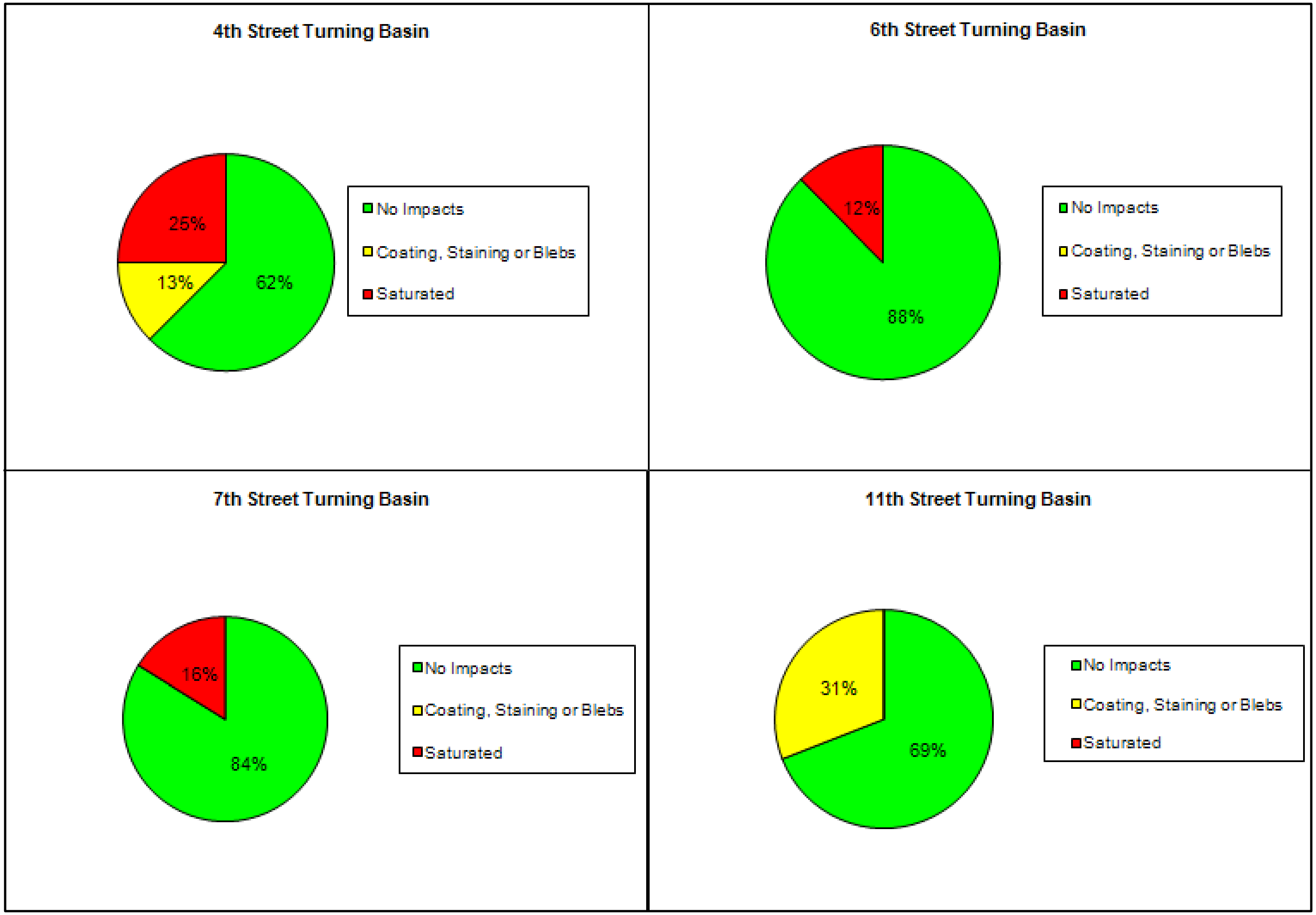

FIGURE 4b
Turning Basin Soft Sediment NAPL Impacts
Gowanus Canal Feasibility Study
Brooklyn, New York

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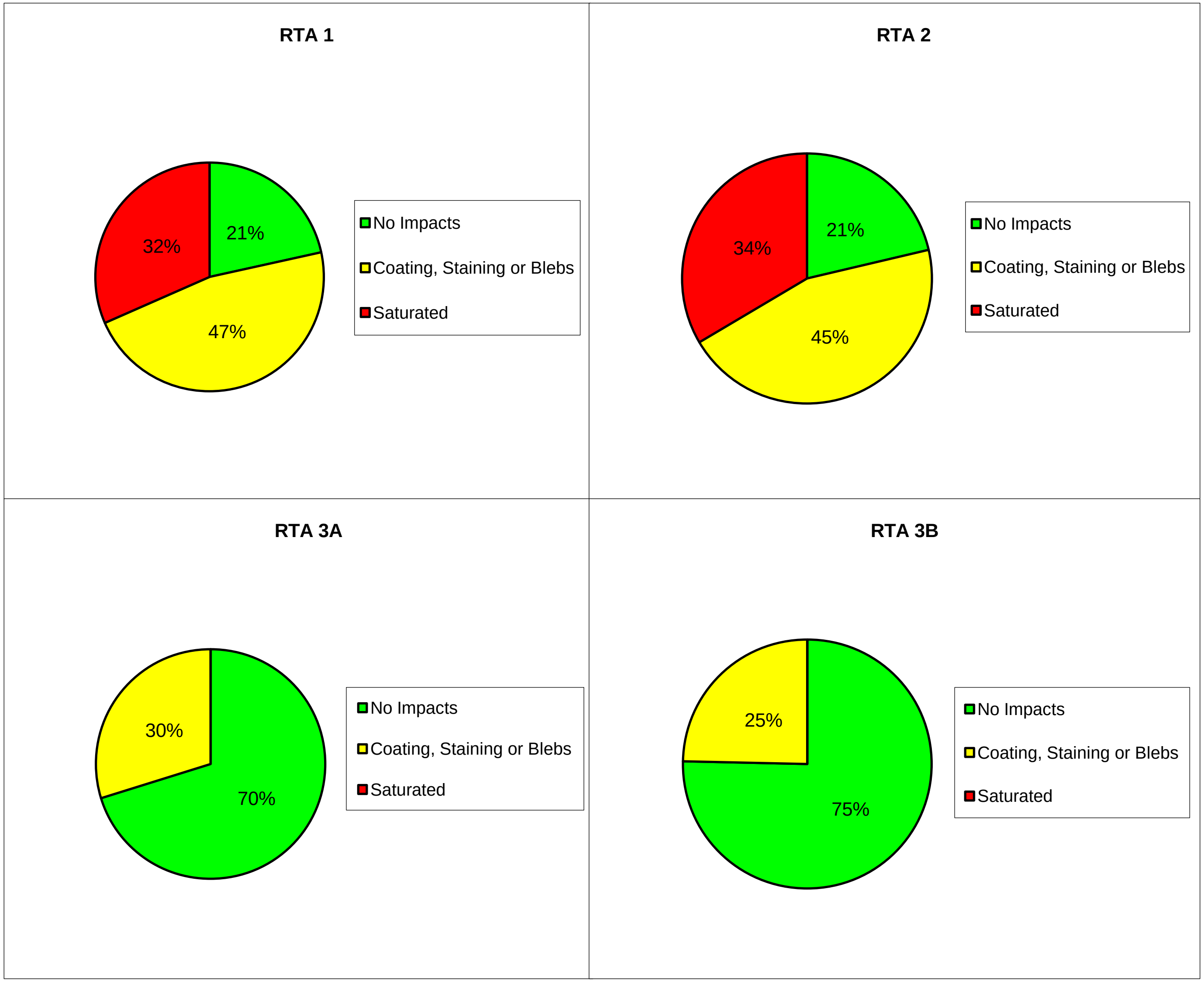

FIGURE 5a
Main Canal Native Sediment NAPL Impacts
Gowanus Canal Feasibility Study
Brooklyn, New York

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FIGURE 5b
Turning Basin Native Sediment NAPL Impacts
Gowanus Canal Feasibility Study
Brooklyn, New York

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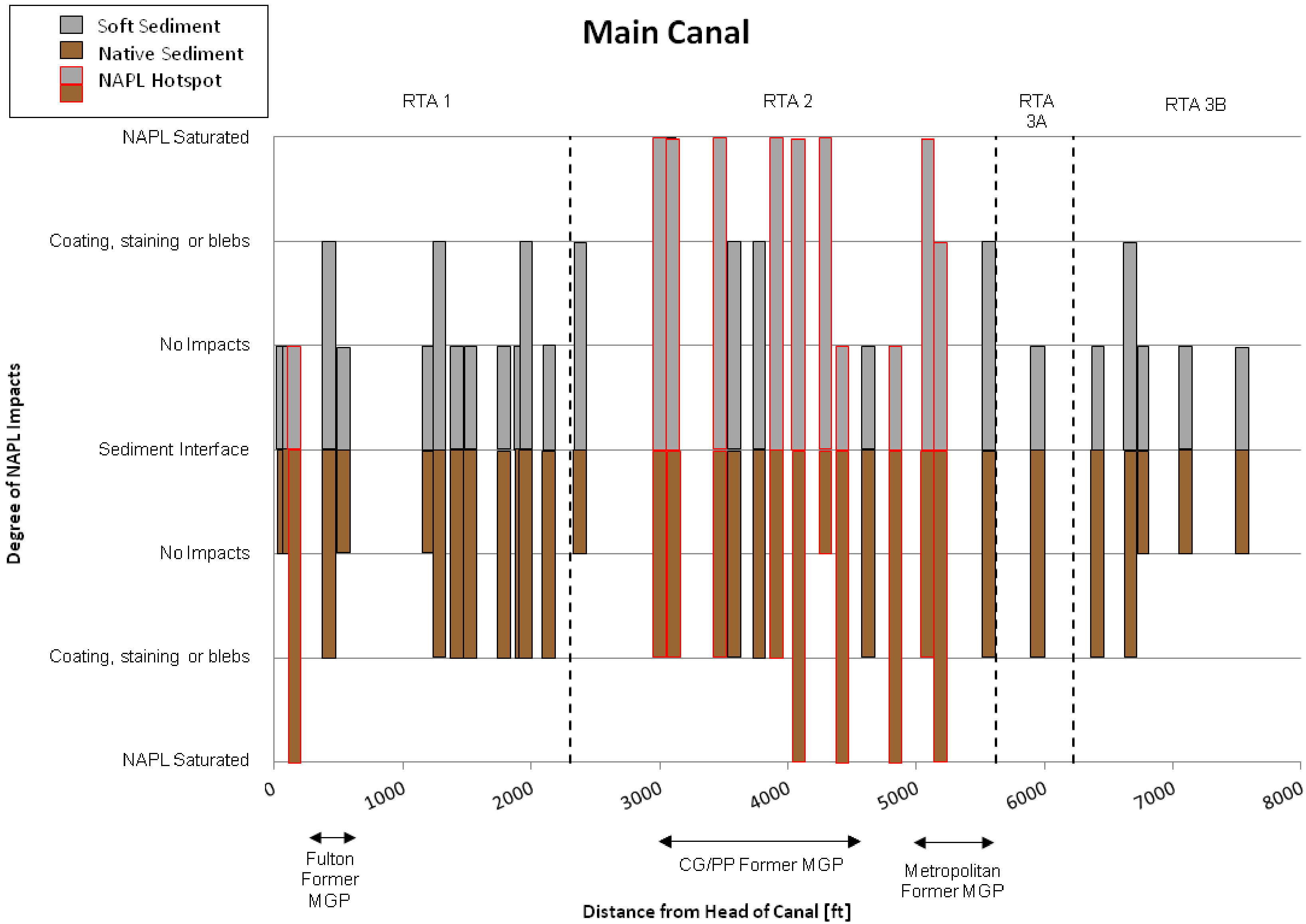

Note: Some samples are not visible due to the proximity of collection. In these cases, the samples with the greatest degree of NAPL impacts are shown.

FIGURE 6a
Main Canal Sediment Interface Impacts
Gowanus Canal Feasibility Study
Brooklyn, New York

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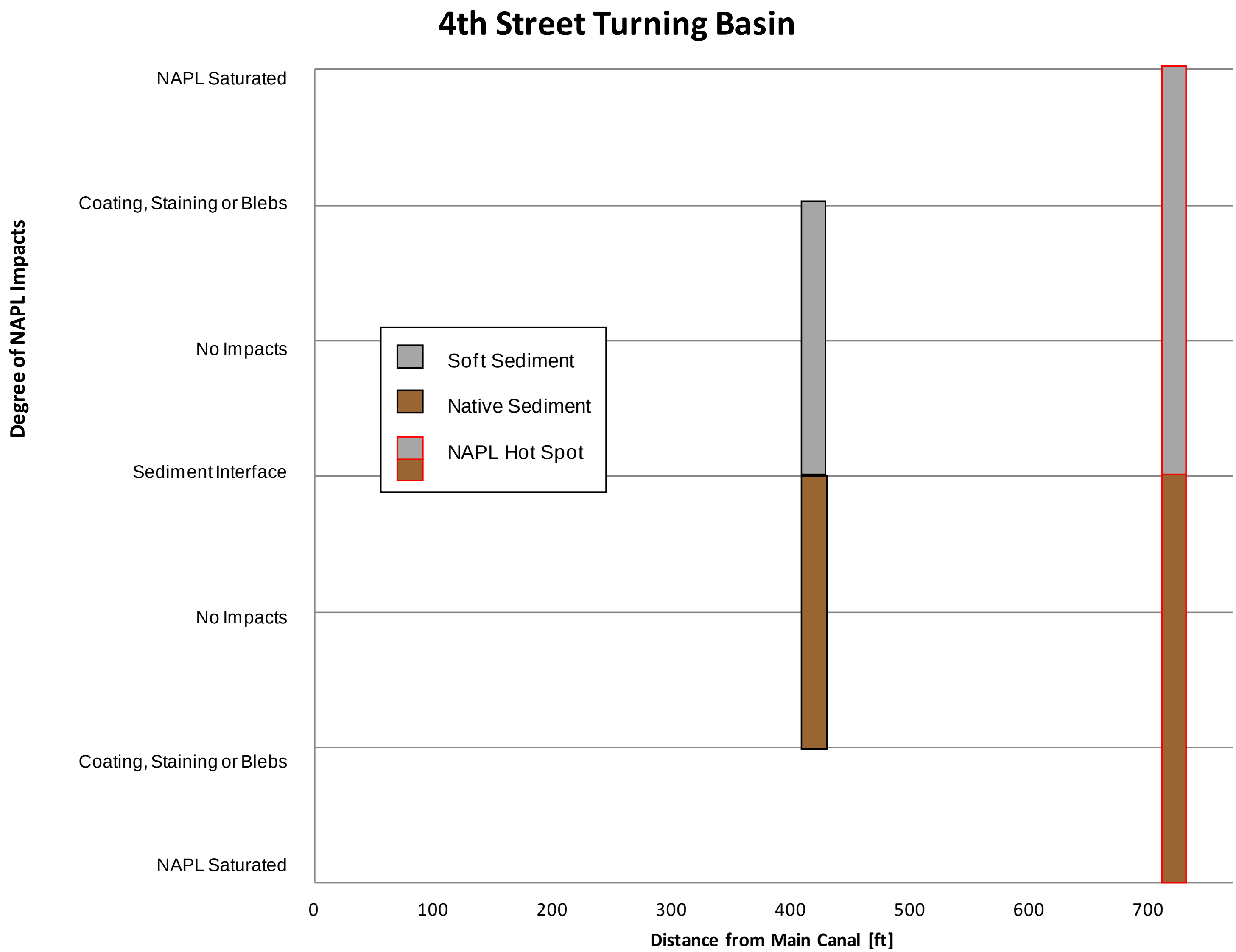

FIGURE 6b
4th Street Turning Basin Sediment Interface Impacts
Gowanus Canal Feasibility Study
Brooklyn, New York

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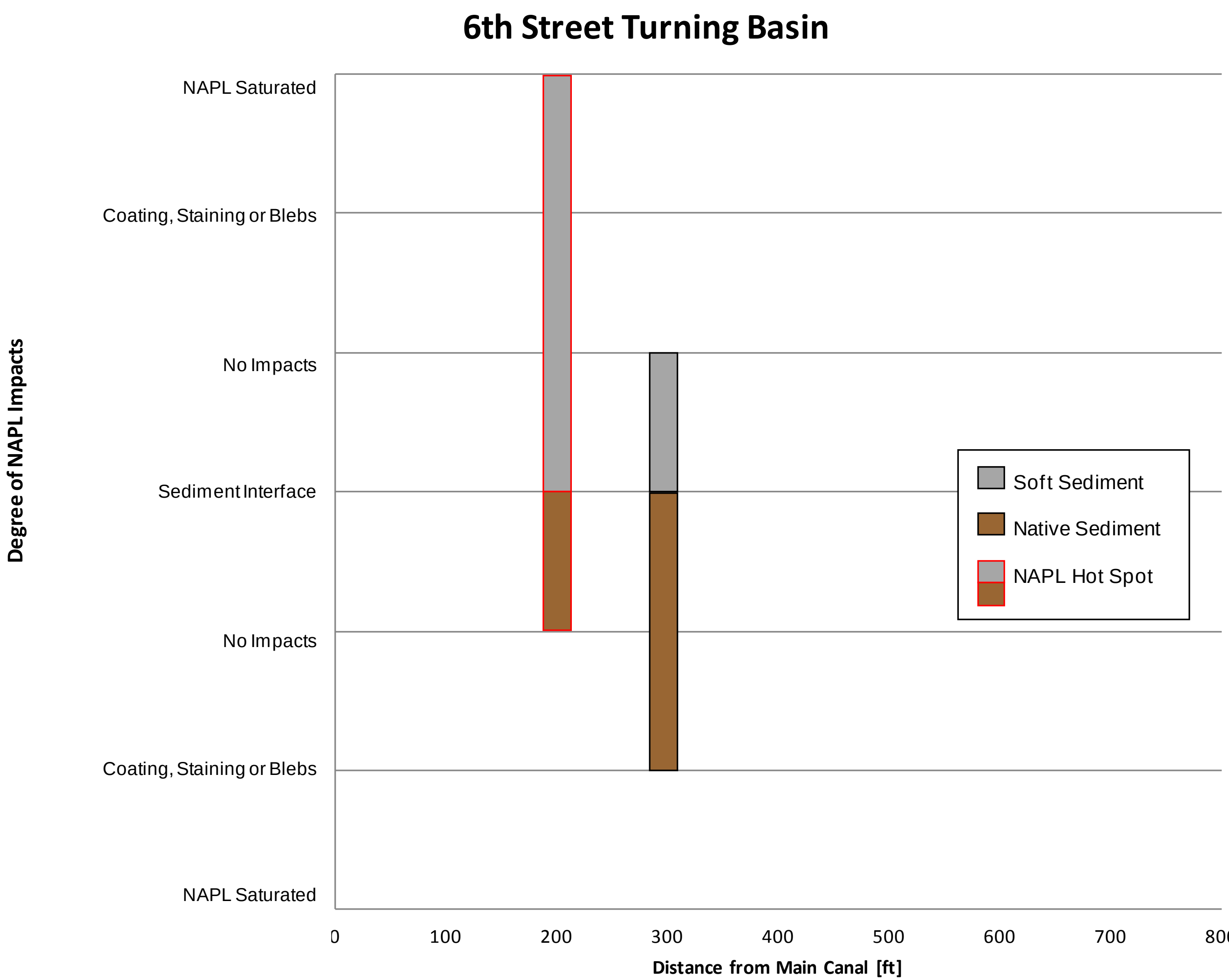

FIGURE 6c
6th Street Turning Basin Sediment Interface Impacts
Gowanus Canal Feasibility Study
Brooklyn, New York

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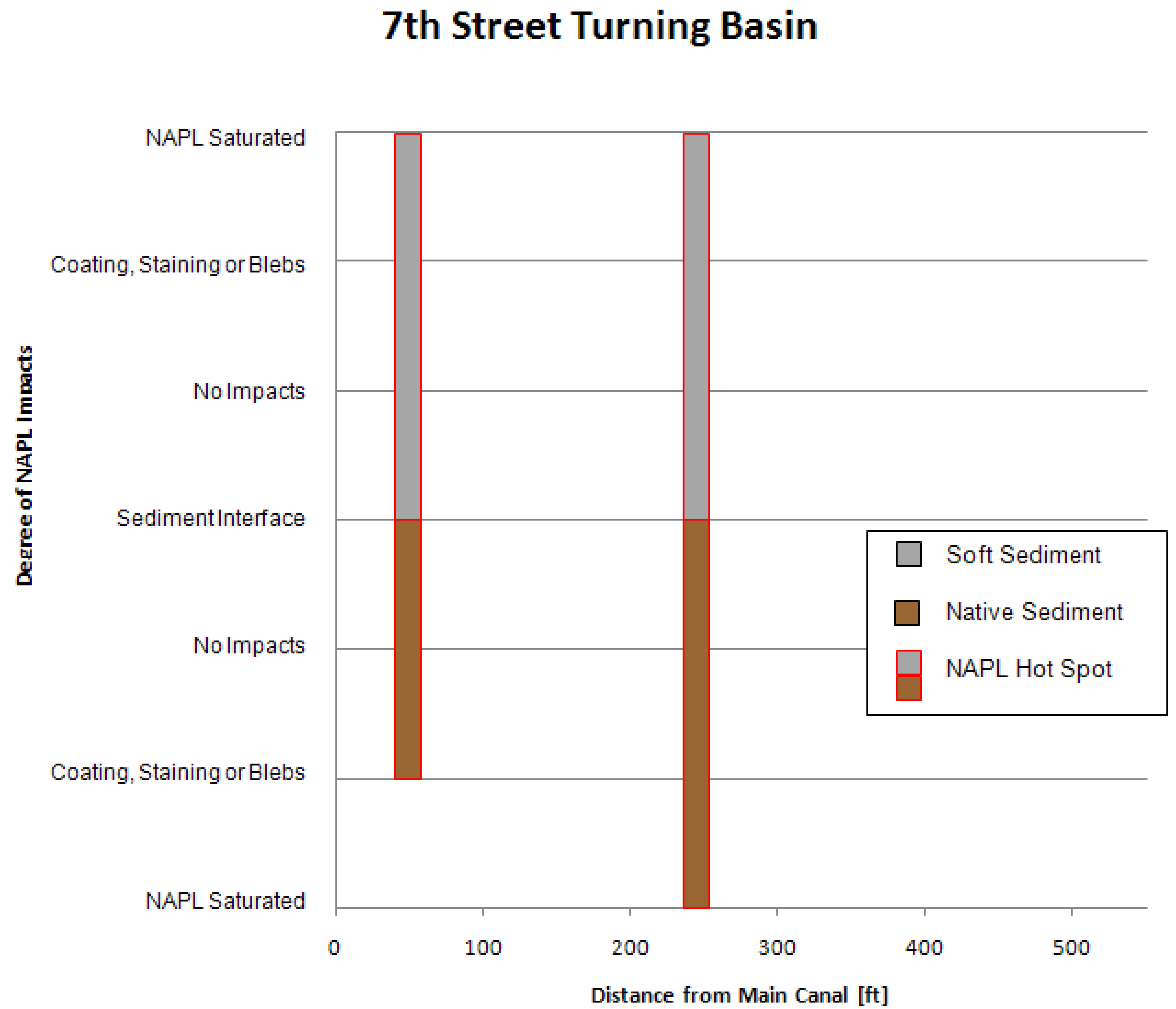

FIGURE 6d
7th Street Turning Basin Sediment Interface Impacts
Gowanus Canal Feasibility Study
Brooklyn, New York

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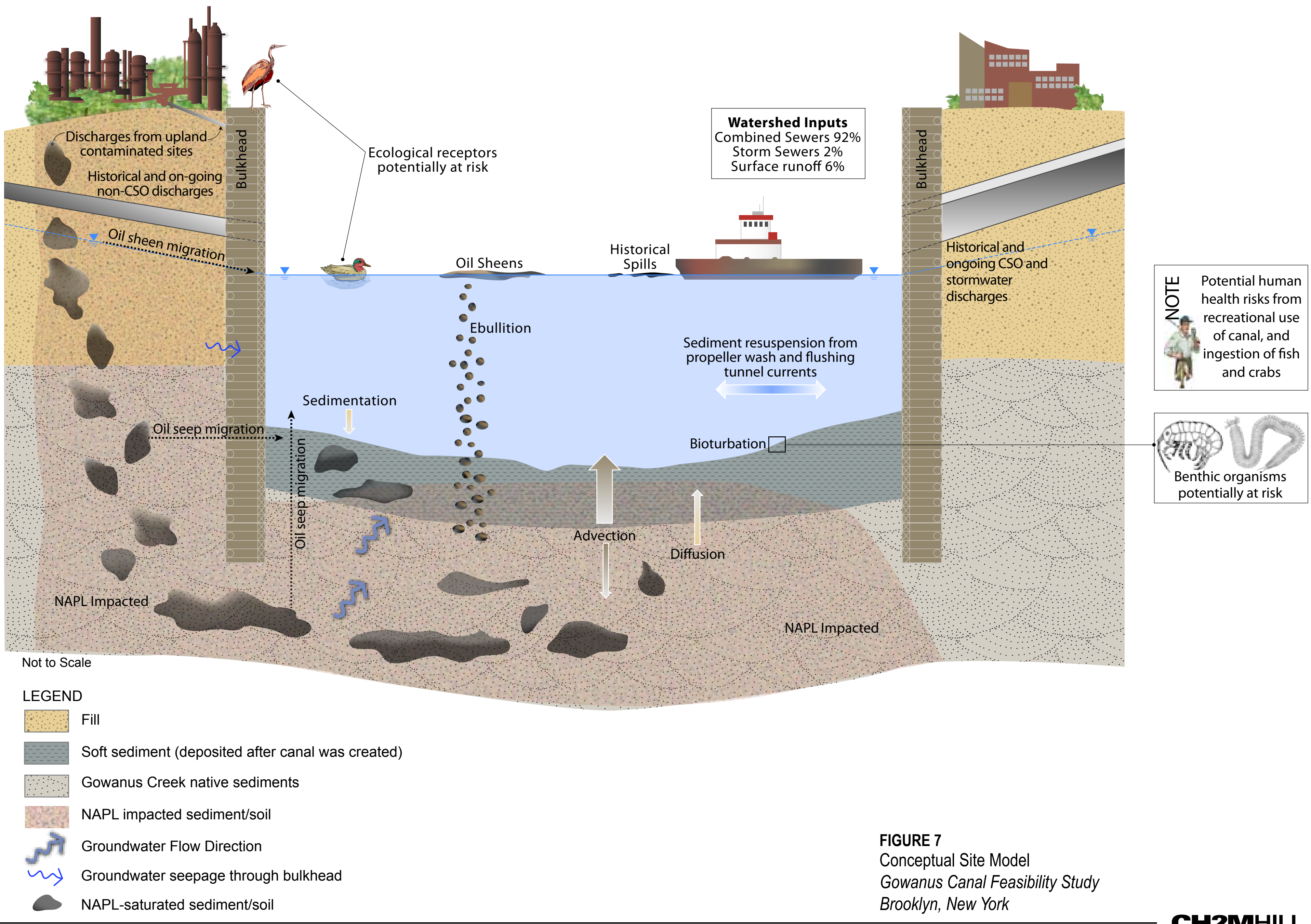

FIGURE 7
Conceptual Site Model
Gowanus Canal Feasibility Study
Brooklyn, New York

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ES080211052107KNV Fig_1-8_ConceptualSiteModel_v4.ai 11/16/2011 lk

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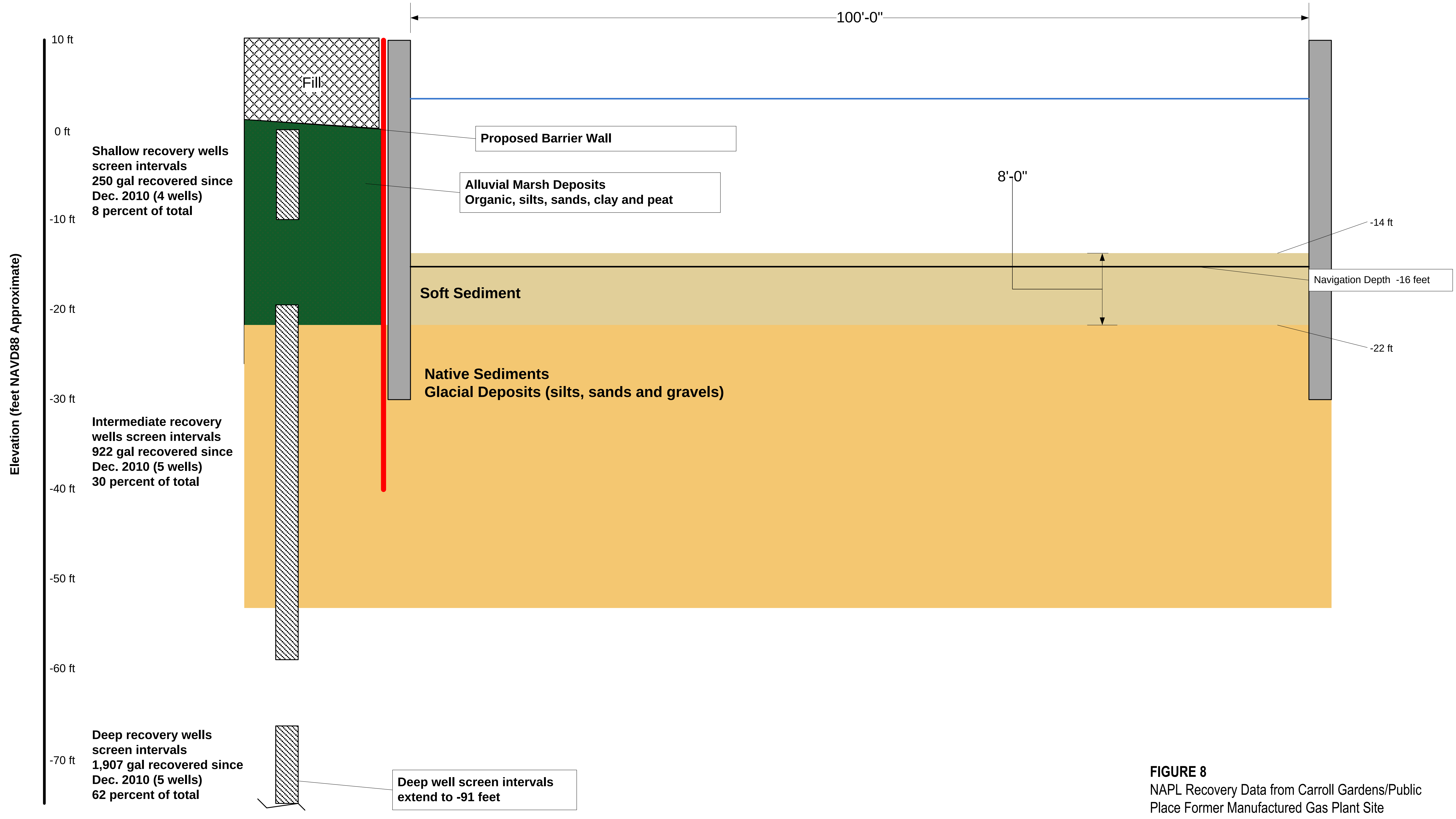

FIGURE 8
NAPL Recovery Data from Carroll Gardens/Public Place Former Manufactured Gas Plant Site
Gowanus Canal Feasibility Study
Brooklyn, New York

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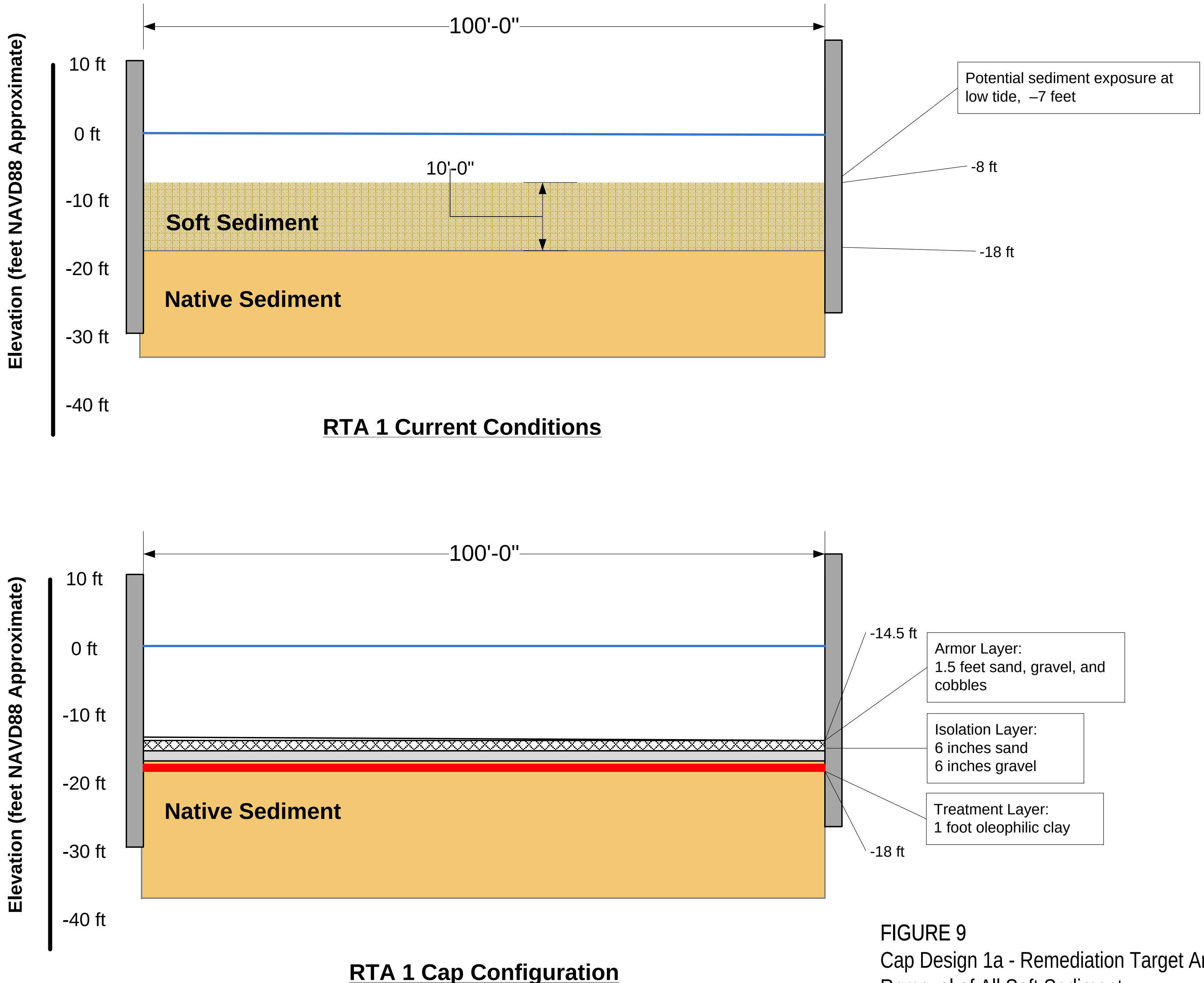

FIGURE 9
Cap Design 1a - Remediation Target Area 1
Removal of All Soft Sediment
Gowanus Canal Feasibility Study
Brooklyn, New York

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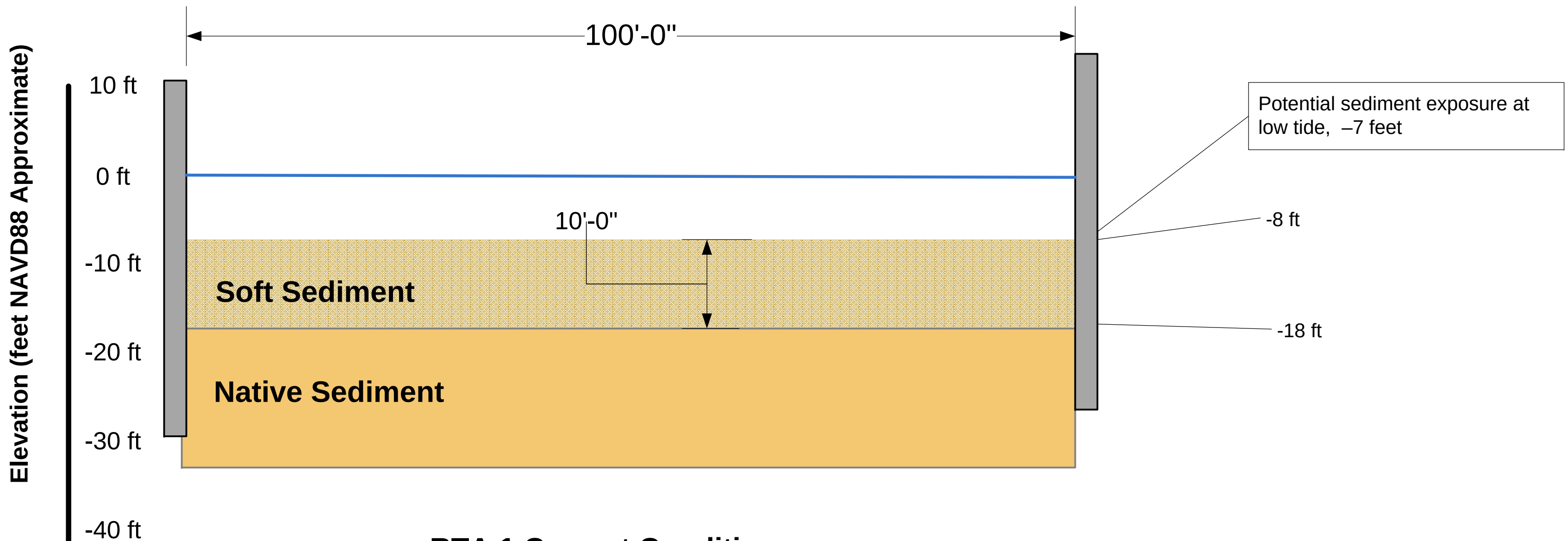
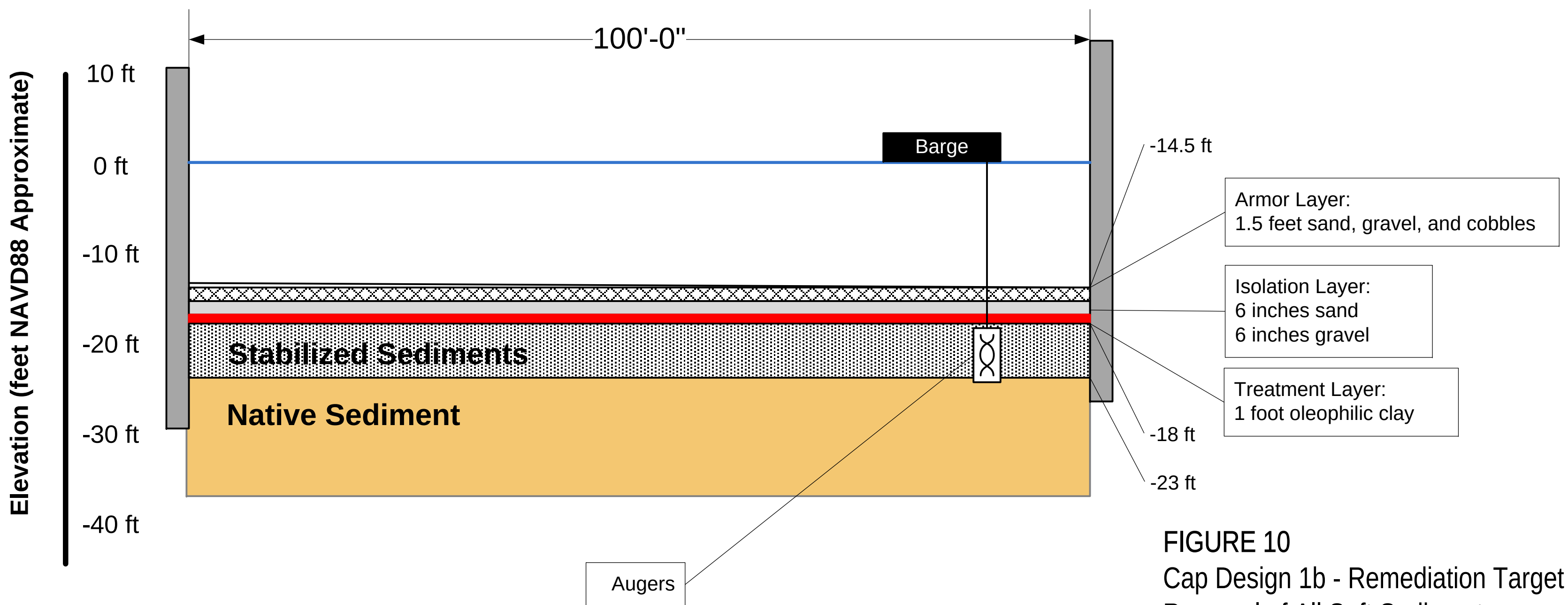
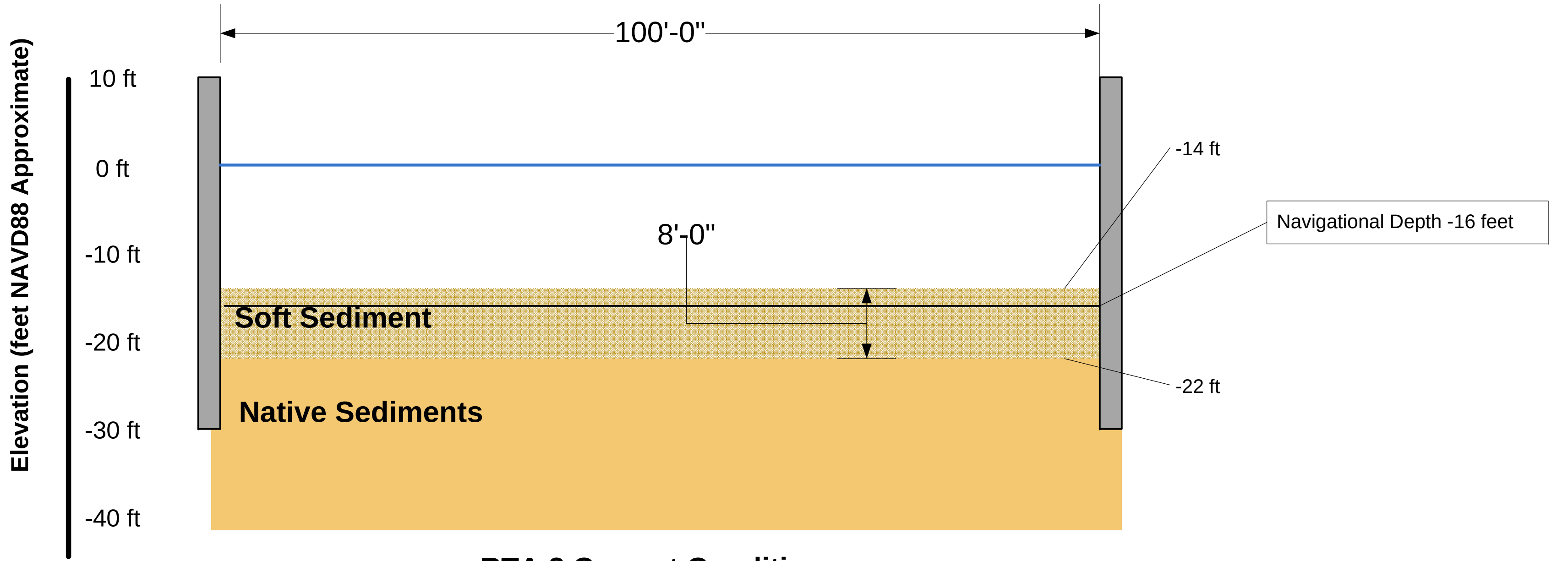


RTA 1 Current Conditions

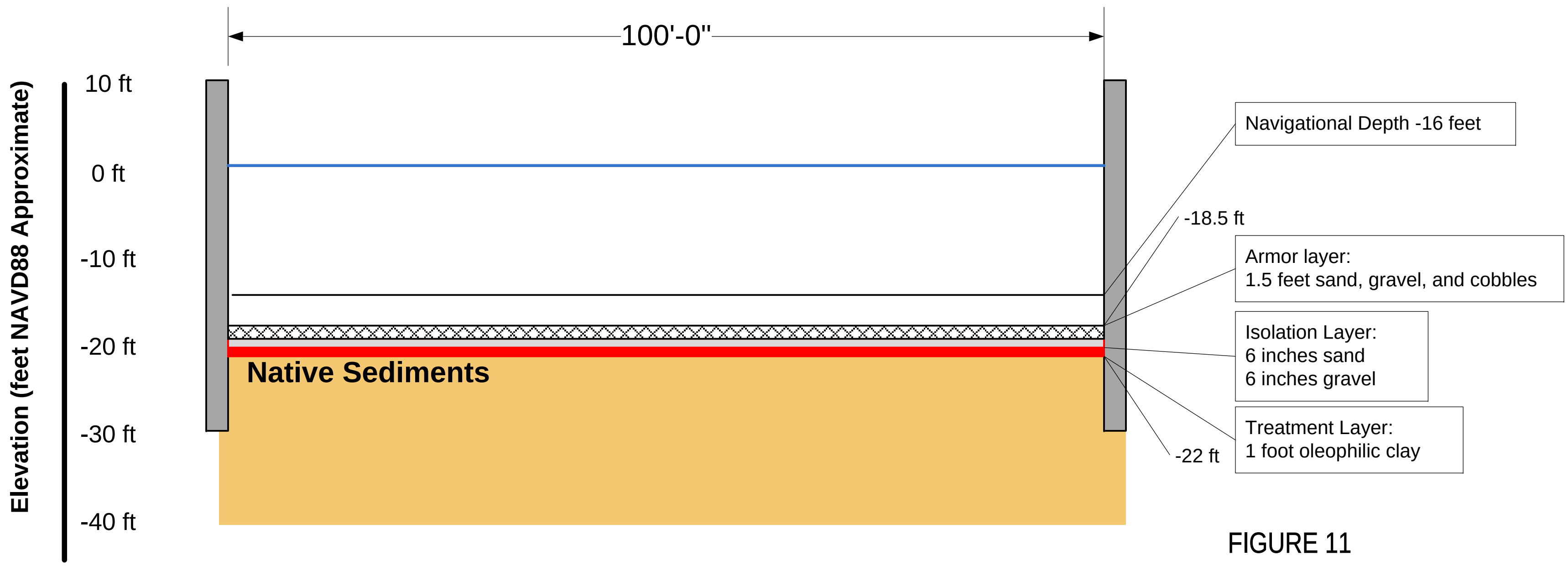


RTA 1 Cap Configuration

FIGURE 10
Cap Design 1b - Remediation Target Area 1
Removal of All Soft Sediment
Gowanus Canal Feasibility Study
Brooklyn, New York



RTA 2 Current Conditions



RTA 2 Cap Configuration

FIGURE 11
Cap Design 2a - Remediation Target Area 2
Removal of All Soft Sediment
Gowanus Canal Feasibility Study
Brooklyn, New York

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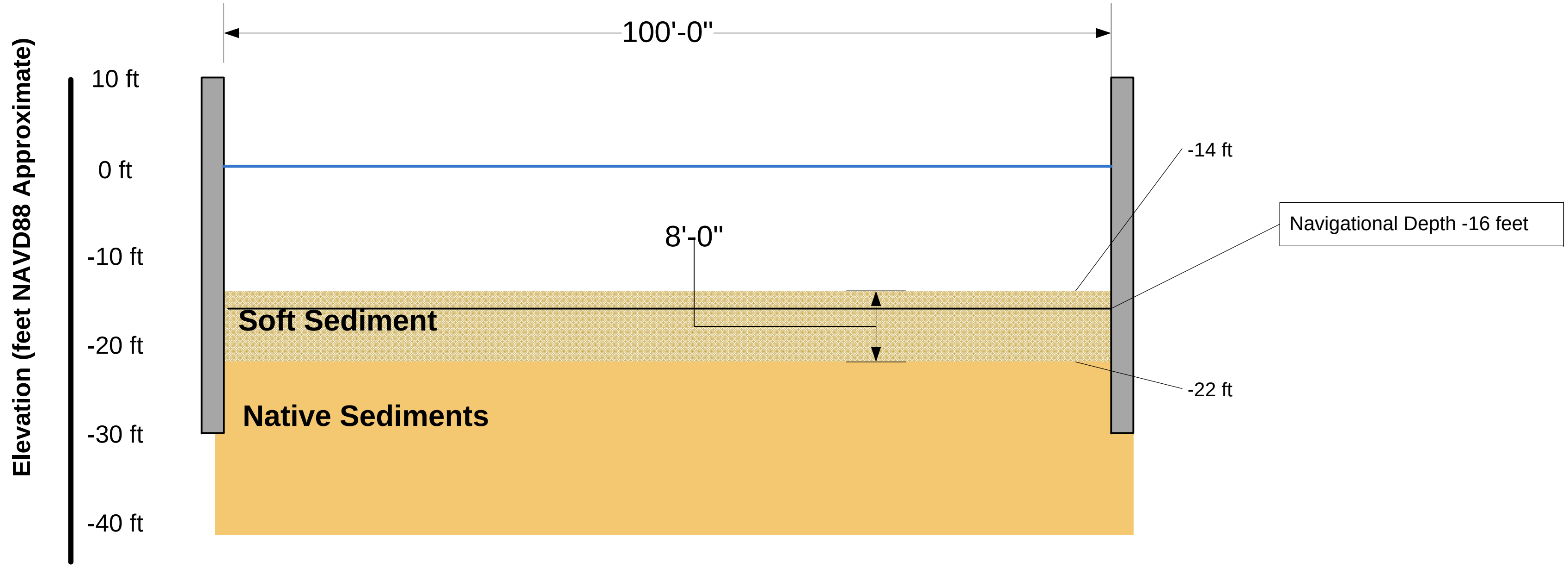

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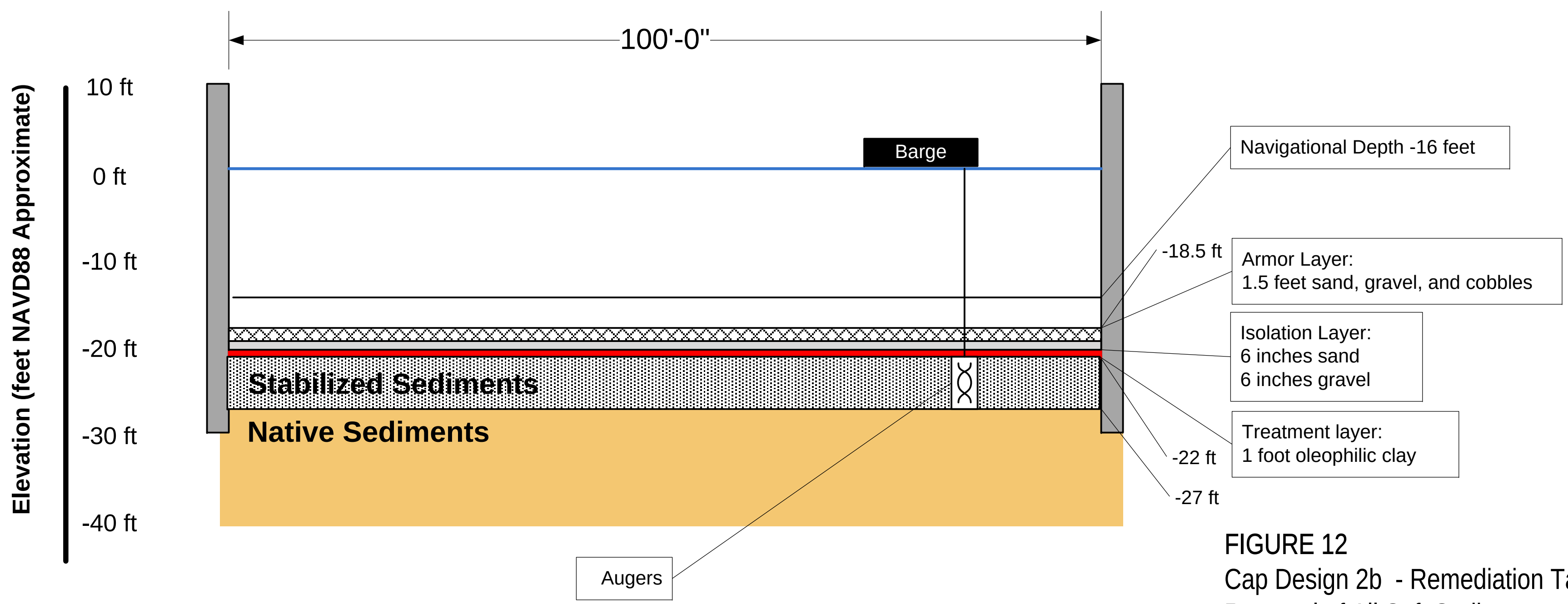

RTA 2 Cap Configuration

FIGURE 12
Cap Design 2b - Remediation Target Area 2
Removal of All Soft Sediment
Gowanus Canal Feasibility Study
Brooklyn, New York

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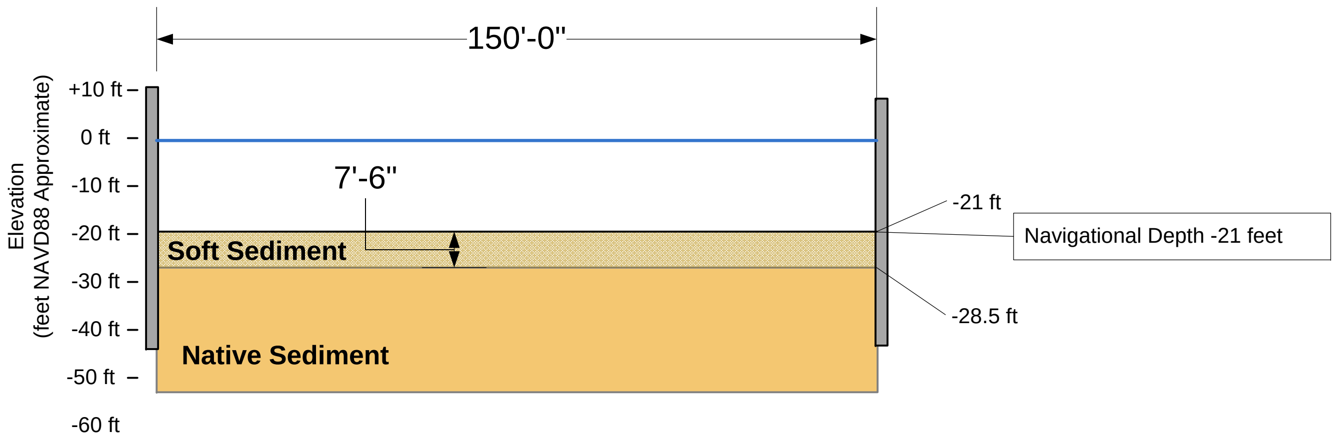
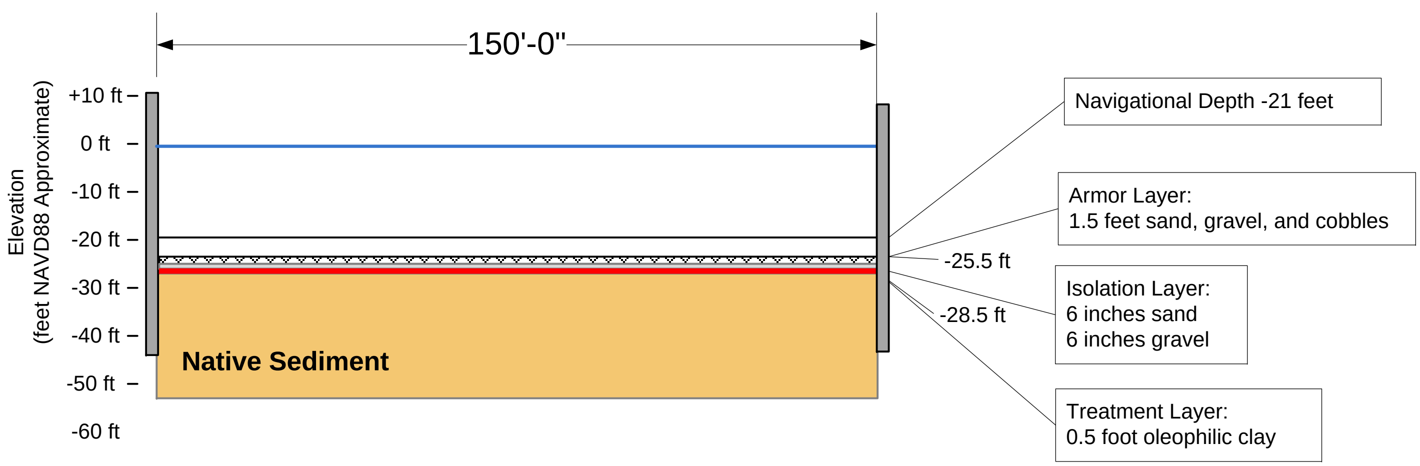


RTA 3A Current Conditions



RTA 3A Cap Configuration

FIGURE 13
Cap Design 3a - Remediation Target Area 3a
Removal of All Soft Sediment
Gowanus Canal Feasibility Study
Brooklyn, New York

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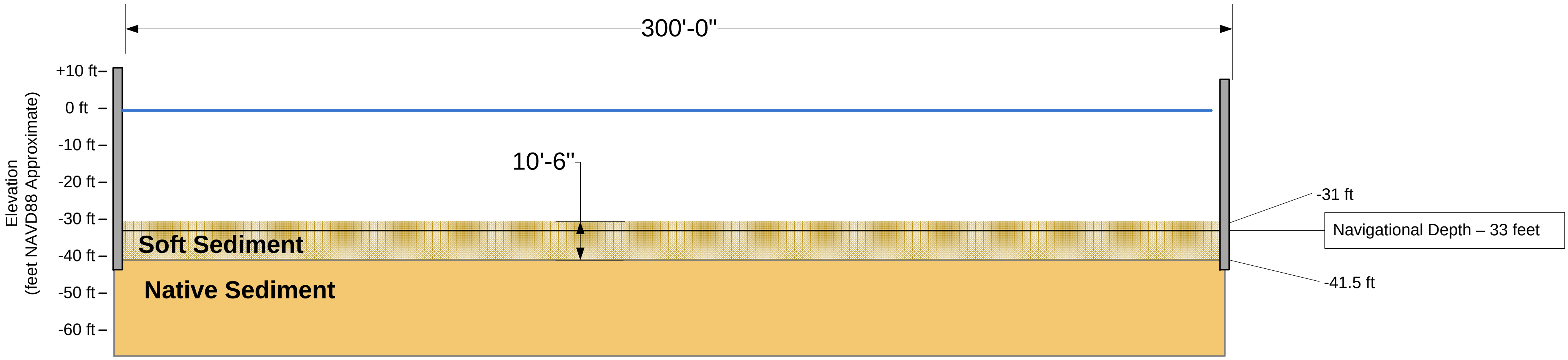
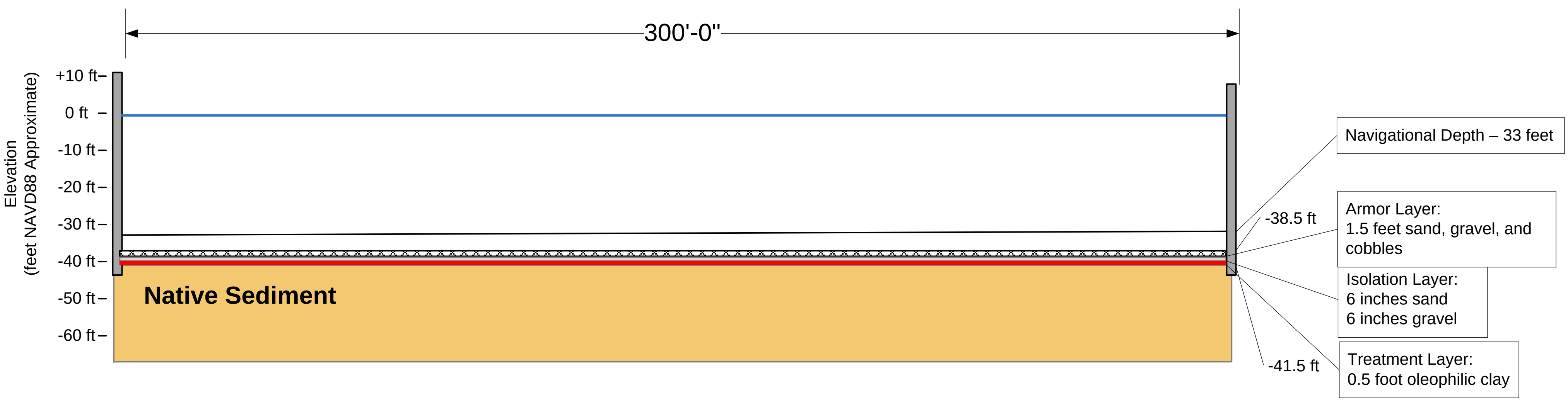


RTA 3B Current Conditions



RTA 3B Cap Configuration

FIGURE 14
Cap Design 3b – Remediation Target Area 3b
Removal of All Soft Sediment
Gowanus Canal Feasibility Study
Brooklyn, New York

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Attachment A
Laboratory Data

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CH2M HILL
Applied Sciences Laboratory (ASL)
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Suite 10350
Corvallis, OR 97330
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Fax 541.752.0276
ASL@CH2M.com

June 3, 2011

Gowanus Canal

422395.RS.01

RE: Laboratory Report for Gowanus Canal
ASL Report #: K1863

Juliana Hess/NJO:

On May 20, 2011, CH2M HILL Applied Sciences Laboratory received four samples with a request for analysis of selected parameters. The analytical results and associated quality control data are enclosed. All analyses were performed by CH2M HILL. As the Analytical Manager for these samples, I certify that this data package is in compliance with the terms and conditions agreed to by the client and CH2M HILL, both technically and for completeness. Release of the data contained in this data package has been authorized by the Laboratory Manager. This report shall not be reproduced except in full, without the written approval of the laboratory.

CH2M HILL Applied Sciences Laboratory appreciates your business and looks forward to serving your analytical needs again. If you should have any questions concerning the data, or if you need additional information, please call Michael Niemet at (541) 768-3726.

Sincerely,

Michael Niemet/CVO, PE
Analytical Manager

Laura McKinley/CVO
Laboratory Project Manager

Enclosures

cc: Jeff Gentry/PDX

CLIENT SAMPLE CROSS-REFERENCE
For Samples Received May 20, 2011

ASL Report #: K1863

Sample ID	Client Sample ID	Date Collected	Time Collected
K186301	CGRW-5D DNAPL	05/19/2011	10:45
K186302	CGRW-5D GW	05/19/2011	10:30
K186303	CGRW-4 DNAPL	05/19/2011	14:00
K186304	CGRW-4 GW	05/19/2011	13:50

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Density, and Specific Gravity by ASTM D445, ASTM D1217

Gowanus

Analysis By: MB

Reviewed By: MN

Sample Name	Matrix	Temperature °F	Specific Gravity by ASTM D1217	Density by ASTM D1217 g/cc	Viscosity cP
CGRW-4	Water	57	1.00	1.00	1.18
CGRW-5D		57	1.03	1.03	1.17
CGRW-4	NAPL	57	1.10	1.10	81.3
CGRW-5D		57	1.05	1.04	119
Quality Control					
Millipore water	Water	70		0.998	
			Published Value:	0.998	
			RPD:	0.000	

CH2MHILL

Interfacial Tension by ASTM D971

Gowanus

Analysis By: MB

Reviewed By: MN

Phase Pair					
Phase One		Phase Two		Temperature	Interfacial Tension
Sample ID	Matrix	Sample ID	Matrix	°F	Dynes/centimeter
CGRW-4	Water	Air	Air	57	53.2
CGRW-4	NAPL	Air	Air	57	33.7
CGRW-4	Water	CGRW-4	NAPL	57	14.3
CGRW-5D	Water	Air	Air	57	60.1
CGRW-5D	NAPL	Air	Air	57	33.3
CGRW-5D	Water	CGRW-5D	NAPL	57	27.1
Quality Control					
DI Water	Water	Air	Air	70	74.4
				Published Value:	72.8
				RPD:	-2.17

Attachment B
NAPL Mobility Calculations

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Attachment B

Calculation of the theoretical upward vertical gradient required to mobilize DNAPL in sediment for Gowanus Canal data set.
Gowanus Canal Feasibility Study
Brooklyn, New York

From:

Cohen, Robert M. and Mercer, James W. (1993). "DNAPL Site Evaluation." EPA/600/R-93/022. February 1993.

Neglecting the capillary pressure gradient, the upward hydraulic gradient, $\mathbf{i_h}$, and associated hydraulic head difference, $\mathbf{\Delta h}$, needed to prevent DNAPL from sinking vertically downward due to gravity are given by

$$i_h = (\rho_n - \rho_w) / \rho_w \qquad (5\text{-}22)$$

and

$$\Delta h = z_n(\rho_n - \rho_w) / \rho_w \qquad (5\text{-}23)$$

where $\mathbf{z_n}$ is the thickness of the DNAPL body.

ρ_w is the density of water,

ρ_n is the DNAPL density.

Calculations:

	units	**CGRW-4**	**CG42-5D**
ρ_n	g/cm^3	1.10	1.04
ρ_w	g/cm^3	1.00	1.03
$\mathbf{i_h}$	**ft/ft**	**0.100**	**0.0160**

Conclusion:

Based on the density data for the two DNAPL and groundwater samples obtained, the upward hydraulic gradient needed to mobilize DNAPL upward would need to be at least 0.016 ft/ft. The upward gradient required may need to be greater than 0.1 ft/ft depending on the relative densities of DNAPL and water at the respective location under consideration.

Appendix B
Groundwater and Combined Sewer Overflow Discharge Evaluation

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Groundwater and Combined Sewer Overflow Discharge Evaluation

This appendix describes the data evaluation process used to assess the potential for contaminated groundwater discharge to recontaminate canal sediments following a remedial action. It also describes how estimated concentrations of polycyclic aromatic hydrocarbons (PAHs) and metals in ongoing combined sewer overflow (CSO) discharges were determined.

Screening of Groundwater Discharge from Upland Sites

Analytical results for groundwater samples collected during the RI were used to evaluate the potential for contaminated groundwater discharge to recontaminate canal sediments following a remedial action. Because there are no established criteria for evaluating PAH concentrations in groundwater with respect to potential risk from groundwater discharge to surface water bodies, a screening approach based on USEPA's equilibrium sediment benchmark (ESB) guidance for PAH mixtures (USEPA, 2003) was developed to identify and prioritize upland sites along Gowanus Canal where contaminated groundwater discharge may be a concern. This approach is based on the following assumptions:

- No attenuation, transformation, or binding of measured groundwater concentrations of PAHs will occur. Therefore, groundwater concentrations of PAHs equal potential PAH concentrations in sediment pore water.
- The principal form of toxicity elicited by PAHs to benthic invertebrates is narcosis. Narcotic toxicants demonstrate additive toxicity; that is, their effects can be added together to summarize the total amount of toxicity present in a mixture of such chemicals (as occurs in sediments).
- The USEPA ESB guidance for PAH mixtures (USEPA, 2003) recommends that 34 PAHs (18 parent compounds and 16 alkylated groups) be analyzed when assessing the risk represented by PAHs in contaminated sediments. However, if results are available for only the commonly quantified PAHs, the guidance provides uncertainty factors that can be applied to account for the missing PAHs. If all 34 PAHs are not available, a subset of either 13 or 23 compounds is used and an uncertainty factor is applied.

The following procedure was used to screen upland sites for potential concern:

- Select final chronic values (FCVs) for the 34 PAHs listed in the USEPA PAH mixtures benchmark document (USEPA, 2003). The FCVs are based on USEPA's National Water Quality Criteria, and are the concentrations of chemicals in water that are considered to be protective of the presence of aquatic life. The FCVs are presented in Table 1.
- Compare measured concentrations of individual PAHs in a representative well to their corresponding FCVs. Table 2 presents the FCVs, the analytical results, and the determination of the associated toxicity units (TUs) for each parameter (which

correspond to the concentration of a given parameter divided by the associated FCV). The parameters evaluated include the following 13 compounds: naphthalene, acenaphthylene, acenapthene, fluorene, anthracene, phenanthrene, pyrene, fluoranthene, benzo(a)anthracene, chrysene, benzo(a)pyrene, benzo(b)fluoranthene, and benzo(k)fluoranthene. Benzo(g,h,i)perylene, indeno(1,2,3-c,d)pyrene, and dibenz(a,h)anthracene were not included in the evaluation. As noted previously, the guidance document recommends that 34 PAHs be analyzed; however, the Gowanus Canal groundwater samples were analyzed only for the 16 PAHs included on the Target Compound List; therefore, the subset of the 13 PAHs was used for this screening.

- Add the ratios of individual PAHs to generate an overall TU for each sample. Because results were available for only a subset of the 34 PAHs, the TU was multiplied by 11.5 to account for the uncertainty associated with the limited list of PAHs. The sums and adjusted sums are both presented in Table 2.

The sampling locations were then ranked by the adjusted TU values (Table 3). Table 4 presents the ranked sampling locations separated by the depth of the well screen (i.e., shallow or intermediate depth). If the calculated TU is less than 1, then the site was assumed to pose no risk to the sediment from groundwater discharge. Because some attenuation of PAH concentrations is expected to occur as groundwater discharges to the canal, sites with calculated TUs between 1 and 10 were assumed to pose minimal risk to the sediment from groundwater discharge.

CSO and Stormwater Discharge Contributions

Estimated future concentrations of PAHs in surface sediments due to ongoing CSO discharges were calculated assuming that there would be no substantial change in the quality of the CSO solids discharged. Wet-weather water sample data collected from CSOs during the RI were used for this screening. Because the CSO wet-weather water samples are considered to represent the quality of solids discharged from the CSOs, CSOs are a major source of solids to the canal, and CSO solids settle within the canal, these levels would be expected to persist in canal surface sediments if no CSO reductions are made. It should be noted that the quantity and possibly the quality of CSO solids may differ in the future as a result of the CSO management actions currently being taken by New York City. An estimate of the contaminant loading associated with CSO and stormwater discharges was calculated for total PAHs, six carcinogenic PAHs, and selected metals, which are the constituents that contribute to unacceptable ecological and human health risks.

The screening was performed based on the simplifying assumptions that (1) all of the PAH and metals contamination is associated with the suspended sediment particles (i.e., minimal dissolved phase contamination), and (2) most of the solids would be deposited locally in the canal.

The following stepwise process was used to develop the estimates:

- The available analytical data include PAH and metals concentration data for CSO water samples, as well as total suspended solids (TSS) data. The contaminant concentration associated with the suspended sediment particles was determined by dividing the water concentration by the TSS result. In instances where multiple samples were collected from an outfall, the average contaminant concentration associated with the suspended sediment was calculated for use in later steps. Tables 5, 6, and 7 present these data and calculation steps for total PAHs, the six carcinogenic PAHs, and the metals that are contributing to unacceptable risk, respectively.

- The range of PAH and metals concentrations calculated for CSO solids was determined by using the data from the four outfalls that contribute 95 percent of the total annual discharge (RH-034, RH-035, OH-007, and RH-031). Tables 8 and 9 provide the annual discharge volumes for CSOs along the canal as well as the average PAH and metals concentrations associated with the suspended sediment fraction for each outfall.

Tables 10 and 11 present the ranges of estimated PAH and metals concentrations associated with CSO solids discharged to the Gowanus Canal. These values represent the upper and lower concentrations observed in the four outfalls comprising 95 percent of the annual discharge volume.

References

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

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TABLE 1

Final Chronic Values for PAHs

Gowanus Canal Feasibility Study

Brooklyn, New York

PAH	FCV µg/L
Naphthalene	193.5
C1 Naphthalene	81.7
Acenaphthylene	306.9
Acenaphthene	55.9
C2 Naphthalenes	30.2
Fluorene	39.3
C3 Naphthalenes	11.1
Anthracene	20.7
Phenanthrene	19.1
C1 Fluorenes	14.0
C4 Naphthalenes	4.05
C1 Phenanthrenes	7.44
C2 Fluorenes	5.31
Pyrene	10.11
Fluoranthene	7.11
C2 Phenanthrenes	3.20
C3 Fluorenes	1.92
C1 Fluoranthenes	4.89
C3 Phenanthrenes	1.26
Benzo(a)anthracene	2.23
Chrysene	2.04
C4 Phenanthrenes	0.56
C1 Chrysenes	0.86
Benzo(a)pyrene	0.96
Perylene	0.90
Benzo(e)pyrene	0.90
Benzo(b)fluoranthene	0.68
Benzo(k)fluoranthene	0.64
C2 Chrysenes	0.48
Benzo(g,h,i)perylene	0.44
C3 Chrysenes	0.17
Indeno(1,2,3-cd)pyrene	0.28
Dibenzo(a,h)anthracene	0.28
C4 Chrysenes	0.07

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TABLE 2

Comparison of Groundwater Sample Results to FCVs for PAHs

Gowanus Canal Feasibility Study

Brooklyn, New York

Field ID	**FCV**	GC-MW01S	Toxic units	GC-MW01S-S-NYC	Toxic units	GC-MW01I	Toxic units	GC-MW01I-S-NYC	Toxic units	GC-MW02I	Toxic units	GC-MW02I-S-NYC	Toxic units
Naphthalene	193.5	0.85	0.00	0	0.00	1.1	0.01	0.32	0.00	0	0.00	0.084	0.00
Acenaphthylene	306.9	0	0.00	0.15	0.00	0	0.00	0	0.00	0	0.00	0.07	0.00
Acenaphthene	55.9	8.7	0.16	3.5	0.06	5.6	0.10	5.4	0.10	4.8	0.09	5.2	0.09
Fluorene	39.3	1.2	0.03	0.31	0.01	1.4	0.04	1.3	0.03	0	0.00	0	0.00
Anthracene	20.7	0	0.00	0	0.00	0.42	0.02	0.52	0.03	0	0.00	0.084	0.00
Phenanthrene	19.1	0.51	0.03	0	0.00	1.1	0.06	0.68	0.04	0	0.00	0.075	0.00
Pyrene	10.11	0.72	0.07	0.51	0.05	0.52	0.05	1.2	0.12	0.5	0.05	0.45	0.04
Fluoranthene	7.11	1.1	0.15	0.69	0.10	0.78	0.11	1.5	0.21	0	0.00	0.035	0.00
Benzo(a)anthracene	2.23	0	0.00	0	0.00	0	0.00	0.38	0.17	0	0.00	0	0.00
Chrysene	2.04	0	0.00	0	0.00	0	0.00	0.36	0.18	0	0.00	0	0.00
Benzo(a)pyrene	0.96	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0.1	0.10
Benzo(b)fluoranthene	0.68	0	0.00	0	0.00	0	0.00	0.28	0.41	0	0.00	0	0.00
Benzo(k)fluoranthene	0.64	0	0.00	0	0.00	0	0.00	0.24	0.37	0	0.00	0	0.00
Sum total of $ESBTU_{FCV}$			0.44		0.22		0.38		1.66		0.14		0.26
Adjusted $ESBTU_{FCV}$[1]			5.10		2.51		4.38		19.05		1.56		2.94

Notes

All concentrations in µg/L

Excluded groundwater samples with no detected PAHs

Minimum Adjusted $ESBTU_{FCV}$[1]	0.00
Maximum Adjusted $ESBTU_{FCV}$[1]	3041
Mean Adjusted $ESBTU_{FCV}$[1]	138

[1] Adjusted with an uncertainty factor at a 95% confidence level associated with using 13 PAHs (uncertainty factor = 11.5).

TABLE 2
Comparison of Groundwater Sample Results to FCVs for PAHs
Gowanus Canal Feasibility Study
Brooklyn, New York

Field ID	**FCV**	GC-MW03S	Toxic units	GC-MW03I	Toxic units	GC-MW04S	Toxic units	GC-MW04I	Toxic units	GC-MW05S	Toxic units	GC-MW05I	Toxic units
Naphthalene	193.5	18	0.09	0.54	0.00	0	0.00	0.25	0.00	2.1	0.01	2.3	0.01
Acenaphthylene	306.9	1.9	0.01	2.3	0.01	0	0.00	0	0.00	0	0.00	0.14	0.00
Acenaphthene	55.9	3	0.05	51	0.91	0.18	0.00	0	0.00	1.1	0.02	0.95	0.02
Fluorene	39.3	2.6	0.07	3.9	0.10	0	0.00	0	0.00	0.27	0.01	0.72	0.02
Anthracene	20.7	1.7	0.08	6.7	0.32	0	0.00	0	0.00	0.21	0.01	0.27	0.01
Phenanthrene	19.1	5.4	0.28	19	0.99	0	0.00	0.13	0.01	1.5	0.08	1.3	0.07
Pyrene	10.11	2.3	0.23	11	1.09	0	0.00	0.32	0.03	0.3	0.03	0.34	0.03
Fluoranthene	7.11	2.6	0.37	10	1.41	0	0.00	0.13	0.02	0.18	0.03	0.19	0.03
Benzo(a)anthracene	2.23	0.62	0.28	0.84	0.38	0	0.00	0	0.00	0	0.00	0	0.00
Chrysene	2.04	0.38	0.19	0.65	0.32	0	0.00	0	0.00	0	0.00	0	0.00
Benzo(a)pyrene	0.96	0.42	0.44	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Benzo(b)fluoranthene	0.68	0.37	0.55	0.15	0.22	0	0.00	0.19	0.28	0	0.00	0	0.00
Benzo(k)fluoranthene	0.64	0.066	0.10	0.041	0.06	0	0.00	0	0.00	0	0.00	0	0.00
Sum total of $ESBTU_{FCV}$			2.73		5.81		0.00		0.34		0.18		0.19
Adjusted $ESBTU_{FCV}$[1]			31.38		66.87		0.04		3.89		2.08		2.17

Notes
All concentrations in µg/L

Excluded groundwater samples with no detected PAHs

Minimum Adjusted $ESBTU_{FCV}$[1]	0.00
Maximum Adjusted $ESBTU_{FCV}$[1]	3041
Mean Adjusted $ESBTU_{FCV}$[1]	138

[1] Adjusted with an uncertainty factor at a 95% confidence level associated with using 13 PAHs (uncertainty factor = 11.5).

TABLE 2
Comparison of Groundwater Sample Results to FCVs for PAHs
Gowanus Canal Feasibility Study
Brooklyn, New York

Field ID	FCV	GC-MW06S	Toxic units	GC-MW06I	Toxic units	GC-MW07S	Toxic units	GC-MW07I	Toxic units	GC-MW08S	Toxic units	GC-MW08I	Toxic units
Naphthalene	193.5	1.9	0.01	6.9	0.04	130	0.67	3,500	18.09	0.17	0.00	0.11	0.00
Acenaphthylene	306.9	0.26	0.00	0.011	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Acenaphthene	55.9	2.2	0.04	1.1	0.02	25	0.45	400	7.16	0.62	0.01	0	0.00
Fluorene	39.3	2.5	0.06	0.15	0.00	10	0.25	150	3.82	0.38	0.01	0	0.00
Anthracene	20.7	0.28	0.01	0.25	0.01	3.2	0.15	88	4.25	0	0.00	0	0.00
Phenanthrene	19.1	0.53	0.03	1.3	0.07	14	0.73	330	17.25	0.16	0.01	0	0.00
Pyrene	10.11	0.35	0.03	0.17	0.02	3.1	0.31	120	11.87	0.12	0.01	0	0.00
Fluoranthene	7.11	0.15	0.02	0.14	0.02	2.4	0.34	72	10.13	0.11	0.02	0	0.00
Benzo(a)anthracene	2.23	0	0.00	0	0.00	0.28	0.13	27	12.12	0	0.00	0	0.00
Chrysene	2.04	0	0.00	0	0.00	0.17	0.08	14	6.86	0	0.00	0	0.00
Benzo(a)pyrene	0.96	0	0.00	0	0.00	0	0.00	11	11.49	0	0.00	0	0.00
Benzo(b)fluoranthene	0.68	0	0.00	0	0.00	0.11	0.16	13	19.19	0	0.00	0	0.00
Benzo(k)fluoranthene	0.64	0	0.00	0	0.00	0	0.00	3.1	4.83	0	0.00	0	0.00
Sum total of $ESBTU_{FCV}$			0.21		0.18		3.28		127.05		0.06		0.00
Adjusted $ESBTU_{FCV}$[1]			2.42		2.02		37.67		1461.12		0.66		0.01

Notes
All concentrations in μg/L

Excluded groundwater samples with no detected PAHs

Minimum Adjusted $ESBTU_{FCV}$[1]	0.00
Maximum Adjusted $ESBTU_{FCV}$[1]	3041
Mean Adjusted $ESBTU_{FCV}$[1]	138

[1] Adjusted with an uncertainty factor at a 95% confidence level associated with using 13 PAHs (uncertainty factor = 11.5).

TABLE 2
Comparison of Groundwater Sample Results to FCVs for PAHs
Gowanus Canal Feasibility Study
Brooklyn, New York

Field ID	**FCV**	GC-MW09S-S-NYC	Toxic units	DUP01_6/24/2010	Toxic units	GC-MW09S	Toxic units	GC-MW09I-S-NYC	Toxic units	GC-MW09I	Toxic units	GC-MW10I-S-NYC	Toxic units
Naphthalene	193.5	2.1	0.01	2.2	0.01	2.2	0.01	2,800	14.47	2,310	11.94	22	0.11
Acenaphthylene	306.9	0.04	0.00	0	0.00	0	0.00	0	0.00	2.3	0.01	0.12	0.00
Acenaphthene	55.9	0.96	0.02	0.83	0.01	0.89	0.02	250	4.48	178	3.19	5.5	0.10
Fluorene	39.3	0.98	0.02	0.66	0.02	0.65	0.02	30	0.76	22.2	0.56	4.1	0.10
Anthracene	20.7	1.1	0.05	0.43	0.02	0.49	0.02	0	0.00	2.3	0.11	1	0.05
Phenanthrene	19.1	4.5	0.24	1.5	0.08	1.7	0.09	21	1.10	15.7	0.82	14	0.73
Pyrene	10.11	3.8	0.38	0.75	0.07	0.79	0.08	0	0.00	0	0.00	4.4	0.44
Fluoranthene	7.11	4	0.56	0.96	0.14	1.1	0.15	0	0.00	0.46	0.06	4.6	0.65
Benzo(a)anthracene	2.23	1.8	0.81	0	0.00	0.41	0.18	0	0.00	0	0.00	1.3	0.58
Chrysene	2.04	1.9	0.93	0	0.00	0.41	0.20	0	0.00	0	0.00	1.4	0.69
Benzo(a)pyrene	0.96	1.5	1.57	0	0.00	0	0.00	0	0.00	0	0.00	1.2	1.25
Benzo(b)fluoranthene	0.68	1.4	2.07	0	0.00	0	0.00	0	0.00	0	0.00	0.82	1.21
Benzo(k)fluoranthene	0.64	1.2	1.87	0	0.00	0	0.00	0	0.00	0	0.00	0.94	1.47
Sum total of $ESBTU_{FCV}$			8.52		0.35		0.77		20.81		16.69		7.38
Adjusted $ESBTU_{FCV}$[1]			98.01		4.04		8.90		239.29		191.98		84.85

Notes
All concentrations in µg/L

Excluded groundwater samples with no detected PAHs

Minimum Adjusted $ESBTU_{FCV}$[1]	0.00
Maximum Adjusted $ESBTU_{FCV}$[1]	3041
Mean Adjusted $ESBTU_{FCV}$[1]	138

[1] Adjusted with an uncertainty factor at a 95% confidence level associated with using 13 PAHs (uncertainty factor = 11.5).

TABLE 2
Comparison of Groundwater Sample Results to FCVs for PAHs
Gowanus Canal Feasibility Study
Brooklyn, New York

Field ID	FCV	GC-MW10I	Toxic units	GC-MW11S	Toxic units	GC-MW11I	Toxic units	GC-MW12S	Toxic units	GC-MW12I	Toxic units	GC-MW13S	Toxic units
Naphthalene	193.5	21.2	0.11	3,500	18.09	49,000	253.23	230	1.19	0	0.00	680	3.51
Acenaphthylene	306.9	0	0.00	40	0.13	140	0.46	0.98	0.00	0	0.00	3	0.01
Acenaphthene	55.9	5.3	0.09	160	2.86	140	2.51	1.4	0.03	0	0.00	130	2.33
Fluorene	39.3	3.7	0.09	63	1.60	68	1.73	1.5	0.04	0	0.00	77	1.96
Anthracene	20.7	2.4	0.12	15	0.72	21	1.01	0	0.00	0	0.00	6.6	0.32
Phenanthrene	19.1	11.1	0.58	59	3.08	83	4.34	3.3	0.17	0.13	0.01	48	2.51
Pyrene	10.11	2.9	0.29	4.7	0.46	4.4	0.44	0	0.00	0	0.00	1.6	0.16
Fluoranthene	7.11	3.7	0.52	4.8	0.68	5	0.70	0.87	0.12	0	0.00	2.1	0.30
Benzo(a)anthracene	2.23	0.76	0.34	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Chrysene	2.04	0.84	0.41	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Benzo(a)pyrene	0.96	0.53	0.55	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Benzo(b)fluoranthene	0.68	0.46	0.68	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Benzo(k)fluoranthene	0.64	0.47	0.73	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Sum total of $ESBTU_{FCV}$			4.52		27.63		264.41		1.55		0.01		11.09
Adjusted $ESBTU_{FCV}$[1]			51.98		317.79		3040.75		17.82		0.08		127.56

Notes
All concentrations in µg/L

Excluded groundwater samples with no detected PAHs

Minimum Adjusted $ESBTU_{FCV}$[1]	0.00
Maximum Adjusted $ESBTU_{FCV}$[1]	3041
Mean Adjusted $ESBTU_{FCV}$[1]	138

[1] Adjusted with an uncertainty factor at a 95% confidence level associated with using 13 PAHs (uncertainty factor = 11.5).

TABLE 2

Comparison of Groundwater Sample Results to FCVs for PAHs

Gowanus Canal Feasibility Study

Brooklyn, New York

Field ID	FCV	GC-MW13I	Toxic units	GC-MW14S	Toxic units	GC-MW14I	Toxic units	GC-MW15S	Toxic units	GC-MW15I	Toxic units	GC-MW16S	Toxic units
Naphthalene	193.5	390	2.02	0.94	0.00	1.3	0.01	0.22	0.00	0	0.00	0.47	0.00
Acenaphthylene	306.9	1.6	0.01	0.12	0.00	0.064	0.00	0	0.00	0	0.00	0	0.00
Acenaphthene	55.9	56	1.00	2.3	0.04	1.6	0.03	0	0.00	0	0.00	5.5	0.10
Fluorene	39.3	49	1.25	0.63	0.02	0.43	0.01	0	0.00	0	0.00	1.4	0.04
Anthracene	20.7	14	0.68	0	0.00	0	0.00	0	0.00	0	0.00	0.21	0.01
Phenanthrene	19.1	74	3.87	0	0.00	0.1	0.01	0	0.00	0	0.00	1.6	0.08
Pyrene	10.11	4.8	0.47	0	0.00	0	0.00	0.12	0.01	0.12	0.01	0.5	0.05
Fluoranthene	7.11	6.2	0.87	0.11	0.02	0	0.00	0	0.00	0	0.00	0.27	0.04
Benzo(a)anthracene	2.23	0.22	0.10	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Chrysene	2.04	0.12	0.06	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Benzo(a)pyrene	0.96	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Benzo(b)fluoranthene	0.68	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0.2	0.30
Benzo(k)fluoranthene	0.64	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Sum total of $ESBTU_{FCV}$			10.32		0.08		0.05		0.01		0.01		0.61
Adjusted $ESBTU_{FCV}$[1]			118.66		0.90		0.60		0.15		0.14		7.05

Notes

All concentrations in µg/L

Excluded groundwater samples with no detected PAHs

Minimum Adjusted $ESBTU_{FCV}$[1]	0.00
Maximum Adjusted $ESBTU_{FCV}$[1]	3041
Mean Adjusted $ESBTU_{FCV}$[1]	138

[1] Adjusted with an uncertainty factor at a 95% confidence level associated with using 13 PAHs (uncertainty factor = 11.5).

TABLE 2

Comparison of Groundwater Sample Results to FCVs for PAHs

Gowanus Canal Feasibility Study

Brooklyn, New York

Field ID	FCV	GC-MW16I	Toxic units	D-07222010-01	Toxic units	GC-MW17S-S-NYC	Toxic units	GC-MW17I	Toxic units	GC-MW17I-S-NYC	Toxic units	GC-MW18S-S-NYC	Toxic units
Naphthalene	193.5	0.18	0.00	0.27	0.00	0.026	0.00	1.4	0.01	1.3	0.01	0.13	0.00
Acenaphthylene	306.9	0.2	0.00	0.22	0.00	0	0.00	0	0.00	0.24	0.00	5.3	0.02
Acenaphthene	55.9	0.38	0.01	0.44	0.01	0	0.00	5.5	0.10	5.4	0.10	6.4	0.11
Fluorene	39.3	0.61	0.02	0.7	0.02	0	0.00	0	0.00	0	0.00	3.6	0.09
Anthracene	20.7	0.46	0.02	0.55	0.03	0.024	0.00	0	0.00	0	0.00	3	0.14
Phenanthrene	19.1	1.4	0.07	1.4	0.07	0.048	0.00	0	0.00	0.2	0.01	1.2	0.06
Pyrene	10.11	1.3	0.13	1.4	0.14	0	0.00	0	0.00	0	0.00	2	0.20
Fluoranthene	7.11	0.78	0.11	0.93	0.13	0.041	0.01	0	0.00	0.15	0.02	2.6	0.37
Benzo(a)anthracene	2.23	0.072	0.03	0.088	0.04	0	0.00	0	0.00	0	0.00	0.63	0.28
Chrysene	2.04	0.073	0.04	0.084	0.04	0.02	0.01	0	0.00	0	0.00	0.61	0.30
Benzo(a)pyrene	0.96	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Benzo(b)fluoranthene	0.68	0	0.00	0.13	0.19	0	0.00	0	0.00	0	0.00	0.25	0.37
Benzo(k)fluoranthene	0.64	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0.25	0.39
Sum total of $ESBTU_{FCV}$			0.43		0.67		0.02		0.11		0.14		2.34
Adjusted $ESBTU_{FCV}$[1]			4.90		7.70		0.22		1.22		1.56		26.86

Notes

All concentrations in μg/L

Excluded groundwater samples with no detected PAHs

Minimum Adjusted $ESBTU_{FCV}$[1]	0.00
Maximum Adjusted $ESBTU_{FCV}$[1]	3041
Mean Adjusted $ESBTU_{FCV}$[1]	138

[1] Adjusted with an uncertainty factor at a 95% confidence level associated with using 13 PAHs (uncertainty factor = 11.5).

TABLE 2

Comparison of Groundwater Sample Results to FCVs for PAHs

Gowanus Canal Feasibility Study

Brooklyn, New York

Field ID	**FCV**	GC-MW18S	Toxic units	GC-MW18I-S-NYC	Toxic units	GC-MW18I	Toxic units	GC-MW19S-S-NYC	Toxic units	GC-MW19S	Toxic units	GC-MW19I-S-NYC	Toxic units
Naphthalene	193.5	99.9	0.52	370	1.91	605	3.13	0.18	0.00	1.3	0.01	0.098	0.00
Acenaphthylene	306.9	8.5	0.03	59	0.19	72.7	0.24	0.078	0.00	0	0.00	0	0.00
Acenaphthene	55.9	7.2	0.13	69	1.24	79.5	1.42	1.7	0.03	2	0.04	0	0.00
Fluorene	39.3	6	0.15	60	1.53	65	1.65	0.55	0.01	1.2	0.03	0	0.00
Anthracene	20.7	2.4	0.12	21	1.01	21.6	1.04	0	0.00	0	0.00	0	0.00
Phenanthrene	19.1	9.5	0.50	81	4.23	87.4	4.57	0	0.00	0	0.00	0.047	0.00
Pyrene	10.11	2	0.20	12	1.19	11.6	1.15	0	0.00	0	0.00	0	0.00
Fluoranthene	7.11	1.6	0.23	12	1.69	9	1.27	0.088	0.01	0	0.00	0.035	0.00
Benzo(a)anthracene	2.23	0.42	0.19	3	1.35	1.8	0.81	0	0.00	0	0.00	0	0.00
Chrysene	2.04	0.4	0.20	2.7	1.32	1.8	0.88	0	0.00	0	0.00	0	0.00
Benzo(a)pyrene	0.96	0	0.00	0	0.00	1.1	1.15	0	0.00	0	0.00	0	0.00
Benzo(b)fluoranthene	0.68	0	0.00	0	0.00	0.48	0.71	0	0.00	0	0.00	0	0.00
Benzo(k)fluoranthene	0.64	0	0.00	1.2	1.87	0.82	1.28	0	0.00	0	0.00	0	0.00
Sum total of $ESBTU_{FCV}$			2.25		17.53		19.29		0.06		0.07		0.01
Adjusted $ESBTU_{FCV}$[1]			25.82		201.58		221.84		0.67		0.84		0.09

Notes

All concentrations in µg/L

Excluded groundwater samples with no detected PAHs

Minimum Adjusted $ESBTU_{FCV}$[1]	0.00
Maximum Adjusted $ESBTU_{FCV}$[1]	3041
Mean Adjusted $ESBTU_{FCV}$[1]	138

[1] Adjusted with an uncertainty factor at a 95% confidence level associated with using 13 PAHs (uncertainty factor = 11.5).

TABLE 2

Comparison of Groundwater Sample Results to FCVs for PAHs

Gowanus Canal Feasibility Study

Brooklyn, New York

Field ID	**FCV**	GC-MW20S	Toxic units	D-07232010-01	Toxic units	GC-MW20I	Toxic units	GC-MW21S	Toxic units	GC-MW23S-S-NG	Toxic units	GC-MW23S	Toxic units
Naphthalene	193.5	42	0.22	50	0.26	3,100	16.02	2.2	0.01	8.8	0.05	5.1	0.03
Acenaphthylene	306.9	6.6	0.02	7.1	0.02	81	0.26	0	0.00	0.67	0.00	0.39	0.00
Acenaphthene	55.9	7.2	0.13	7	0.13	94	1.68	1.2	0.02	2.1	0.04	1.6	0.03
Fluorene	39.3	9.1	0.23	8.7	0.22	48	1.22	0.5	0.01	1.5	0.04	1.2	0.03
Anthracene	20.7	3	0.14	3	0.14	8.5	0.41	0.6	0.03	0.83	0.04	0.51	0.02
Phenanthrene	19.1	9.1	0.48	9	0.47	50	2.61	1.5	0.08	3.6	0.19	2.3	0.12
Pyrene	10.11	4.6	0.45	4.7	0.46	4.8	0.47	0.43	0.04	1.5	0.15	0.71	0.07
Fluoranthene	7.11	2.7	0.38	3.1	0.44	3.1	0.44	0.6	0.08	1.9	0.27	1.1	0.15
Benzo(a)anthracene	2.23	0.36	0.16	0.39	0.18	0	0.00	0	0.00	0.61	0.27	0.24	0.11
Chrysene	2.04	0.25	0.12	0.24	0.12	0	0.00	0	0.00	0.64	0.31	0.31	0.15
Benzo(a)pyrene	0.96	0	0.00	0	0.00	0	0.00	0	0.00	0.67	0.70	0.24	0.25
Benzo(b)fluoranthene	0.68	0	0.00	0.21	0.31	0	0.00	0	0.00	0.37	0.55	0	0.00
Benzo(k)fluoranthene	0.64	0	0.00	0	0.00	0	0.00	0	0.00	0.33	0.51	0.21	0.33
Sum total of $ESBTU_{FCV}$			2.34		2.75		23.12		0.28		3.12		1.29
Adjusted $ESBTU_{FCV}$[1]			26.89		31.59		265.92		3.22		35.82		14.88

Notes

All concentrations in μg/L

Excluded groundwater samples with no detected PAHs

Minimum Adjusted $ESBTU_{FCV}$[1]	0.00
Maximum Adjusted $ESBTU_{FCV}$[1]	3041
Mean Adjusted $ESBTU_{FCV}$[1]	138

[1] Adjusted with an uncertainty factor at a 95% confidence level associated with using 13 PAHs (uncertainty factor = 11.5).

TABLE 2

Comparison of Groundwater Sample Results to FCVs for PAHs

Gowanus Canal Feasibility Study

Brooklyn, New York

Field ID	**FCV**	GC-MWXX	Toxic units	GC-MW-23I(33.75-38.75)	Toxic units	GC-MW23I-S-NG	Toxic units	GC-MW24S	Toxic units	GC-MW24I	Toxic units	GC-MW25S	Toxic units
Naphthalene	193.5	5.1	0.03	0	0.00	1.2	0.01	4.5	0.02	8.1	0.04	0	0.00
Acenaphthylene	306.9	0.35	0.00	18	0.06	13	0.04	1.5	0.00	0	0.00	0	0.00
Acenaphthene	55.9	1.5	0.03	210	3.76	140	2.51	1.1	0.02	0	0.00	0	0.00
Fluorene	39.3	1.1	0.03	41	1.04	64	1.63	0.17	0.00	0	0.00	0	0.00
Anthracene	20.7	0.56	0.03	13	0.63	20	0.96	0	0.00	0	0.00	0	0.00
Phenanthrene	19.1	2.5	0.13	59	3.08	80	4.18	0	0.00	0	0.00	0	0.00
Pyrene	10.11	0.75	0.07	7.7	0.76	15	1.48	2.8	0.28	9.1	0.90	0	0.00
Fluoranthene	7.11	1.2	0.17	6.4	0.90	12	1.69	1.4	0.20	0.27	0.04	0	0.00
Benzo(a)anthracene	2.23	0.25	0.11	2	0.90	5.2	2.33	0.19	0.09	0	0.00	0	0.00
Chrysene	2.04	0.31	0.15	2.5	1.22	5.9	2.89	0.14	0.07	0	0.00	0	0.00
Benzo(a)pyrene	0.96	0.56	0.58	1.4	1.46	3.6	3.76	0	0.00	0	0.00	0	0.00
Benzo(b)fluoranthene	0.68	0.19	0.28	0.76	1.12	1.4	2.07	0	0.00	0	0.00	0	0.00
Benzo(k)fluoranthene	0.64	0.23	0.36	0.92	1.43	1.9	2.96	0	0.00	0	0.00	0	0.00
Sum total of $ESBTU_{FCV}$			1.97		16.38		26.52		0.68		0.98		0.00
Adjusted $ESBTU_{FCV}$[1]			22.67		188.32		304.93		7.82		11.27		0.00

Notes

All concentrations in µg/L

Excluded groundwater samples with no detected PAHs

Minimum Adjusted $ESBTU_{FCV}$[1]	0.00
Maximum Adjusted $ESBTU_{FCV}$[1]	3041
Mean Adjusted $ESBTU_{FCV}$[1]	138

[1] Adjusted with an uncertainty factor at a 95% confidence level associated with using 13 PAHs (uncertainty factor = 11.5).

TABLE 2

Comparison of Groundwater Sample Results to FCVs for PAHs

Gowanus Canal Feasibility Study

Brooklyn, New York

Field ID	FCV	GC-MW25I	Toxic units	GC-MW26S	Toxic units	GC-MW26I	Toxic units	GC-MW27S	Toxic units	GC-MW27I	Toxic units	GC-MW28S	Toxic units
Naphthalene	193.5	0.4	0.00	0.93	0.00	0.8	0.00	17	0.09	1,700	8.79	1.4	0.01
Acenaphthylene	306.9	0	0.00	0	0.00	0	0.00	0.11	0.00	9.5	0.03	0	0.00
Acenaphthene	55.9	0.11	0.00	0.09	0.00	0.19	0.00	5.9	0.11	210	3.76	0.54	0.01
Fluorene	39.3	0	0.00	0	0.00	0	0.00	3.2	0.08	84	2.14	0.18	0.00
Anthracene	20.7	0	0.00	0	0.00	0	0.00	2	0.10	24	1.16	0	0.00
Phenanthrene	19.1	0.39	0.02	0.12	0.01	0.32	0.02	8.6	0.45	110	5.75	0.14	0.01
Pyrene	10.11	0.24	0.02	0	0.00	0.16	0.02	2.9	0.29	16	1.58	0	0.00
Fluoranthene	7.11	0.13	0.02	0	0.00	0	0.00	1.7	0.24	10	1.41	0	0.00
Benzo(a)anthracene	2.23	0	0.00	0	0.00	0	0.00	0.66	0.30	2.1	0.94	0	0.00
Chrysene	2.04	0	0.00	0	0.00	0	0.00	0.33	0.16	1.2	0.59	0	0.00
Benzo(a)pyrene	0.96	0	0.00	0	0.00	0	0.00	0.48	0.50	0	0.00	0	0.00
Benzo(b)fluoranthene	0.68	0.13	0.19	0	0.00	0	0.00	0.58	0.86	1.3	1.92	0	0.00
Benzo(k)fluoranthene	0.64	0	0.00	0	0.00	0	0.00	0.12	0.19	0.29	0.45	0	0.00
Sum total of $ESBTU_{FCV}$			0.26		0.01		0.04		3.35		28.51		0.03
Adjusted $ESBTU_{FCV}$[1]			2.97		0.15		0.46		38.52		327.90		0.33

Notes

All concentrations in μg/L

Excluded groundwater samples with no detected PAHs

Minimum Adjusted $ESBTU_{FCV}$[1]	0.00
Maximum Adjusted $ESBTU_{FCV}$[1]	3041
Mean Adjusted $ESBTU_{FCV}$[1]	138

[1] Adjusted with an uncertainty factor at a 95% confidence level associated with using 13 PAHs (uncertainty factor = 11.5).

TABLE 2

Comparison of Groundwater Sample Results to FCVs for PAHs

Gowanus Canal Feasibility Study

Brooklyn, New York

Field ID	FCV	D-07212010-01	Toxic units	GC-MW28I	Toxic units	GC-MW29S	Toxic units	GC-MW29I	Toxic units	GC-MW30S-S-NG	Toxic units	GC-MW30S(7-16)	Toxic units
Naphthalene	193.5	0	0.00	0.049	0.00	0.17	0.00	71	0.37	1,100	5.68	1,400	7.24
Acenaphthylene	306.9	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	3.2	0.01
Acenaphthene	55.9	0	0.00	0	0.00	0.17	0.00	4.2	0.08	490	8.77	550	9.85
Fluorene	39.3	0	0.00	0	0.00	0.17	0.00	0.67	0.02	36	0.92	41	1.04
Anthracene	20.7	0	0.00	0	0.00	0	0.00	0.14	0.01	21	1.01	20	0.96
Phenanthrene	19.1	0.12	0.01	0.1	0.01	0.37	0.02	0.53	0.03	85	4.44	94	4.91
Pyrene	10.11	0	0.00	0	0.00	0.17	0.02	0.13	0.01	17	1.68	15	1.48
Fluoranthene	7.11	0	0.00	0	0.00	0.18	0.03	0.1	0.01	12	1.69	12	1.69
Benzo(a)anthracene	2.23	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Chrysene	2.04	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Benzo(a)pyrene	0.96	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Benzo(b)fluoranthene	0.68	0	0.00	0.13	0.19	0.17	0.25	0	0.00	0	0.00	0	0.00
Benzo(k)fluoranthene	0.64	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Sum total of $ESBTU_{FCV}$			0.01		0.20		0.32		0.52		24.20		27.19
Adjusted $ESBTU_{FCV}$[1]			0.07		2.27		3.69		5.99		278.30		312.65

Notes

All concentrations in µg/L

Excluded groundwater samples with no detected PAHs

Minimum Adjusted $ESBTU_{FCV}$[1]	0.00
Maximum Adjusted $ESBTU_{FCV}$[1]	3041
Mean Adjusted $ESBTU_{FCV}$[1]	138

[1] Adjusted with an uncertainty factor at a 95% confidence level associated with using 13 PAHs (uncertainty factor = 11.5).

TABLE 2

Comparison of Groundwater Sample Results to FCVs for PAHs

Gowanus Canal Feasibility Study

Brooklyn, New York

Field ID	**FCV**	GC-MW30I(30-35)	Toxic units	GC-MW31S-S-NG	Toxic units	GC-MW31S(6.75-14.6)	Toxic units	GC-MW31I-S-NG	Toxic units	GC-MW31I(30-35)	Toxic units	GC-MW32S-S-NG	Toxic units
Naphthalene	193.5	3,700	19.12	1.8	0.01	0	0.00	6,600	34.11	6,000	31.01	0.21	0.00
Acenaphthylene	306.9	4.2	0.01	0	0.00	0	0.00	0	0.00	0	0.00	0.05	0.00
Acenaphthene	55.9	180	3.22	0.95	0.02	0.3	0.01	350	6.27	370	6.62	1	0.02
Fluorene	39.3	31	0.79	0	0.00	0.092	0.00	95	2.42	79	2.01	0.74	0.02
Anthracene	20.7	5	0.24	0.066	0.00	0.057	0.00	19	0.92	23	1.11	0.18	0.01
Phenanthrene	19.1	28	1.46	0	0.00	0.28	0.01	120	6.27	120	6.27	0.29	0.02
Pyrene	10.11	4.3	0.43	0	0.00	0.025	0.00	0	0.00	9.4	0.93	0.62	0.06
Fluoranthene	7.11	0	0.00	0.16	0.02	0.06	0.01	0	0.00	8.8	1.24	0.73	0.10
Benzo(a)anthracene	2.23	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0.097	0.04
Chrysene	2.04	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0.086	0.04
Benzo(a)pyrene	0.96	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0.15	0.16
Benzo(b)fluoranthene	0.68	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0.043	0.06
Benzo(k)fluoranthene	0.64	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0.042	0.07
Sum total of $ESBTU_{FCV}$			25.28		0.05		0.04		49.98		49.19		0.60
Adjusted $ESBTU_{FCV}$[1]			290.69		0.60		0.41		574.79		565.72		6.87

Notes

All concentrations in µg/L

Excluded groundwater samples with no detected PAHs

Minimum Adjusted $ESBTU_{FCV}$[1]	0.00
Maximum Adjusted $ESBTU_{FCV}$[1]	3041
Mean Adjusted $ESBTU_{FCV}$[1]	138

[1] Adjusted with an uncertainty factor at a 95% confidence level associated with using 13 PAHs (uncertainty factor = 11.5).

TABLE 2

Comparison of Groundwater Sample Results to FCVs for PAHs

Gowanus Canal Feasibility Study

Brooklyn, New York

Field ID	**FCV**	GC-MW-32S(12-19)	Toxic units	GC-MW-32I(40-45)	Toxic units	GC-MW32I-S-NG	Toxic units	GC-MW33S	Toxic units	D-07152010-01	Toxic units	GC-MW33I	Toxic units
Naphthalene	193.5	0.19	0.00	14,000	72.35	12,000	62.02	20	0.10	6,900	35.66	6,900	35.66
Acenaphthylene	306.9	0.045	0.00	170	0.55	180	0.59	0	0.00	0	0.00	1.1	0.00
Acenaphthene	55.9	1.1	0.02	190	3.40	180	3.22	1.9	0.03	190	3.40	250	4.48
Fluorene	39.3	0.89	0.02	55	1.40	99	2.52	0.36	0.01	36	0.92	48	1.22
Anthracene	20.7	0.49	0.02	0	0.00	23	1.11	0	0.00	7.2	0.35	7.7	0.37
Phenanthrene	19.1	0.89	0.05	78	4.08	99	5.18	0.49	0.03	33	1.73	45	2.35
Pyrene	10.11	0.82	0.08	0	0.00	18	1.78	0	0.00	1.5	0.15	1.8	0.18
Fluoranthene	7.11	0.91	0.13	0	0.00	13	1.83	0	0.00	1.4	0.20	1.8	0.25
Benzo(a)anthracene	2.23	0.27	0.12	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Chrysene	2.04	0.29	0.14	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Benzo(a)pyrene	0.96	0.19	0.20	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Benzo(b)fluoranthene	0.68	0.13	0.19	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Benzo(k)fluoranthene	0.64	0.2	0.31	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Sum total of $ESBTU_{FCV}$			1.29		81.78		78.24		0.17		42.39		44.52
Adjusted $ESBTU_{FCV}$[1]			14.81		940.52		899.73		1.98		487.54		511.92

Notes

All concentrations in µg/L

Excluded groundwater samples with no detected PAHs

Minimum Adjusted $ESBTU_{FCV}$[1]	0.00
Maximum Adjusted $ESBTU_{FCV}$[1]	3041
Mean Adjusted $ESBTU_{FCV}$[1]	138

[1] Adjusted with an uncertainty factor at a 95% confidence level associated with using 13 PAHs (uncertainty factor = 11.5).

TABLE 2

Comparison of Groundwater Sample Results to FCVs for PAHs

Gowanus Canal Feasibility Study

Brooklyn, New York

Field ID	**FCV**	GC-MW34S	Toxic units	GC-MW34I	Toxic units	GC-MW35S	Toxic units	GC-MW35I	Toxic units	D-07222010-02	Toxic units	GC-MW36S	Toxic units
Naphthalene	193.5	0	0.00	5.1	0.03	210	1.09	340	1.76	12	0.06	5.2	0.03
Acenaphthylene	306.9	0	0.00	3.3	0.01	21	0.07	19	0.06	1.7	0.01	1.6	0.01
Acenaphthene	55.9	100	1.79	310	5.55	79	1.41	75	1.34	74	1.32	69	1.24
Fluorene	39.3	25	0.64	0	0.00	38	0.97	37	0.94	36	0.92	34	0.87
Anthracene	20.7	21	1.01	26	1.25	12	0.58	14	0.68	4.8	0.23	4.6	0.22
Phenanthrene	19.1	60	3.14	96	5.02	81	4.23	98	5.12	43	2.25	36	1.88
Pyrene	10.11	9.6	0.95	8.7	0.86	13	1.29	15	1.48	9.9	0.98	7.8	0.77
Fluoranthene	7.11	5.9	0.83	12	1.69	8.3	1.17	9.9	1.39	11	1.55	9.9	1.39
Benzo(a)anthracene	2.23	0	0.00	0	0.00	0.78	0.35	0.8	0.36	0.11	0.05	0.42	0.19
Chrysene	2.04	0	0.00	0	0.00	0.44	0.22	0.64	0.31	0	0.00	0.21	0.10
Benzo(a)pyrene	0.96	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Benzo(b)fluoranthene	0.68	0	0.00	0	0.00	0.34	0.50	0.22	0.32	0	0.00	0	0.00
Benzo(k)fluoranthene	0.64	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Sum total of $ESBTU_{FCV}$			8.36		14.41		11.87		13.78		7.36		6.69
Adjusted $ESBTU_{FCV}$[1]			96.09		165.70		136.50		158.42		84.68		76.96

Notes

All concentrations in µg/L

Excluded groundwater samples with no detected PAHs

Minimum Adjusted $ESBTU_{FCV}$[1]	0.00
Maximum Adjusted $ESBTU_{FCV}$[1]	3041
Mean Adjusted $ESBTU_{FCV}$[1]	138

[1] Adjusted with an uncertainty factor at a 95% confidence level associated with using 13 PAHs (uncertainty factor = 11.5).

TABLE 2

Comparison of Groundwater Sample Results to FCVs for PAHs

Gowanus Canal Feasibility Study

Brooklyn, New York

Field ID	**FCV**	GC-MW36I	Toxic units	GC-MW37S	Toxic units	GC-MW37I	Toxic units	D-07262010-01	Toxic units	GC-MW38S	Toxic units	GC-MW38I	Toxic units
Naphthalene	193.5	1	0.01	0.1	0.00	0.48	0.00	0.44	0.00	0.68	0.00	2.1	0.01
Acenaphthylene	306.9	28	0.09	0	0.00	6.3	0.02	7.3	0.02	10	0.03	2.6	0.01
Acenaphthene	55.9	320	5.73	1.2	0.02	23	0.41	23	0.41	35	0.63	2.2	0.04
Fluorene	39.3	8.5	0.22	0.48	0.01	13	0.33	13	0.33	2.9	0.07	3.9	0.10
Anthracene	20.7	9.7	0.47	0.72	0.03	5	0.24	5.3	0.26	0	0.00	1.6	0.08
Phenanthrene	19.1	110	5.75	0	0.00	3	0.16	7.2	0.38	0.21	0.01	9.1	0.48
Pyrene	10.11	8.3	0.82	2.2	0.22	3.7	0.37	3.9	0.39	0.24	0.02	1.6	0.16
Fluoranthene	7.11	8.4	1.18	1.4	0.20	2.8	0.39	2.2	0.31	0.19	0.03	1.1	0.15
Benzo(a)anthracene	2.23	0.15	0.07	0.32	0.14	0.28	0.13	0.31	0.14	0	0.00	0.088	0.04
Chrysene	2.04	0.08	0.04	0.18	0.09	0.16	0.08	0.18	0.09	0	0.00	0.059	0.03
Benzo(a)pyrene	0.96	0	0.00	0	0.00	0	0.00	0.19	0.20	0	0.00	0	0.00
Benzo(b)fluoranthene	0.68	0	0.00	0	0.00	0	0.00	0.14	0.21	0	0.00	0.12	0.18
Benzo(k)fluoranthene	0.64	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Sum total of $ESBTU_{FCV}$			14.37		0.72		2.13		2.73		0.80		1.27
Adjusted $ESBTU_{FCV}$[1]			165.25		8.23		24.47		31.38		9.18		14.60

Notes

All concentrations in μg/L

Excluded groundwater samples with no detected PAHs

Minimum Adjusted $ESBTU_{FCV}$[1]	0.00
Maximum Adjusted $ESBTU_{FCV}$[1]	3041
Mean Adjusted $ESBTU_{FCV}$[1]	138

[1] Adjusted with an uncertainty factor at a 95% confidence level associated with using 13 PAHs (uncertainty factor = 11.5).

TABLE 2

Comparison of Groundwater Sample Results to FCVs for PAHs

Gowanus Canal Feasibility Study

Brooklyn, New York

Field ID	**FCV**	GC-MW39S	Toxic units	GC-MW39I	Toxic units	GC-MW40I	Toxic units	GC-MW-41S(8-13)	Toxic units	GC-MW41S-S-NG	Toxic units	GC-MW-41I(53-58)	Toxic units
Naphthalene	193.5	1	0.01	990	5.12	0	0.00	940	4.86	320	1.65	3	0.02
Acenaphthylene	306.9	0	0.00	5.8	0.02	0.5	0.00	3.1	0.01	6.6	0.02	0.21	0.00
Acenaphthene	55.9	28	0.50	62	1.11	0.41	0.01	170	3.04	180	3.22	4	0.07
Fluorene	39.3	7.4	0.19	24	0.61	0.68	0.02	78	1.98	78	1.98	3.9	0.10
Anthracene	20.7	2.9	0.14	8.1	0.39	1.1	0.05	22	1.06	24	1.16	2.3	0.11
Phenanthrene	19.1	0	0.00	38	1.99	4.2	0.22	150	7.84	150	7.84	14	0.73
Pyrene	10.11	8.4	0.83	4.7	0.46	0.8	0.08	14	1.38	16	1.58	1	0.10
Fluoranthene	7.11	5.2	0.73	2.9	0.41	1.4	0.20	23	3.24	23	3.24	1.7	0.24
Benzo(a)anthracene	2.23	1.4	0.63	0	0.00	0	0.00	0	0.00	0.99	0.44	0	0.00
Chrysene	2.04	0.97	0.48	0	0.00	0.074	0.04	0	0.00	0.69	0.34	0	0.00
Benzo(a)pyrene	0.96	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Benzo(b)fluoranthene	0.68	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Benzo(k)fluoranthene	0.64	0	0.00	0	0.00	0.07	0.11	0	0.00	0	0.00	0	0.00
Sum total of $ESBTU_{FCV}$			3.50		10.11		0.72		23.42		21.48		1.37
Adjusted $ESBTU_{FCV}$[1]			40.26		116.22		8.28		269.32		247.04		15.73

Notes

All concentrations in μg/L

Excluded groundwater samples with no detected PAHs

Minimum Adjusted $ESBTU_{FCV}$[1]	0.00
Maximum Adjusted $ESBTU_{FCV}$[1]	3041
Mean Adjusted $ESBTU_{FCV}$[1]	138

[1] Adjusted with an uncertainty factor at a 95% confidence level associated with using 13 PAHs (uncertainty factor = 11.5).

TABLE 2

Comparison of Groundwater Sample Results to FCVs for PAHs

Gowanus Canal Feasibility Study

Brooklyn, New York

Field ID	**FCV**	GC-MW41I-S-NG	Toxic units	GC-MW42S	Toxic units	GC-MW42I	Toxic units	GC-MW43S	Toxic units	GC-MW43I	Toxic units	GC-MW44S	Toxic units
Naphthalene	193.5	0.72	0.00	2.4	0.01	1.3	0.01	0.2	0.00	0.3	0.00	0.41	0.00
Acenaphthylene	306.9	0.82	0.00	0	0.00	0	0.00	13	0.04	4.3	0.01	0	0.00
Acenaphthene	55.9	6.7	0.12	0	0.00	0	0.00	8.7	0.16	7.5	0.13	0.38	0.01
Fluorene	39.3	7.1	0.18	0	0.00	0	0.00	21	0.53	16	0.41	0.14	0.00
Anthracene	20.7	3.9	0.19	0	0.00	0	0.00	9.1	0.44	6	0.29	0	0.00
Phenanthrene	19.1	19	0.99	0	0.00	0	0.00	18	0.94	21	1.10	0.52	0.03
Pyrene	10.11	2.4	0.24	0	0.00	0	0.00	7.8	0.77	3.8	0.38	0.28	0.03
Fluoranthene	7.11	3.5	0.49	0.16	0.02	0	0.00	4.5	0.63	2.8	0.39	0.23	0.03
Benzo(a)anthracene	2.23	0.21	0.09	0	0.00	0	0.00	0.5	0.22	0.38	0.17	0	0.00
Chrysene	2.04	0.19	0.09	0	0.00	0	0.00	0.27	0.13	0.23	0.11	0	0.00
Benzo(a)pyrene	0.96	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Benzo(b)fluoranthene	0.68	0	0.00	0	0.00	0	0.00	0.24	0.35	0.15	0.22	0	0.00
Benzo(k)fluoranthene	0.64	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Sum total of $ESBTU_{FCV}$			2.41		0.03		0.01		4.23		3.22		0.10
Adjusted $ESBTU_{FCV}$[1]			27.66		0.40		0.08		48.63		37.01		1.15

Notes

All concentrations in μg/L

Excluded groundwater samples with no detected PAHs

Minimum Adjusted $ESBTU_{FCV}$[1]	0.00
Maximum Adjusted $ESBTU_{FCV}$[1]	3041
Mean Adjusted $ESBTU_{FCV}$[1]	138

[1] Adjusted with an uncertainty factor at a 95% confidence level associated with using 13 PAHs (uncertainty factor = 11.5).

TABLE 2

Comparison of Groundwater Sample Results to FCVs for PAHs

Gowanus Canal Feasibility Study

Brooklyn, New York

Field ID	**FCV**	GC-MW44I	Toxic units	D-07082010-01	Toxic units	GC-MW45S	Toxic units	GC-MW45I	Toxic units	GC-MW46D	Toxic units	GC-MW47S	Toxic units
Naphthalene	193.5	0.48	0.00	0.3	0.00	0.66	0.00	5,400	27.91	0.33	0.00	1,800	9.30
Acenaphthylene	306.9	0.76	0.00	0.47	0.00	1.1	0.00	7.7	0.03	3.3	0.01	110	0.36
Acenaphthene	55.9	5.1	0.09	3.6	0.06	160	2.86	220	3.94	11	0.20	68	1.22
Fluorene	39.3	1.2	0.03	0.79	0.02	80	2.04	73	1.86	0.16	0.00	49	1.25
Anthracene	20.7	0.4	0.02	0.27	0.01	29	1.40	17	0.82	0	0.00	17	0.82
Phenanthrene	19.1	1.6	0.08	1.2	0.06	110	5.75	82	4.29	0.15	0.01	84	4.39
Pyrene	10.11	0.71	0.07	0.42	0.04	14	1.38	12	1.19	0	0.00	26	2.57
Fluoranthene	7.11	0.45	0.06	0.33	0.05	11	1.55	7.6	1.07	0	0.00	14	1.97
Benzo(a)anthracene	2.23	0	0.00	0	0.00	1.3	0.58	2.1	0.94	0	0.00	4.5	2.02
Chrysene	2.04	0	0.00	0	0.00	0.84	0.41	1.2	0.59	0	0.00	3	1.47
Benzo(a)pyrene	0.96	0	0.00	0.18	0.19	0.85	0.89	1.3	1.36	0	0.00	2.1	2.19
Benzo(b)fluoranthene	0.68	0	0.00	0.16	0.24	1	1.48	1.4	2.07	0	0.00	2.3	3.40
Benzo(k)fluoranthene	0.64	0	0.00	0	0.00	0.29	0.45	0.39	0.61	0	0.00	0.61	0.95
Sum total of $ESBTU_{FCV}$			0.36		0.68		18.80		46.65		0.22		31.91
Adjusted $ESBTU_{FCV}$[1]			4.18		7.77		216.20		536.53		2.55		366.93

Notes

All concentrations in μg/L

Excluded groundwater samples with no detected PAHs

Minimum Adjusted $ESBTU_{FCV}$[1]	0.00
Maximum Adjusted $ESBTU_{FCV}$[1]	3041
Mean Adjusted $ESBTU_{FCV}$[1]	138

[1] Adjusted with an uncertainty factor at a 95% confidence level associated with using 13 PAHs (uncertainty factor = 11.5).

TABLE 2

Comparison of Groundwater Sample Results to FCVs for PAHs

Gowanus Canal Feasibility Study

Brooklyn, New York

Field ID	**FCV**	GC-MW47I	Toxic units
Naphthalene	193.5	2,800	14.47
Acenaphthylene	306.9	170	0.55
Acenaphthene	55.9	100	1.79
Fluorene	39.3	57	1.45
Anthracene	20.7	20	0.96
Phenanthrene	19.1	61	3.19
Pyrene	10.11	10	0.99
Fluoranthene	7.11	4	0.56
Benzo(a)anthracene	2.23	0.79	0.35
Chrysene	2.04	0.37	0.18
Benzo(a)pyrene	0.96	0.35	0.37
Benzo(b)fluoranthene	0.68	0.36	0.53
Benzo(k)fluoranthene	0.64	0.086	0.13
Sum total of $ESBTU_{FCV}$			25.54
Adjusted $ESBTU_{FCV}$[1]			293.68

Notes

All concentrations in µg/L

Excluded groundwater samples with no detected PAHs

Minimum Adjusted $ESBTU_{FCV}$[1]	0.00
Maximum Adjusted $ESBTU_{FCV}$[1]	3041
Mean Adjusted $ESBTU_{FCV}$[1]	138

[1] Adjusted with an uncertainty factor at a 95% confidence level associated with using 13 PAHs (uncertainty factor = 11.5).

TABLE 3

Ranking of Groundwater Samples by Adjusted TU Sum

Gowanus Canal Feasibility Study

Brooklyn, New York

Field ID	Adjusted $ESBTU_{FCV}$ [1]
GC-MW25S	0.00
GC-MW08I	0.01
GC-MW04S	0.04
D-07212010-01	0.07
GC-MW42I	0.08
GC-MW12I	0.08
GC-MW19I-S-NYC	0.09
GC-MW15I	0.14
GC-MW26S	0.15
GC-MW15S	0.15
GC-MW17S-S-NYC	0.22
GC-MW28S	0.33
GC-MW42S	0.40
GC-MW31S(6.75-14.6)	0.41
GC-MW26I	0.46
GC-MW14I	0.60
GC-MW31S-S-NG	0.60
GC-MW08S	0.66
GC-MW19S-S-NYC	0.67
GC-MW19S	0.84
GC-MW14S	0.90
GC-MW44S	1.15
GC-MW17I	1.22
GC-MW02I	1.56
GC-MW17I-S-NYC	1.56
GC-MW33S	1.98
GC-MW06I	2.02
GC-MW05S	2.08
GC-MW05I	2.17
GC-MW28I	2.27
GC-MW06S	2.42
GC-MW01S-S-NYC	2.51
GC-MW46D	2.55
GC-MW02I-S-NYC	2.94
GC-MW25I	2.97
GC-MW21S	3.22
GC-MW29S	3.69
GC-MW04I	3.89
DUP01_6/24/2010	4.04
GC-MW44I	4.18
GC-MW01I	4.38
GC-MW16I	4.90
GC-MW01S	5.10
GC-MW29I	5.99
GC-MW32S-S-NG	6.87
GC-MW16S	7.05

TABLE 3

Ranking of Groundwater Samples by Adjusted TU Sum

Gowanus Canal Feasibility Study

Brooklyn, New York

Field ID	Adjusted $ESBTU_{FCV}$[1]
D-07222010-01	7.70
D-07082010-01	7.77
GC-MW24S	7.82
GC-MW37S	8.23
GC-MW40I	8.28
GC-MW09S	8.90
GC-MW38S	9.18
GC-MW24I	11.27
GC-MW38I	14.60
GC-MW-32S(12-19)	14.81
GC-MW23S	14.88
GC-MW-41I(53-58)	15.73
GC-MW12S	17.82
GC-MW01I-S-NYC	19.05
GC-MWXX	22.67
GC-MW37I	24.47
GC-MW18S	25.82
GC-MW18S-S-NYC	26.86
GC-MW20S	26.89
GC-MW41I-S-NG	27.66
D-07262010-01	31.38
GC-MW03S	31.38
D-07232010-01	31.59
GC-MW23S-S-NG	35.82
GC-MW43I	37.01
GC-MW07S	37.67
GC-MW27S	38.52
GC-MW39S	40.26
GC-MW43S	48.63
GC-MW10I	51.98
GC-MW03I	66.87
GC-MW36S	76.96
D-07222010-02	84.68
GC-MW10I-S-NYC	84.85
GC-MW34S	96.09
GC-MW09S-S-NYC	98.01
GC-MW39I	116.22
GC-MW13I	118.66
GC-MW13S	127.56
GC-MW35S	136.50
GC-MW35I	158.42
GC-MW36I	165.25
GC-MW34I	165.70
GC-MW-23I(33.75-38.75	188.32
GC-MW09I	191.98
GC-MW18I-S-NYC	201.58

TABLE 3

Ranking of Groundwater Samples by Adjusted TU Sum

Gowanus Canal Feasibility Study

Brooklyn, New York

Field ID	Adjusted $ESBTU_{FCV}$ [1]
GC-MW45S	216.20
GC-MW18I	221.84
GC-MW09I-S-NYC	239.29
GC-MW41S-S-NG	247.04
GC-MW20I	265.92
GC-MW-41S(8-13)	269.32
GC-MW30S-S-NG	278.30
GC-MW30I(30-35)	290.69
GC-MW47I	293.68
GC-MW23I-S-NG	304.93
GC-MW30S(7-16)	312.65
GC-MW11S	317.79
GC-MW27I	327.90
GC-MW47S	366.93
D-07152010-01	487.54
GC-MW33I	511.92
GC-MW45I	536.53
GC-MW31I(30-35)	565.72
GC-MW31I-S-NG	574.79
GC-MW32I-S-NG	899.73
GC-MW-32I(40-45)	940.52
GC-MW07I	1461.12
GC-MW11I	3040.75

Notes:

Excluded groundwater samples with no detected PAHs

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TABLE 4

Ranking of Groundwater Samples by Adjusted TU Sum: Shallow and Intermediate Wells

Gowanus Canal Feasibility Study

Brooklyn, New York

Shallow wells		Intermediate wells	
Field ID	**Adjusted ESBTU$_{FCV}$[1]**	**Field ID**	**Adjusted ESBTU$_{FCV}$[1]**
GC-MW25S	0	GC-MW08I	0
GC-MW04S	0	GC-MW42I	0
GC-MW26S	0	GC-MW12I	0
GC-MW15S	0	GC-MW19I-S-NYC	0
GC-MW17S-S-NYC	0	GC-MW15I	0
GC-MW28S	0	GC-MW26I	0
GC-MW42S	0	GC-MW14I	1
GC-MW31S(6.75-14.6)	0	GC-MW17I	1
GC-MW31S-S-NG	1	GC-MW02I	2
GC-MW08S	1	GC-MW17I-S-NYC	2
GC-MW19S-S-NYC	1	GC-MW06I	2
GC-MW19S	1	GC-MW05I	2
GC-MW14S	1	GC-MW28I	2
GC-MW44S	1	GC-MW46D	3
GC-MW33S	2	GC-MW02I-S-NYC	3
GC-MW05S	2	GC-MW25I	3
GC-MW06S	2	GC-MW04I	4
GC-MW01S-S-NYC	3	GC-MW44I	4
GC-MW21S	3	GC-MW01I	4
GC-MW29S	4	GC-MW16I	5
GC-MW01S	5	GC-MW29I	6
GC-MW32S-S-NG	7	GC-MW40I	8
GC-MW16S	7	GC-MW24I	11
GC-MW24S	8	GC-MW38I	15
GC-MW37S	8	GC-MW-41I(53-58)	16
GC-MW09S	9	GC-MW01I-S-NYC	19
GC-MW38S	9	GC-MW37I	24
GC-MW-32S(12-19)	15	GC-MW41I-S-NG	28
GC-MW23S	15	GC-MW43I	37
GC-MW12S	18	GC-MW10I	52
GC-MW18S	26	GC-MW03I	67
GC-MW18S-S-NYC	27	GC-MW10I-S-NYC	85
GC-MW20S	27	GC-MW39I	116
GC-MW03S	31	GC-MW13I	119
GC-MW23S-S-NG	36	GC-MW35I	158
GC-MW07S	38	GC-MW36I	165
GC-MW27S	39	GC-MW34I	166
GC-MW39S	40	GC-MW-23I(33.75-38.75)	188
GC-MW43S	49	GC-MW09I	192
GC-MW36S	77	GC-MW18I-S-NYC	202
GC-MW34S	96	GC-MW18I	222
GC-MW09S-S-NYC	98	GC-MW09I-S-NYC	239
GC-MW13S	128	GC-MW20I	266
GC-MW35S	136	GC-MW30I(30-35)	291
GC-MW45S	216	GC-MW47I	294
GC-MW41S-S-NG	247	GC-MW23I-S-NG	305
GC-MW-41S(8-13)	269	GC-MW27I	328
GC-MW30S-S-NG	278	GC-MW33I	512
GC-MW30S(7-16)	313	GC-MW45I	537
GC-MW11S	318	GC-MW31I(30-35)	566
GC-MW47S	367	GC-MW31I-S-NG	575
		GC-MW32I-S-NG	900
		GC-MW-32I(40-45)	941
		GC-MW07I	1461
		GC-MW11I	3041

Notes:

Excluded groundwater samples with no detected PAHs

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TABLE 5

Data and Calculations Used to Determine Total PAH Concentrations Associated with Total Suspended Solids

Gowanus Canal Feasibility Study

Brooklyn, New York

Location ID	Field ID	Sample Type	Study Loc	Wet or Dry	Total PAHs (µg/L)	TSS (mg/L)	TSS (kg/L)	PAH solids (µg/kg)	PAH solids (mg/kg)	Average PAH solids (mg/kg)
OH-005	GC-SWOH005-WW-1	N	CSO	WET	0	46	0.000046	0	0	71
OH-005	GC-SWOH005-WW-3	N	CSO	WET	2.71	19	0.000019	142632	143	
OH-006	GC-SWOH006-WW-3	N	CSO	WET	1.61	132	0.000132	12197	12	12
OH-007	**GC-SWOH007-WW-3**	**N**	**CSO**	**WET**	**2.55**	**40**	**0.00004**	**63750**	**64**	**64**
RH-031	**GC-SWRH031-WW2**	**N**	**CSO**	**WET**	**8.21**	**377**	**0.000377**	**21777**	**22**	**103**
RH-031	**GC-SWRH031-WW-3**	**N**	**CSO**	**WET**	**10.37**	**56**	**0.000056**	**185179**	**185**	
RH-033	GC-SWRH033-WW-1	N	CSO	WET	17.616	24	0.000024	734000	734	390
RH-033	GC-SWRH033-WW-3	N	CSO	WET	3.01	66	0.000066	45606	46	
RH-034	**GC-SWRH034-WW-1**	**N**	**CSO**	**WET**	**3.71**	**38**	**0.000038**	**97632**	**98**	**65**
RH-034	**GC-SWRH034-WW2**	**N**	**CSO**	**WET**	**2.32**	**70**	**0.00007**	**33143**	**33**	
RH-034	**GC-SWRH034-WW-3**	**N**	**CSO**	**WET**	**1.658**	**--**	**--**	**--**	**--**	
RH-035	**GC-SWRH035-WW2**	**N**	**CSO**	**WET**	**3.56**	**989**	**0.000989**	**3600**	**4**	**13**
RH-035	**GC-SWRH035-WW-3**	**N**	**CSO**	**WET**	**2.717**	**126**	**0.000126**	**21563**	**22**	
RH-036	GC-SWRH036-WW-1	N	CSO	WET	0	45	0.000045	0	0	19
RH-036	GC-SWRH036-WW-3	N	CSO	WET	0.69	18	0.000018	38333	38	
RH-037	GC-SWRH037-WW-1	N	CSO	WET	33.6	102	0.000102	329412	329	190
RH-037	GC-SWRH037-WW-3	N	CSO	WET	4.69	91	0.000091	51538	52	
RH-038	GC-SWRH038-WW-1	N	CSO	WET	31.45	186	0.000186	169086	169	211
RH-038	GC-SWRH038-WW-3	N	CSO	WET	8.835	35	0.000035	252429	252	

Note:

Boldface: four outfalls that account for 95% of annual discharge; range of total PAH on solids 13 - 103 mg/kg

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TABLE 6

Data and Calculations Used to Determine PAH Concentrations Associated with Total Suspended Solids

Gowanus Canal Feasibility Study

Brooklyn, New York

Location ID	Field ID	Sample Type	Study Loc	Wet or Dry	Concentration (µg/L)						TSS (mg/L)	TSS (kg/L)	BAA solids (mg/kg)	BAP solids (mg/kg)	BBF solids (mg/kg)	BKF solids (mg/kg)	DA solids (mg/kg)	ID solids (mg/kg)	Average BAA solids (mg/kg)	Average BAP solids (mg/kg)	Average BBF solids (mg/kg)	Average BKF solids (mg/kg)	Average DA solids (mg/kg)	Average ID solids (mg/kg)
					BAA	BAP	BBF	BKF	DA	ID														
OH-005	GC-SWOH005-WW-1	N	CSO	WET	0.5	0.5	0.5	0.5	0.5	0.5	46	0.000046	10.9	10.9	10.9	10.9	10.9	10.9						
OH-005	GC-SWOH005-WW-3	N	CSO	WET	0.1	0.3	0.3	0.26	0.15	0.16	19	0.000019	7.4	14.7	15.8	13.7	7.9	8.4	9.1	12.8	13.3	12.3	9.4	9.6
OH-006	GC-SWOH006-WW-3	N	CSO	WET	0.5	0.5	0.5	0.5	0.5	1.3	132	0.000132	3.8	3.8	3.8	3.8	3.8	9.8	3.8	3.8	3.8	3.8	3.8	9.8
OH-007	GC-SWOH007-WW-3	N	CSO	WET	0.2	0.1	0.3	0.25	0.16	0.15	40	0.00004	3.8	1.3	7.3	6.3	4.0	3.8	3.8	1.3	7.3	6.3	4.0	3.8
RH-031	GC-SWRH031-WW2	N	CSO	WET	0.2	0.2	0.2	0.1	0.05	0.17	377	0.000377	0.6	0.4	0.5	0.3	0.1	0.4						
RH-031	GC-SWRH031-WW-3	N	CSO	WET	0.4	0.6	0.8	0.31	0.45	0.32	56	0.000056	6.3	10.5	14.3	5.5	8.0	5.6	3.4	5.5	7.4	2.9	4.1	3.0
RH-033	GC-SWRH033-WW-1	N	CSO	WET	0.2	0.1	0.4	0.07	0.05	0.39	24	0.000024	7.9	2.1	16.3	2.8	2.1	16.3						
RH-033	GC-SWRH033-WW-3	N	CSO	WET	0.1	0.1	0.1	0.05	0.05	0.11	66	0.000066	1.7	0.8	0.8	0.8	0.8	1.6	4.8	1.4	8.5	1.8	1.4	8.9
RH-034	GC-SWRH034-WW-1	N	CSO	WET	0.5	0.5	0.9	0.26	0.5	0.95	38	0.000038	13.2	13.2	22.4	6.8	13.2	25.0						
RH-034	GC-SWRH034-WW2	N	CSO	WET	0.1	0.1	0.2	0.15	0.14	0.16	70	0.00007	0.7	0.7	2.4	2.1	2.0	2.3						
RH-034	GC-SWRH034-WW-3	N	CSO	WET	0.1	0.1	0.2	0.14	0.19	0.21	--	--	--	--	--	--	--	--	6.9	6.9	12.4	4.5	7.6	13.6
RH-035	GC-SWRH035-WW2	N	CSO	WET	0.1	0.2	0.2	0.11	0.05	0.16	989	0.000989	0.1	0.2	0.2	0.1	0.1	0.2						
RH-035	GC-SWRH035-WW-3	N	CSO	WET	0.2	0.2	0.2	0.11	0.1	0.13	126	0.000126	1.5	1.3	1.3	0.9	0.8	1.0	0.8	0.7	0.7	0.5	0.4	0.6
RH-036	GC-SWRH036-WW-1	N	CSO	WET	0.5	0.5	0.5	0.5	0.5	0.25	45	0.000045	11.1	11.1	11.1	11.1	11.1	5.6						
RH-036	GC-SWRH036-WW-3	N	CSO	WET	0.1	0.1	0.1	0.05	0.05	0.12	18	0.000018	2.8	2.8	6.1	2.8	2.8	6.7	6.9	6.9	8.6	6.9	6.9	6.1
RH-037	GC-SWRH037-WW-1	N	CSO	WET	0.5	0.5	0.5	0.5	0.5	0.25	102	0.000102	4.9	4.9	4.9	4.9	4.9	2.5						
RH-037	GC-SWRH037-WW-3	N	CSO	WET	0.1	0.3	0.4	0.14	0.28	0.28	91	0.000091	1.2	3.2	4.1	1.5	3.1	3.1	3.1	4.0	4.5	3.2	4.0	2.8
RH-038	GC-SWRH038-WW-1	N	CSO	WET	0.2	0.1	0.3	0.05	0.05	0.27	186	0.000186	1.0	0.3	1.4	0.3	0.3	1.5						
RH-038	GC-SWRH038-WW-3	N	CSO	WET	0.1	0.1	0.2	0.16	0.1	0.18	35	0.000035	3.1	1.4	6.0	4.6	2.7	5.1	2.1	0.8	3.7	2.4	1.5	3.3

Notes:

Shaded Cells - not detected; value is one half the detection limit

BAA - Benzo(a)anthracene

BAP - Benzo(a)pyrene

BBF - Benzo(b)fluoranthene

BKF - Benzo(k)fluoranthene

DA - Dibenz(a,h)anthracene

ID - Indeno(1,2,3-c,d)pyrene

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TABLE 7

Data and Calculations Used to Determine Metal Concentrations Associated with Total Suspended Solids

Gowanus Canal Feasibility Study

Brooklyn, New York

Location ID	Field ID	Sample Type	Study Loc	Wet or Dry	Total concentration (µg/L)				TSS (mg/L)	TSS (kg/L)	Ba solids (µg/kg)	Cu solids (µg/kg)	Pb solids (µg/kg)	Ni solids (µg/kg)	Ba solids (mg/kg)	Cu solids (mg/kg)	Pb solids (mg/kg)	Ni solids (mg/kg)	Average Ba solids (mg/kg)	Average Cu solids (mg/kg)	Average Pb solids (mg/kg)	Average Ni solids (mg/kg)
					Barium	Copper	Lead	Nickel														
OH-005	GC-SWOH005-WW-1	N	CSO	WET	63.7	53.7	188	9.1	46	0.000046	1384783	1167391	4086957	197826	1385	1167	4087	198	1385	1021	3391	152
OH-005	GC-SWOH005-WW-3	N	CSO	WET	R	16.6	51.2	2	19	0.000019	--	873684	2694737	105263	--	874	2695	105				
OH-006	GC-SWOH006-WW-3	N	CSO	WET	62	42	58.3	5.1	132	0.000132	469697	318182	441667	38636	470	318	442	39	470	318	442	39
OH-007	GC-SWOH007-WW-3	N	CSO	WET	37.7	37.4	56.4	5.5	40	0.00004	942500	935000	1410000	137500	943	935	1410	138	943	935	1410	138
RH-031	GC-SWRH031-WW-2	N	CSO	WET	56.1	92.2	71.3	5.5	377	0.000377	148806	244562	189125	14589	149	245	189	15	688	288	463	27
RH-031	GC-SWRH031-WW-3	N	CSO	WET	68.7	18.6	41.3	2.2	56	0.000056	1226786	332143	737500	39286	1227	332	738	39				
RH-033	GC-SWRH033-WW-1	N	CSO	WET	65.5	25.2	21.6	5.5	24	0.000024	2729167	1050000	900000	229167	2729	1050	900	229	1420	1050	502	229
RH-033	GC-SWRH033-WW-3	N	CSO	WET	7.3	R	6.8	R	66	0.000066	110606	--	103030	--	111	--	103	--				
RH-034	GC-SWRH034-WW-1	N	CSO	WET	66.2	33.2	21.9	5.7	38	0.000038	1742105	873684	576316	150000	1742	874	576	150				
RH-034	GC-SWRH034-WW-2	N	CSO	WET	109	160	146	17.6	70	0.00007	1557143	2285714	2085714	251429	1557	2286	2086	251	1650	1580	1331	201
RH-034	GC-SWRH034-WW-3	N	CSO	WET	31.3	45.4	14.6	4.3	--	--	--	--	--	--	--	--	--	--				
RH-035	GC-SWRH035-WW-2	N	CSO	WET	68.3	92.7	73.5	6.9	989	0.000989	69060	93731	74317	6977	69	94	74	7	160	177	249	16
RH-035	GC-SWRH035-WW-3	N	CSO	WET	31.6	32.7	53.4	3.2	126	0.000126	250794	259524	423810	25397	251	260	424	25				
RH-036	GC-SWRH036-WW-1	N	CSO	WET	112	127	420	10.4	45	0.000045	2488889	2822222	9333333	231111	2489	2822	9333	231	1556	1747	5022	129
RH-036	GC-SWRH036-WW-3	N	CSO	WET	11.2	12.1	12.8	0.5	18	0.000018	622222	672222	711111	27778	622	672	711	28				
RH-037	GC-SWRH037-WW-1	N	CSO	WET	69.7	51.3	15.2	5	102	0.000102	683333	502941	149020	49020	683	503	149	49	680	434	360	47
RH-037	GC-SWRH037-WW-3	N	CSO	WET	61.5	33.2	51.9	4.1	91	0.000091	675824	364835	570330	45055	676	365	570	45				
RH-038	GC-SWRH038-WW-1	N	CSO	WET	83.8	42.3	38.3	4.3	186	0.000186	450538	227419	205914	23118	451	227	206	23	647	407	476	49
RH-038	GC-SWRH038-WW-3	N	CSO	WET	29.5	20.5	26.1	2.6	35	0.000035	842857	585714	745714	74286	843	586	746	74				

Notes:

Shaded Cells - not detected; value is one half the detection limit

R - rejected result; value not used in calculation

Ba - barium

Cu - copper

Pb - lead

Ni - nickel

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TABLE 8

Average Total PAH and Carcinogenic PAH concentrations on Suspended Sediment and Annual CSO Discharge Volumes

Gowanus Canal Feasibility Study

Brooklyn, New York

Location ID	Annual CSO Discharge Volume (MG)	% Annual CSO Discharge	Average Total PAH Wet Weather Solids (mg/kg)	Average BAA Solids (mg/kg)	Average BAP Solids (mg/kg)	Average BBF Solids (mg/kg)	Average BKF Solids (mg/kg)	Average DA Solids (mg/kg)	Average ID Solids (mg/kg)
RH-034	121	34%	65	6.9	6.9	12.4	4.5	7.6	13.6
RH-033	0.2	0.06%	390	4.8	1.4	8.5	1.8	1.4	8.9
RH-038	0.9	0.26%	211	2.1	0.8	3.7	2.4	1.5	3.3
RH-037	0.5	0.14%	190	3.1	4.0	4.5	3.2	4.0	2.8
RH-036	1.6	0.45%	19	6.9	6.9	8.6	6.9	6.9	6.1
OH-005	0.7	0.20%	71	9.1	12.8	13.3	12.3	9.4	9.6
OH-007	69	20%	64	3.8	1.3	7.3	6.3	4.0	3.8
RH-035	111	31%	13	0.8	0.7	0.7	0.5	0.4	0.6
RH-031	35	10%	103	3.4	5.5	7.4	2.9	4.1	3.0
OH-006	13	3.7%	12	7.4	14.7	15.8	13.7	7.9	8.4
Total	352.9	100%							

Note:

Shaded rows indicate outfalls that contribute 95 percent of the total annual discharge to the canal.

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TABLE 9

Average Metal Concentrations on Suspended Sediment and Annual CSO Discharge Volumes

Gowanus Canal Feasibility Study

Brooklyn, New York

Location ID	Annual CSO Discharge Volume (MG)	% Annual CSO Discharge	Average Ba Solids (mg/kg)	Average Cu Solids (mg/kg)	Average Pb Solids (mg/kg)	Average Ni Solids (mg/kg)
RH-034	121	34%	1650	1580	1331	201
RH-033	0.2	0.06%	1420	1050	502	229
RH-038	0.9	0.26%	647	407	476	49
RH-037	0.5	0.14%	680	434	360	47
RH-036	1.6	0.45%	1556	1747	5022	129
OH-005	0.7	0.20%	1385	1021	3391	152
OH-007	69	20%	943	935	1410	138
RH-035	111	31%	160	177	249	16
RH-031	35	10%	688	288	463	27
OH-006	13	3.7%	470	318	442	39
Total	352.9	100%				

Note:

Shaded rows indicate outfalls that contribute 95 percent of the total annual discharge to the canal.

Ba - barium

Cu - copper

Pb - lead

Ni - nickel

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TABLE 10

Range of Estimated PAH Concentrations on CSO Solids Discharged to Gowanus Canal

Gowanus Canal Feasibility Study

Brooklyn, New York

	Concentration (mg/kg)						
CSO wet weather solids[1]	Total PAHs	BAA	BAP	BBF	BKF	DA	ID
Lower bound	13	0.8	0.7	0.7	0.5	0.4	0.6
Upper bound	103	6.9	6.9	12.4	6.3	7.6	13.6

Notes:

BAA - benzo(a) anthracene, BAP - benzo(a)pyrene, BBF - benzo(b)fluoranthene, BKF - benzo(k)fluoranthene, DA - dibenz(a,h)anthracene, ID - indeno(1,2,3-c,d)pyrene

[1] Based on CSO wet weather data for the four outfalls that account for 95 percent of the annual CSO discharge

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TABLE 11

Range of Estimated Metals Concentrations on CSO Solids Discharged to Gowanus Canal

Gowanus Canal Feasibility Study

Brooklyn, New York

CSO wet weather solids[1]	Concentration (mg/kg)			
	Ba	**Cu**	**Pb**	**Ni**
Lower bound	160	177	249	16.2
Upper bound	1650	1580	1410	201

Notes:

[1] Based on CSO wet weather data for the four outfalls that account for 95 percent of the annual CSO discharge

Ba - barium

Cu - copper

Pb - lead

Ni - nickel

Appendix C
Development of Remediation Goals

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Appendix C.1
Development of Preliminary Remediation Goals

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Development of Preliminary Remediation Goals

This appendix describes the development of ecological and human health-based preliminary remediation goals (PRGs) for the Gowanus Canal Feasibility Study (FS).

1. Ecological Preliminary Remediation Goals

PRGs were determined for two receptor groups and associated exposure pathways:

- Benthic organisms through direct toxicity (total PAHs)
- Herbivorous birds through dietary exposure (total PAHs)

The development of PRGs for each receptor group is described below.

Although the BERA concluded that mercury poses a site-related risk to omnivorous birds, closer examination of the data indicates that exposures to mercury are similar in the Gowanus Canal and the Gowanus Bay and Upper New York Bay reference area. Omnivorous bird exposure occurs via ingestion of sediment, benthic invertebrates, small prey fish, and aquatic plants. Table 1 compares the measured sediment, benthic invertebrate, small prey fish, and calculated aquatic plant mercury concentrations from the data set used in the baseline ecological risk assessment (BERA). The comparison shows that the ranges of concentrations overlap between the site and reference area and that the mean concentrations are similar. Therefore, if the BERA had calculated risk estimates for the Gowanus Bay and Upper New York Bay reference area, the results would be similar to what was calculated for Gowanus Canal, indicting no site-related risk to omnivorous birds from mercury. Therefore, a PRG specifically for the protection of omnivorous birds from exposure to mercury was not developed. However, it is expected that the remediation target areas that are developed based on the PRGs for PAHs will also address site-related mercury.

1.1 Total PAH PRG for the Protection of Benthic Organisms

PRGs for total PAHs protective of benthic organisms were derived through an analysis of the toxicity test and colocated sediment chemistry results to identify the highest total PAH concentration that did not result in unacceptable effects. Sediment toxicity data were available from the remedial investigation (RI) (USEPA, 2011) for two test species. Survival and growth of the polychaete *Nereis virens* and survival, growth, and reproduction of the amphipod *Leptocheirus plumulosus* were measured in sediment samples from 17 locations, five of which were selected to represent reference conditions. Laboratory control sediment was also used in each test. Test results are summarized in Table 2.

Two samples, from locations 326 (reference) and 313 (canal), were excluded from any further analysis. As documented in the RI, the sample from reference location 326 had a greater number and magnitude of exceedances of screening values for metals than the other reference locations. In addition, each amphipod toxicity test endpoint was reduced relative to the other reference samples. The sample from Gowanus Canal location 313 had one of the lowest concentrations of total PAHs but showed reduced amphipod survival and growth. Although it was not possible to determine the cause of toxicity in this sample, it appeared unlikely that significant toxicity would have resulted from the total PAH concentration in the sample. The sample also had the greatest measured total organic carbon (TOC) content, indicating the potential for the toxicity to be from some confounding factor such as ammonia or sulfides.

Two approaches were used to derive potential PRGs for total PAHs. First, graphical plots of each toxicity test endpoint versus the total PAH concentration and the TOC-normalized total PAH concentration were evaluated (Figure 1 through Figure 5). Plots were prepared for TOC-normalized total PAHs to account for the effect of TOC on the bioavailability of the PAHs and its potential to influence the total PAH dose-response curve. For these plots, all results were normalized to the laboratory control and presented as the percent of control. Included on each plot is a horizontal line (green) representing the lowest toxicity test result for a reference sample (considered the lower bound of the reference envelope). Also included on each plot is a line (black dashed) representing a 20 percent reduction in test result relative to the control.

The PRG was determined by first identifying the lowest concentration that was outside the lower of the two horizontal lines (i.e., the lowest adverse effect level), and then selecting the total PAH concentration immediately below that (the greatest no observed adverse effect concentration, or NOAEC). The results are presented in Table 3. The potential PRGs ranged from 289 mg/kg dry weight (dw) for polychaete survival and growth to 4.4 mg/kg organic carbon (OC) dw for amphipod growth and reproduction.

The recommended sediment PRG for the protection of benthic organisms is 7.8 mg total PAH/kg dw. This value is the greatest no-effect level for the most sensitive toxicity test endpoints (amphipod growth and reproduction). This value is the lowest dry weight PAH concentration that did not cause unacceptable adverse effects in the toxicity tests. The PRG was selected based on dry weight concentration rather than TOC-normalized concentration because the dose-response relationship of dry weight PAH concentration with the amphipod growth and reproduction endpoints appeared to be more predictive than the TOC-normalized dose-response relationships for these endpoints, particularly at the lower end of the concentration range (Figures 4 and 5).

The second approach used to derive PRGs was to estimate a total PAH concentration associated with a various percent reductions in response. Toxicity Response Analysis Program (TRAP) software, version 1.2 (http://www.epa.gov/med/Prods_Pubs/trap.htm), was used to fit a model to the data so that the effects concentrations could be determined. Because the polychaete endpoints had lower responses (with no treatments having 100 percent mortality or zero growth) than the amphipods, this analysis focused on the amphipod test data alone.

A 20 percent effects concentration (EC_{20}) is typically considered a chronic response threshold and could be an appropriate PRG. TRAP estimates of EC_{20} concentrations ranged from 72 mg/kg dw total PAH for the survival endpoint to 12.3 mg/kg dw for the growth endpoint (Table 4). The 95 percent confidence intervals around these estimates were large, indicating high variability of the dose-response relationships; none of the relationships was statistically significant. Therefore, the TRAP results were used only to verify the PRGs developed using the graphical approach.

To ensure that target areas for remediation based on the total PAH PRG would also be protective of effects from metals and PCBs, the total PAH concentrations were compared with total PCB (based total PCB from congener analysis) and concentrations of metals that were identified as potential risk drivers in the RI (barium, cadmium, copper, lead, mercury, nickel and silver) (Figures 6 through 13). On each figure, the selected PRG for total PAH is indicated with a horizontal line, and the effects-range low (ER-L) and effects-range median (ER-M) values (Buchman, 2008) for the metal or PCB are indicated with vertical lines. Only locations where toxicity tests were performed are shown on the figures (11 canal and 4 reference locations). These plots show that removal of canal sediments with greater than 7.8 mg/kg total PAH would also remove potentially toxic levels (based on the ER-M) of the metals and PCBs. It should be noted that concentrations of mercury and PCBs in reference locations were greater than the ER-M, while total PAH concentrations were near or below the total PAH PRG. Note that PCB data from the congener analysis were unavailable for two of the reference locations.

1.2 Total PAH PRG for the Protection of Herbivorous Birds

A PRG for total PAHs protective of herbivorous birds was derived using the food web model developed for the RI. The model was used to estimate the concentration of total PAHs in sediment that would not pose unacceptable risk to waterfowl eating aquatic plants in the Gowanus Canal. Based on the input parameters used in the RI, a total PAH concentration of 226 mg/kg dw would not pose unacceptable risk and could serve as a PRG.

2. Human Health Preliminary Remediation Goals

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

PRGs were not calculated for carcinogenic PAHs for exposure to sediment that overtops the canal during significant storm events for lifetime (child/adult) residents because sediment remediation based on the recreational use scenario will also address potential risks from exposure to sediment and surface water during a canal overflow event.

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

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

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

Where:

EPC = exposure point concentration (mg/kg)

Target Risk Level = a target risk level of 10^{-5} was chosen so that the cumulative risk from exposure to all six carcinogenic PAHs would be less than 10^{-4}, which is the upper bound of USEPA's acceptable risk range

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

The PRGs for surface sediment and surface water are calculated in Tables 5 and 6, respectively.

3. References

Buchman, M.F. 2008. NOAA Screening Quick Reference Tables. *NOAA OR&R Report 08-1.* Office of Response and Restoration Division, National Oceanic and Atmospheric Administration. Seattle, WA. 34 pp.

USEPA (U.S. Environmental Protection Agency). 2011. *Draft Gowanus Canal Remedial Investigation Report.* January.

TABLE 1

Comparison of Concentrations in Exposure Media for Omnivorous Birds Between Gowanus Canal and Reference Area Samples

Gowanus Canal Feasibility Study

Brooklyn, New York

Exposure Media	Mercury Concentration					
	Gowanus Canal			Reference Area		
	Min	Max	Mean	Min	Max	Mean
Sediment (mg/kg dw)	0.59	2.3	1.27	0.16	3.7	1.12
Benthic Invertebrate (mg/kg ww)[a]	0.079	0.142	0.115	0.085	0.316	0.168
Small Prey Fish (mg/kg ww)	0.072	0.1	0.087	0.076	0.089	0.083
Aquatic Plant (mg/kg dw)[b]	0.202	0.791	0.437	0.055	1.27	0.385

Notes:

All data from the Gowanus Canal Remedial Investigation report

[a] Whole body blue crab

[b] Aquatic plant tissue concentrations were estimated using sediment data and bioconcentration factor of 0.344

dw - dry weight

ww - wet weight

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TABLE 2

Summary of Whole Sediment Total PAH Concentrations and Colocated Sediment Toxicity Test Results

Gowanus Canal Feasibility Study

Brooklyn, New York

						Polychaete				Amphipod					
Area	**Station**	**Total PAHs mg/kg**	**TOC mg/kg**	**Fraction TOC**	**Total PAHs mg/kg OC**	**Survival (%)**	**Percent of Control**	**Growth (Wet Biomass - g/organism)**	**Percent of Control**	**Survival (%)**	**Percent of Control**	**Growth (Dry Biomass - mg/organism)**	**Percent of Control**	**Reproduction (# of Juveniles/ Female)**	**Percent of Control**
Canal	315	6,670.0	81,800	0.08	81,540	71.3%	73.1%	1.79	63.1%	0.0%	0.0%		0.0%		0.0%
	314	3,559.0	109,000	0.11	32,651	75.0%	80.0%	2.24	79.0%	0.0%	0.0%		0.0%		0.0%
	319	289.0	49,300	0.05	5,862	97.5%	100.0%	2.76	97.3%	53.8%	66.2%	0.175	16.5%	0	0.0%
	318	236.0	94,900	0.09	2,487	86.3%	88.5%	2.53	89.2%	35.6%	43.8%	0.105	9.9%	0	0.0%
	310	66.9	94,600	0.09	707	83.8%	85.9%	2.67	94.1%	27.5%	33.8%	0.13	12.3%	0	0.0%
	303	39.4	73,100	0.07	539	87.5%	89.7%	2.668	94.0%	81.3%	100.1%	0.886	83.7%	1.58	32.5%
	321	33.9	51,100	0.05	663	92.5%	94.9%	2.66	93.8%	68.8%	84.7%	0.418	39.5%	0.47	9.7%
	307A	29.1	43,000	0.04	677	93.8%	96.2%	3.21	113.1%	79.4%	97.7%	0.576	54.4%	0.87	17.9%
	307B	28.7	54,400	0.05	528	87.5%	90.0%	2.58	90.9%	70.0%	90.0%	0.645	61.0%	2.2	45.0%
	324	16.4	35,000	0.04	469	87.5%	89.7%	2.82	99.4%	85.6%	105.4%	0.666	62.9%	0.88	18.1%
	309	13.8	45,000	0.05	307	85.0%	90.0%	2.65	93.4%	86.3%	106.2%	0.643	60.8%	0.96	19.8%
Reference	328	7.8	22,500	0.02	348	85.0%	90.0%	2.582	91.0%	75.0%	90.0%	0.797	75.3%	3.56	73.3%
	333	4.4	26,400	0.03	167	85.0%	90.0%	2.756	97.1%	76.8%	94.5%	0.673	63.6%	2.45	50.4%
	330	4.2	34,500	0.03	122	87.5%	90.0%	2.689	94.8%	91.9%	113.1%	1.096	103.6%	5.24	107.8%
	329	3.4	29,500	0.03	116	85.0%	90.0%	2.251	79.3%	90.6%	111.5%	0.791	74.8%	2.12	43.6%

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TABLE 3

Potential Total PAH Preliminary Remediation Goals Based on Comparison of Toxicity Test Results to Reference and Control

Gowanus Canal Feasibility Study

Brooklyn, New York

Test Species	Endpoint	Based on Dry Weight Plot		Based on OC Normalized Plot	
		Sample	PRG (mg/kg dw)	Sample	PRG (mg/kg dw)
Polychaete					
	Survival	319	289	319	289
	Growth	319	289	319	289
Amphipod					
	Survival	303	39	303	39
	Growth	328	7.8	333	4.4
	Reproduction	328	7.8	333	4.4

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TABLE 4

Results of Total PAH Dose Response Models for the Amphipod

Gowanus Canal Feasibility Study

Brooklyn, New York

	Survival		Growth		Reproduction	
Response	**Total PAHs mg/kg dw**	**95% CI**	**Total PAHs mg/kg dw**	**95% CI**	**Total PAHs mg/kg dw**	**95% CI**
EC_{50}	191.1	(48.6-751.8)	37.2	(8.4-164.9)	23.9	(10.7-53.2)
EC_{20}	72.0	(6.4-814.2)	12.3	(0.5-293.6)	15.1	(3.2-70.4)
EC_{10}	40.7	(1.5-1114.3)	6.5	(0.09-452.2)	11.5	(1.5-87.3)
EC_{5}	24.1	(0.4-1561.1)	3.6	0.02-684.5)	9.0	(0.8-107.5)

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TABLE 5

Calculation of Human Health PRGs for Sediment

Gowanus Canal Feasibility Study

Brooklyn, New York

Surface Sediment—exposed and nearshore sediment in Gowanus Canal; Recreational Adult/Adolescent/Child

Chemical	Exposure Point Concentration (MG/KG)	Carcinogenic Risk				RGO - 10^{-6} (MG/KG)	PRG - 10^{-5} (MG/KG)
		Inh	Ing	Der	Total		
Benzo(a)anthracene	1.3E+02	--	2.3E-05	3.0E-05	5.3E-05	2.4E+00	2.4E+01
Benzo(a)pyrene	1.1E+02	--	1.9E-04	2.5E-04	4.4E-04	2.4E-01	2.4E+00
Benzo(b)fluoranthene	1.1E+02	--	2.0E-05	2.6E-05	4.7E-05	2.4E+00	2.4E+01
Benzo(k)fluoranthene	6.5E+01	--	1.2E-06	1.5E-06	2.7E-06	2.4E+01	2.4E+02
Dibenz(a,h)anthracene	6.2E+00	--	1.1E-05	1.4E-05	2.6E-05	2.4E-01	2.4E+00
Indeno(1,2,3-c,d)pyrene	4.9E+01	--	8.8E-06	1.1E-05	2.0E-05	2.4E+00	2.4E+01

For carcinogens: PRG = (Exposure Point Concentration x Target Risk Level)/ Calculated Cancer Risk

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TABLE 6

Calculation of Human Health PRGs for Surface Water

Gowanus Canal Feasibility Study

Brooklyn, New York

Surface Water—direct contact with surface water in Gowanus Canal; Recreational Adult/Adolescent/Child
(Wet weather surface water data used to calculate PRGs; however, PRGs will be the same for either dry or wet weather)

Chemical	Exposure Point Concentration (MG/L)	Carcinogenic Risk				RGO - 10^{-6} (MG/KG)	PRG - 10^{-5} (MG/L)
		Inh	Ing	Der	Total		
Benzo(a)anthracene	1.0E-01	--	2.7E-08	5.9E-06	5.9E-06	1.8E-02	1.8E-01
Benzo(a)pyrene	2.1E-01	--	5.4E-07	1.9E-04	1.9E-04	1.1E-03	1.1E-02
Benzo(b)fluoranthene	1.9E-01	--	5.0E-08	1.8E-05	1.8E-05	1.1E-02	1.1E-01
Dibenz(a,h)anthracene	1.0E-01	--	2.7E-07	1.5E-04	1.5E-04	6.7E-04	6.7E-03
Indeno(1,2,3-c,d)pyrene	5.0E-01	--	1.3E-07	4.6E-05	4.6E-05	1.1E-02	1.1E-01

For carcinogens: PRG = (Exposure Point Concentration x Target Risk Level)/ Calculated Cancer Risk

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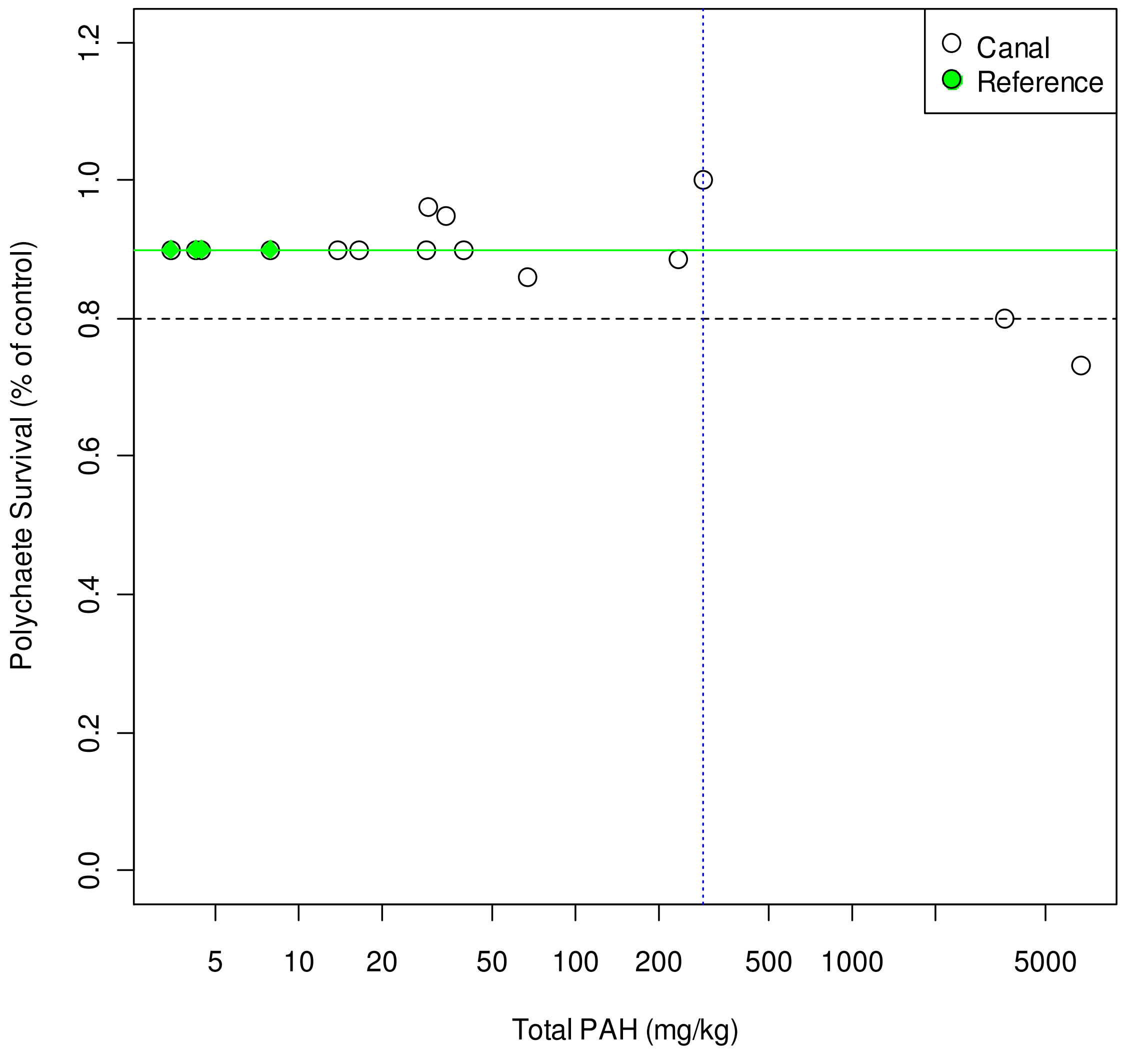

FIGURE 1a
The Relationship Between Polychaete Survival and Total PAHs – Dry Weight Basis
Gowanus Canal Feasibility Study
Brooklyn, New York

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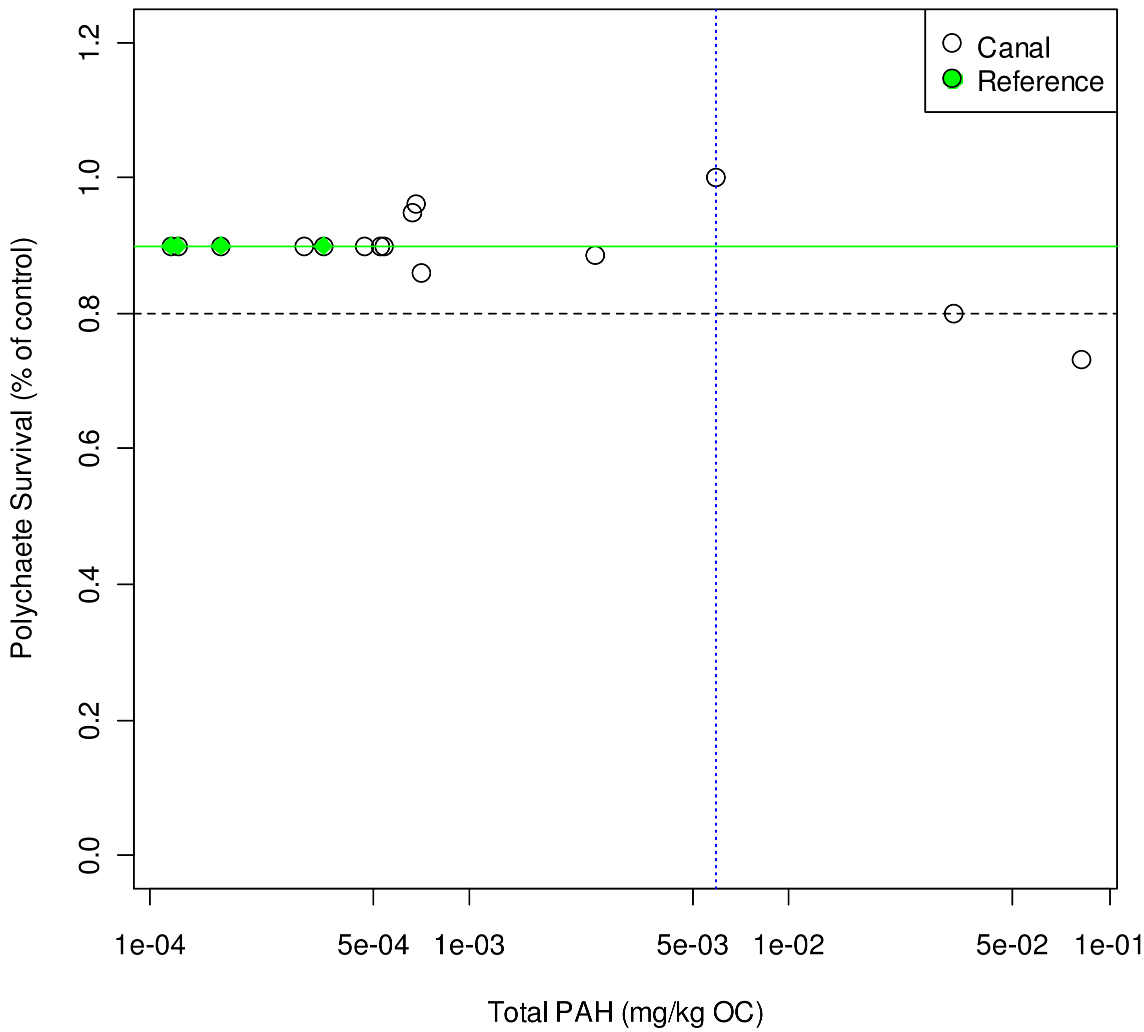

FIGURE 1b
The Relationship Between Polychaete Survival and Total PAHs – Organic Carbon Normalized
Gowanus Canal Feasibility Study
Brooklyn, New York

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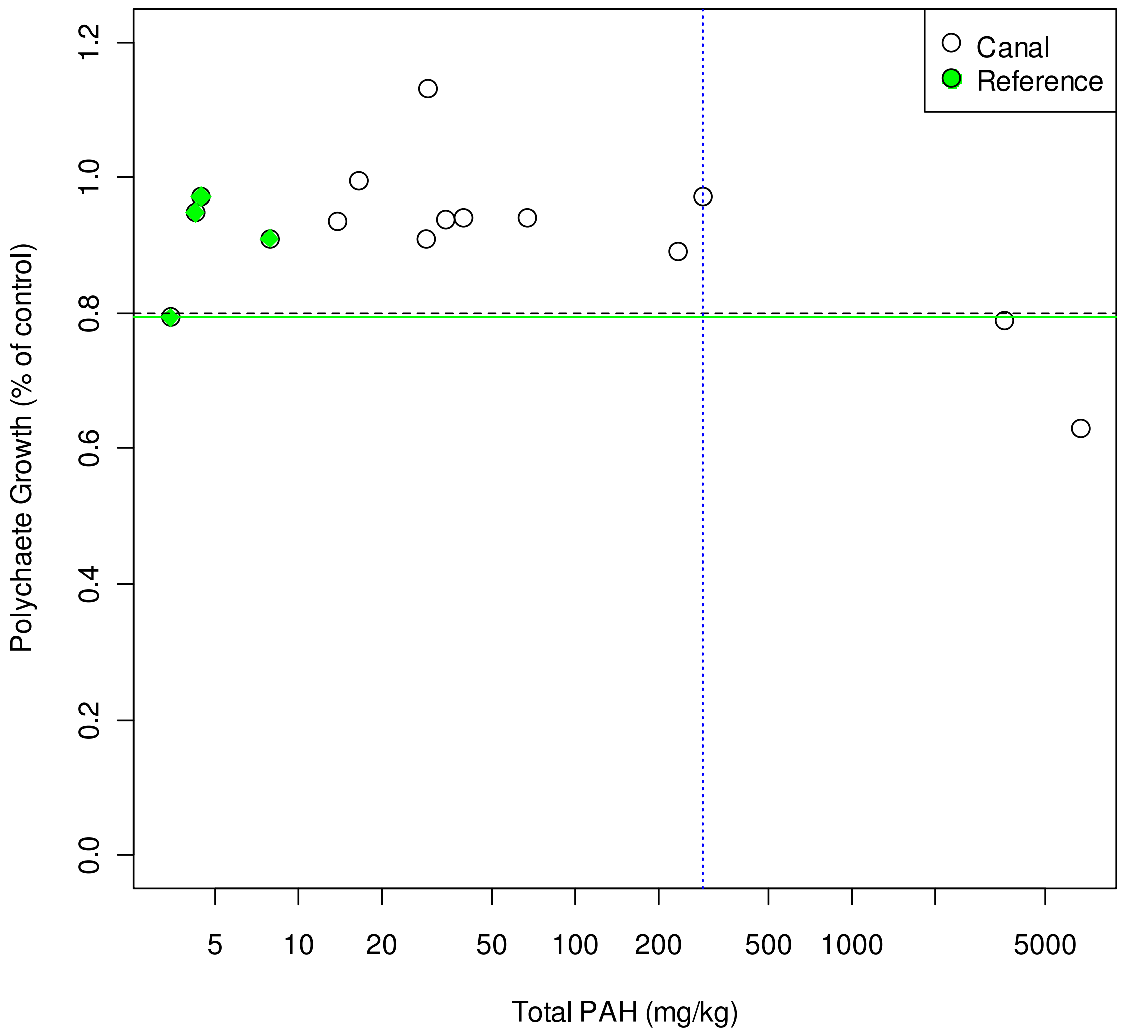

FIGURE 2a
The Relationship Between Polychaete Growth and Total PAHs – Dry Weight Basis
Gowanus Canal Feasibility Study
Brooklyn, New York

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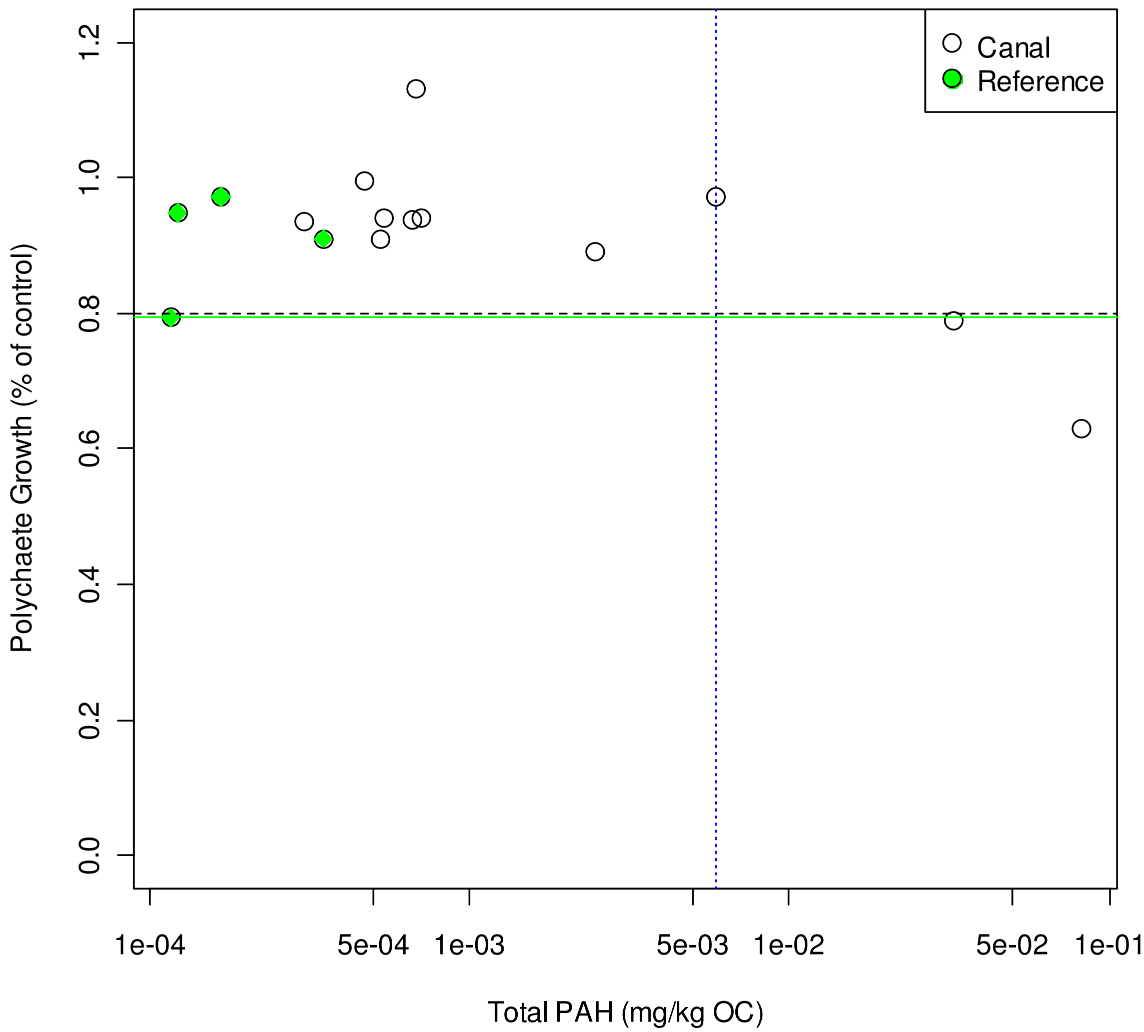

FIGURE 2b
The Relationship Between Polychaete Growth and Total PAHs – Organic Carbon Normalized
Gowanus Canal Feasibility Study
Brooklyn, New York

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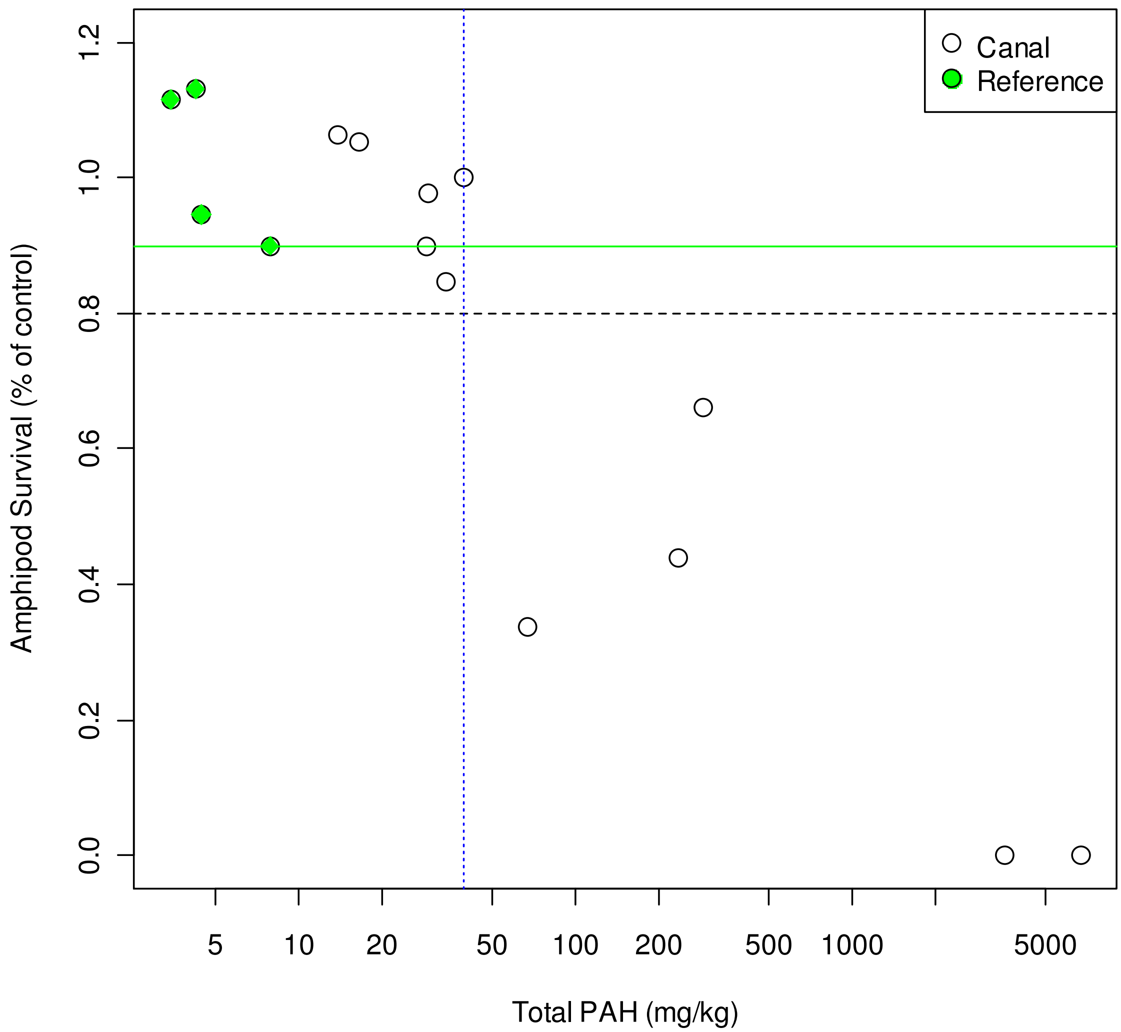

FIGURE 3a
The Relationship Between Amphipod Survival and Total PAHs – Dry Weight Basis
Gowanus Canal Feasibility Study
Brooklyn, New York

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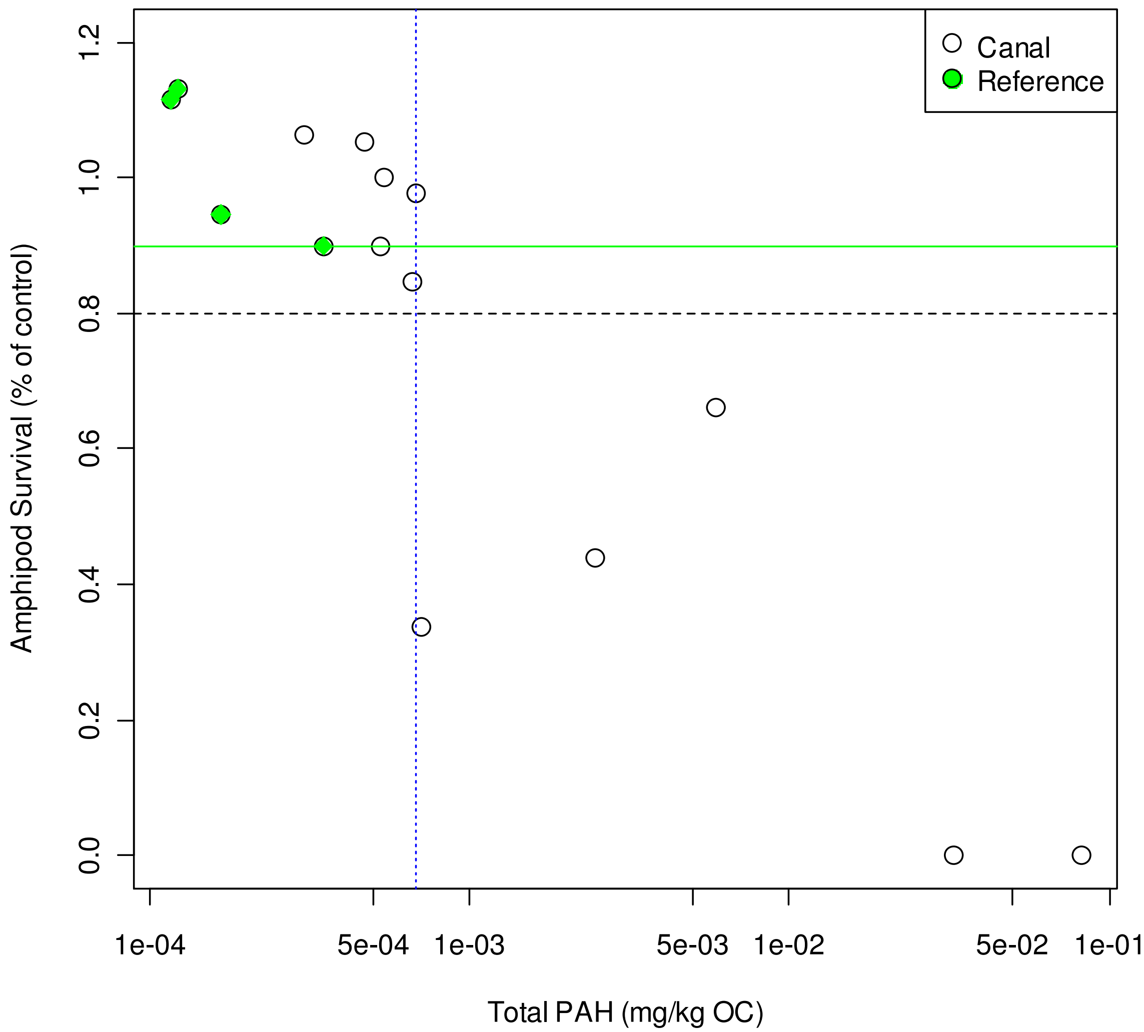

FIGURE 3b
The Relationship Between Amphipod Survival and Total PAHs – Organic Carbon Normalized
Gowanus Canal Feasibility Study
Brooklyn, New York

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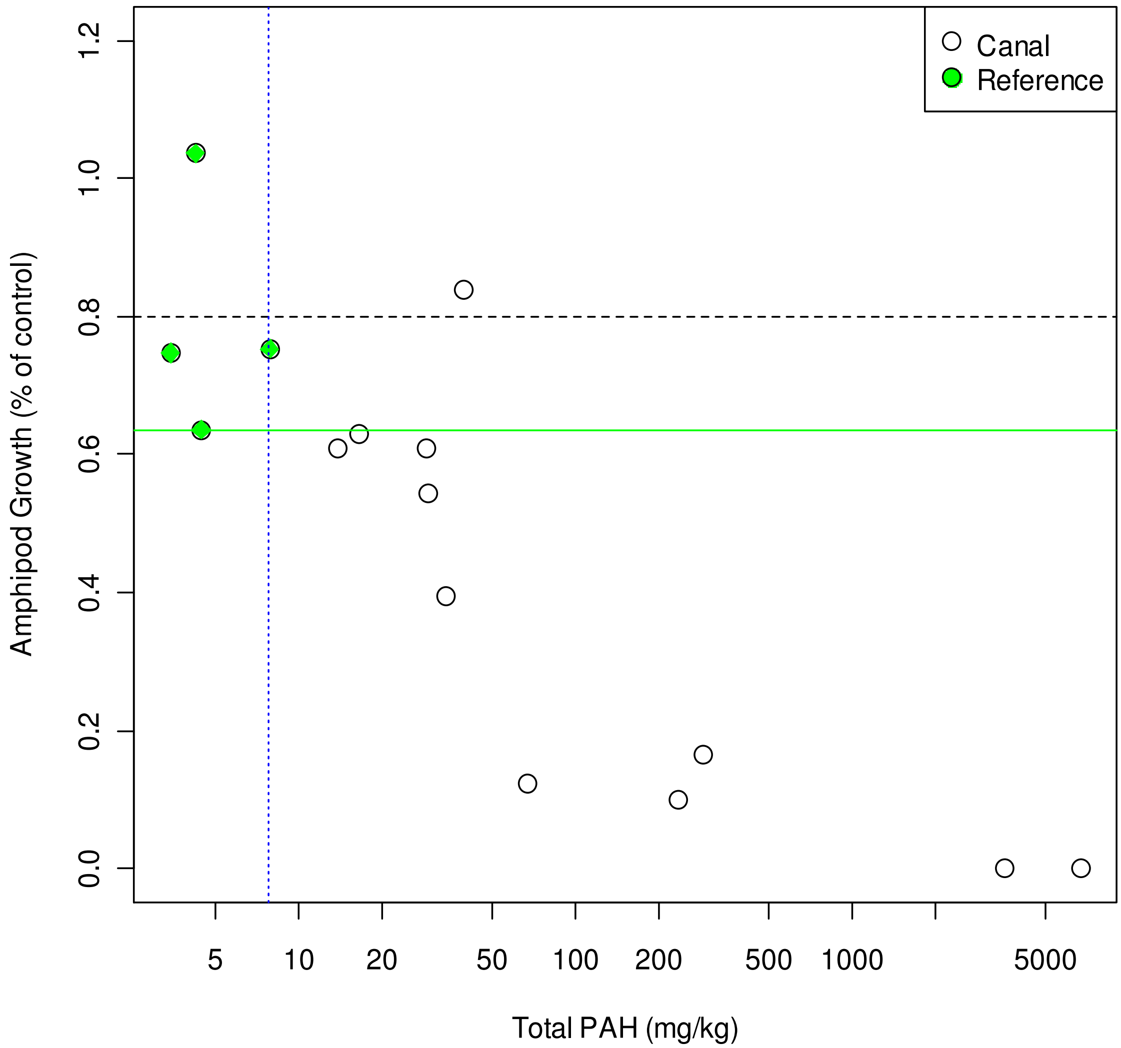

FIGURE 4a
The Relationship Between Amphipod Growth and Total PAHs – Dry Weight Basis
Gowanus Canal Feasibility Study
Brooklyn, New York

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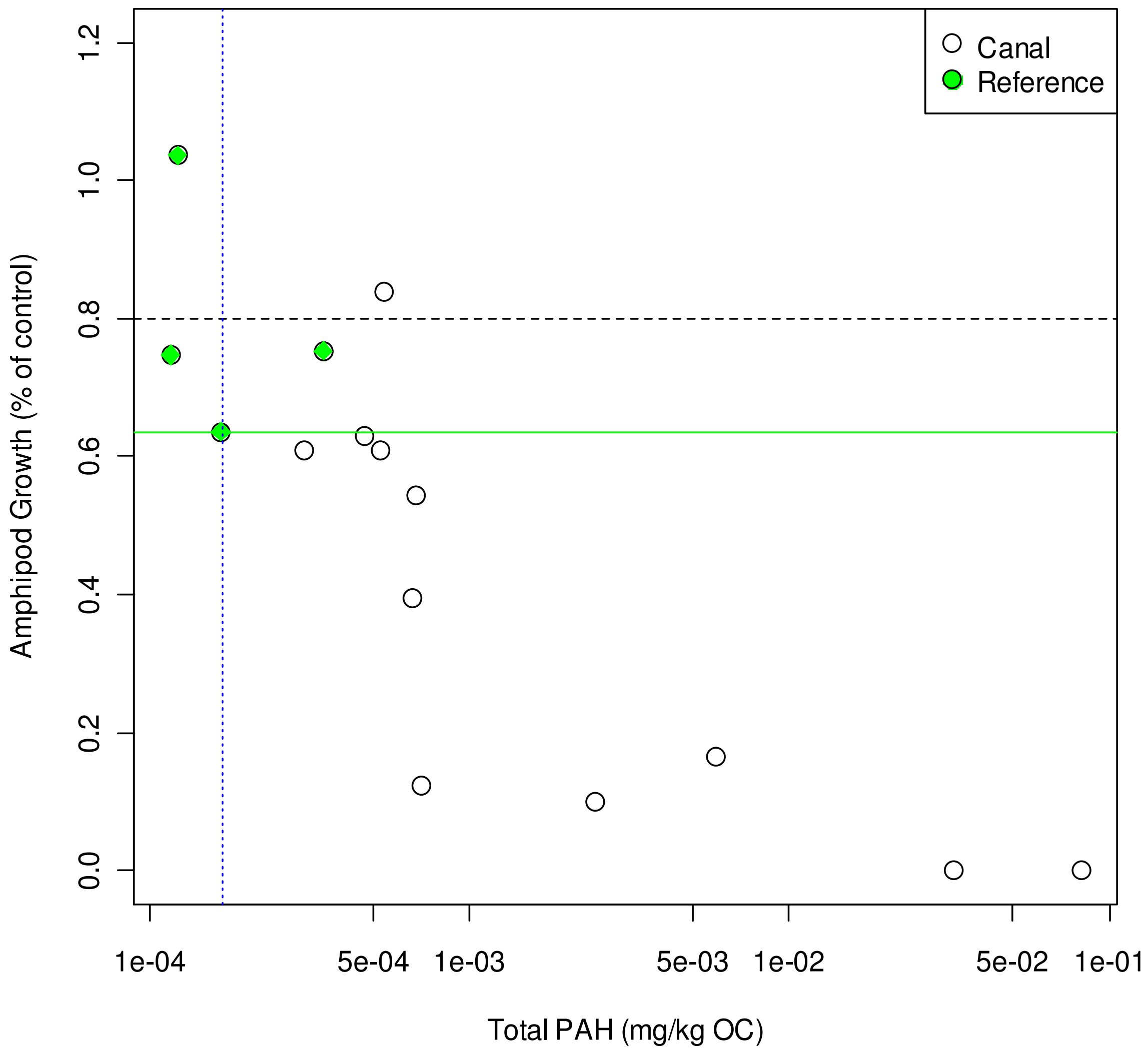

FIGURE 4b
The Relationship Between Amphipod Growth and Total PAHs – Organic Carbon Normalized
Gowanus Canal Feasibility Study
Brooklyn, New York

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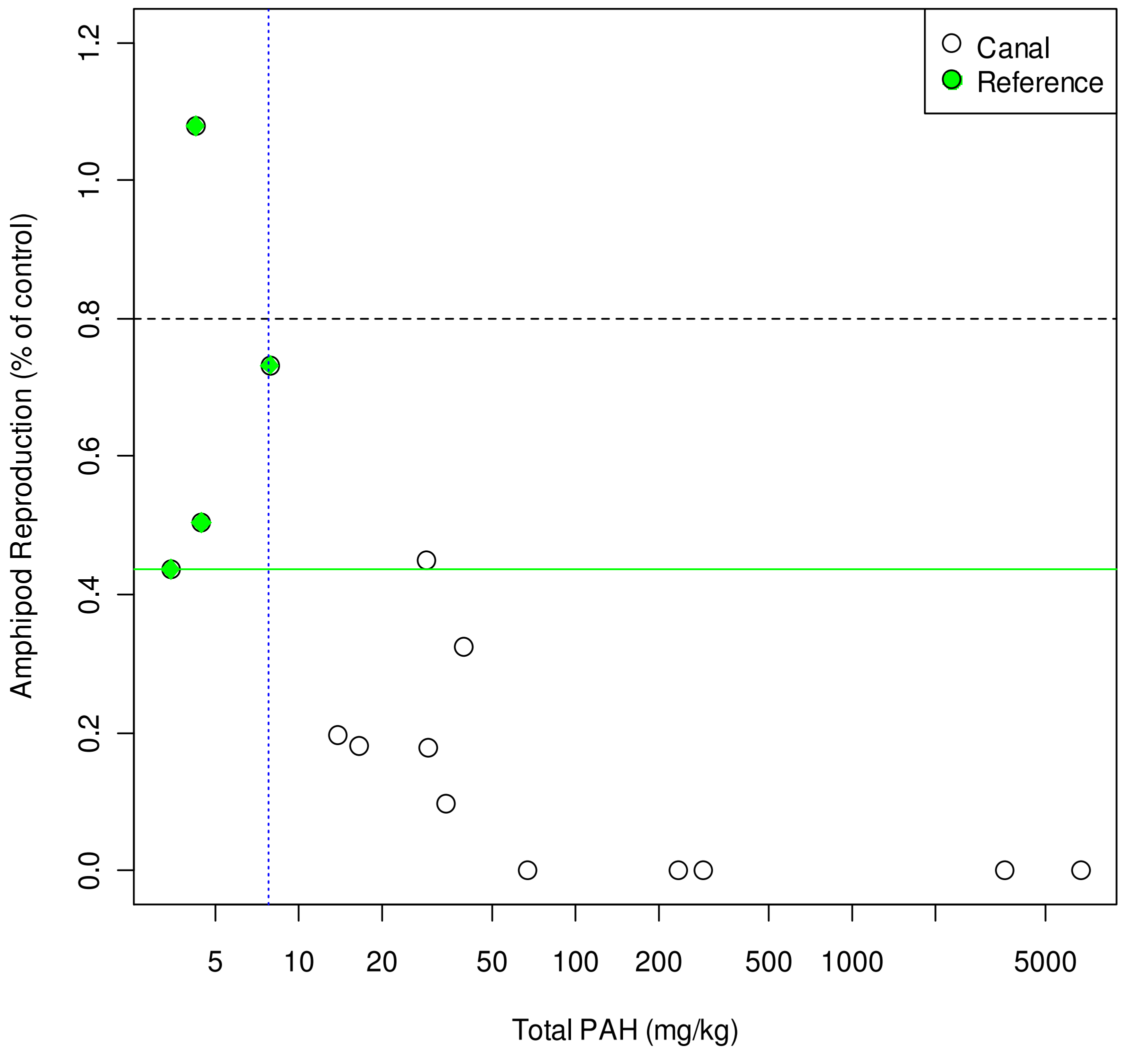

FIGURE 5a
The Relationship Between Amphipod Reproduction and Total PAHs – Dry Weight Basis
Gowanus Canal Feasibility Study
Brooklyn, New York

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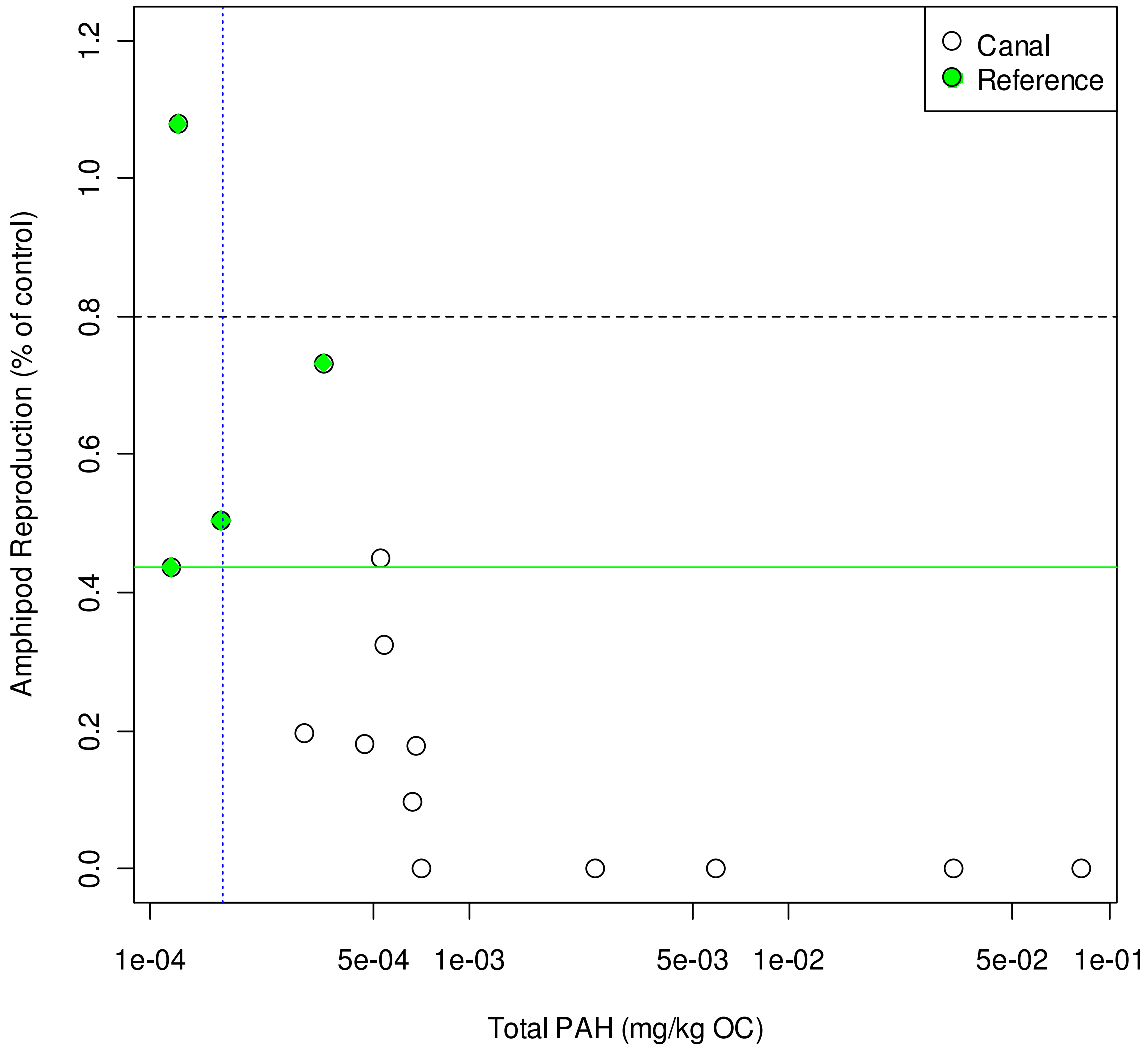

FIGURE 5b
The Relationship Between Amphipod Reproduction and Total PAHs – Organic Carbon Normalized
Gowanus Canal Feasibility Study
Brooklyn, New York

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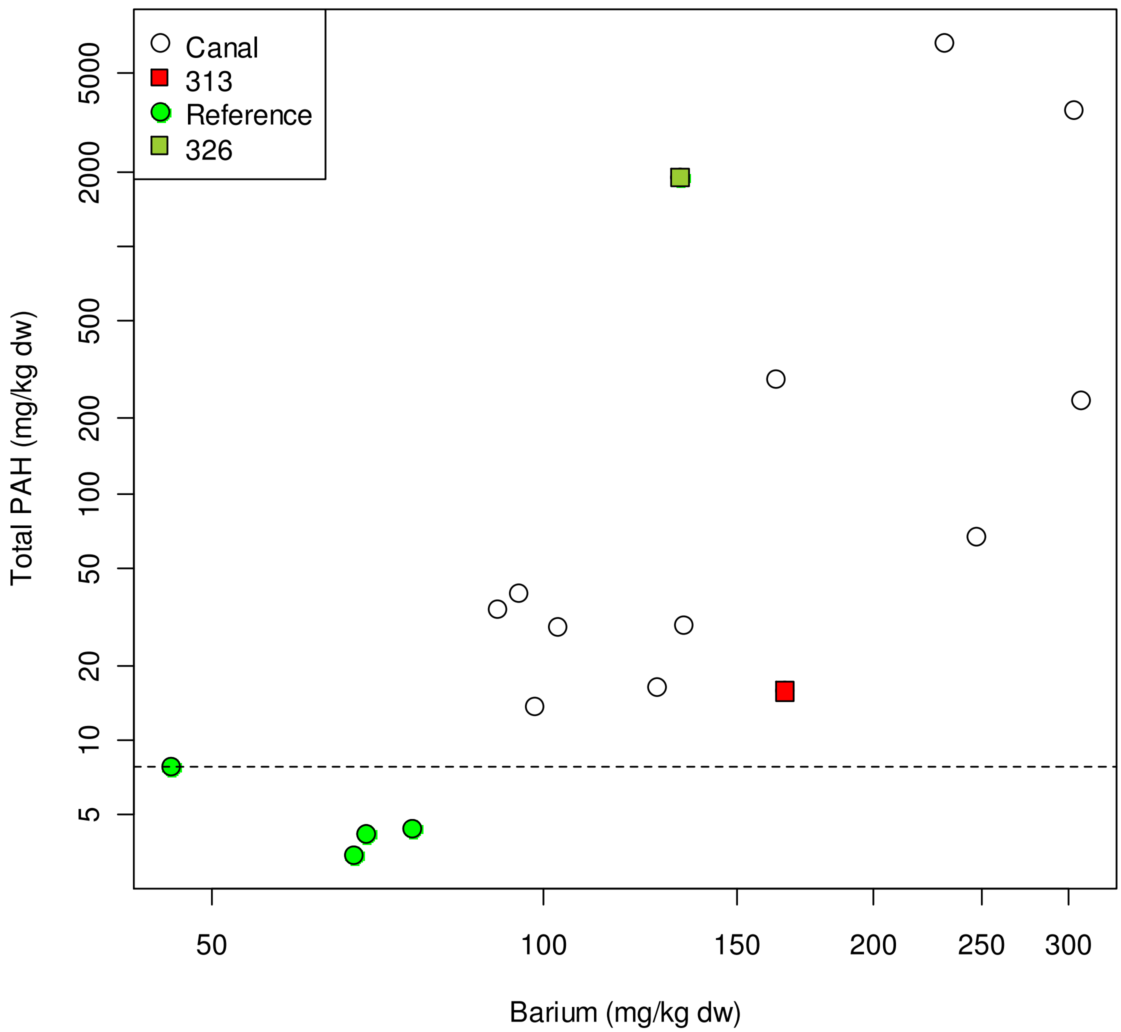

FIGURE 6
Comparison of Total PAH Concentrations and Barium Concentrations
Gowanus Canal Feasibility Study
Brooklyn, New York

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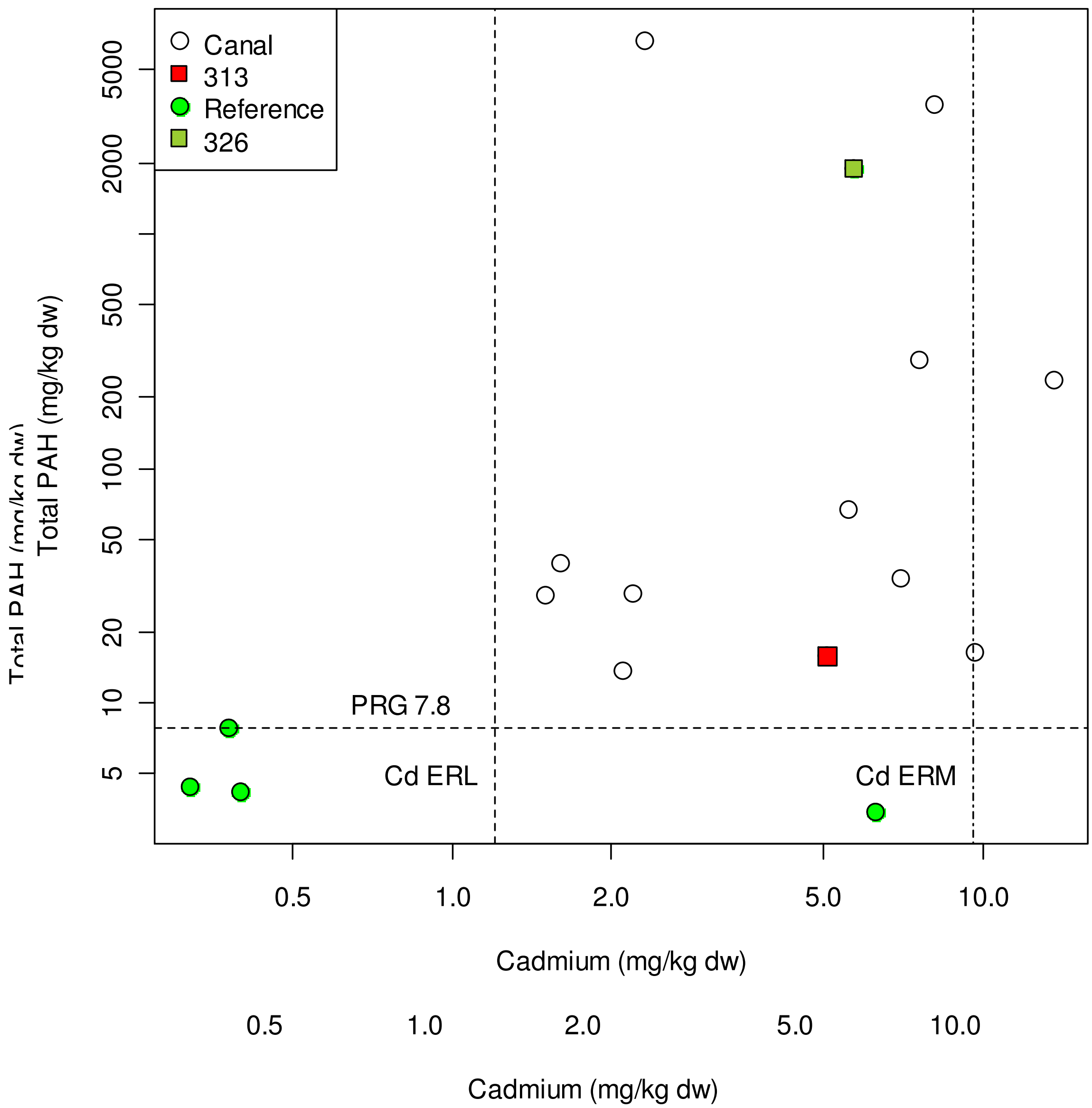

FIGURE 7
Comparison of Total PAH Concentrations and Cadmium Concentrations
Gowanus Canal Feasibility Study
Brooklyn, New York

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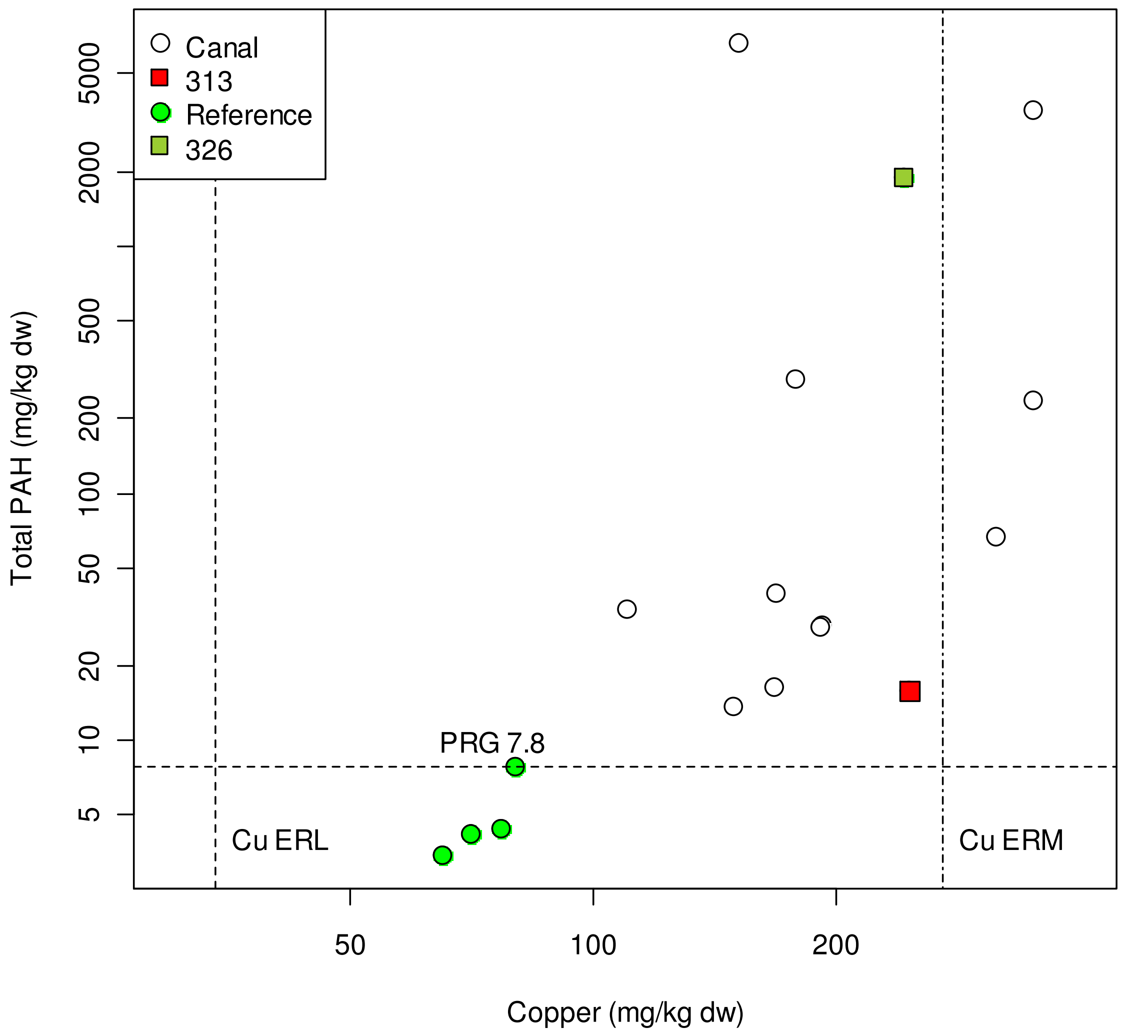

FIGURE 8
Comparison of Total PAH Concentrations and Copper Concentrations
Gowanus Canal Feasibility Study
Brooklyn, New York

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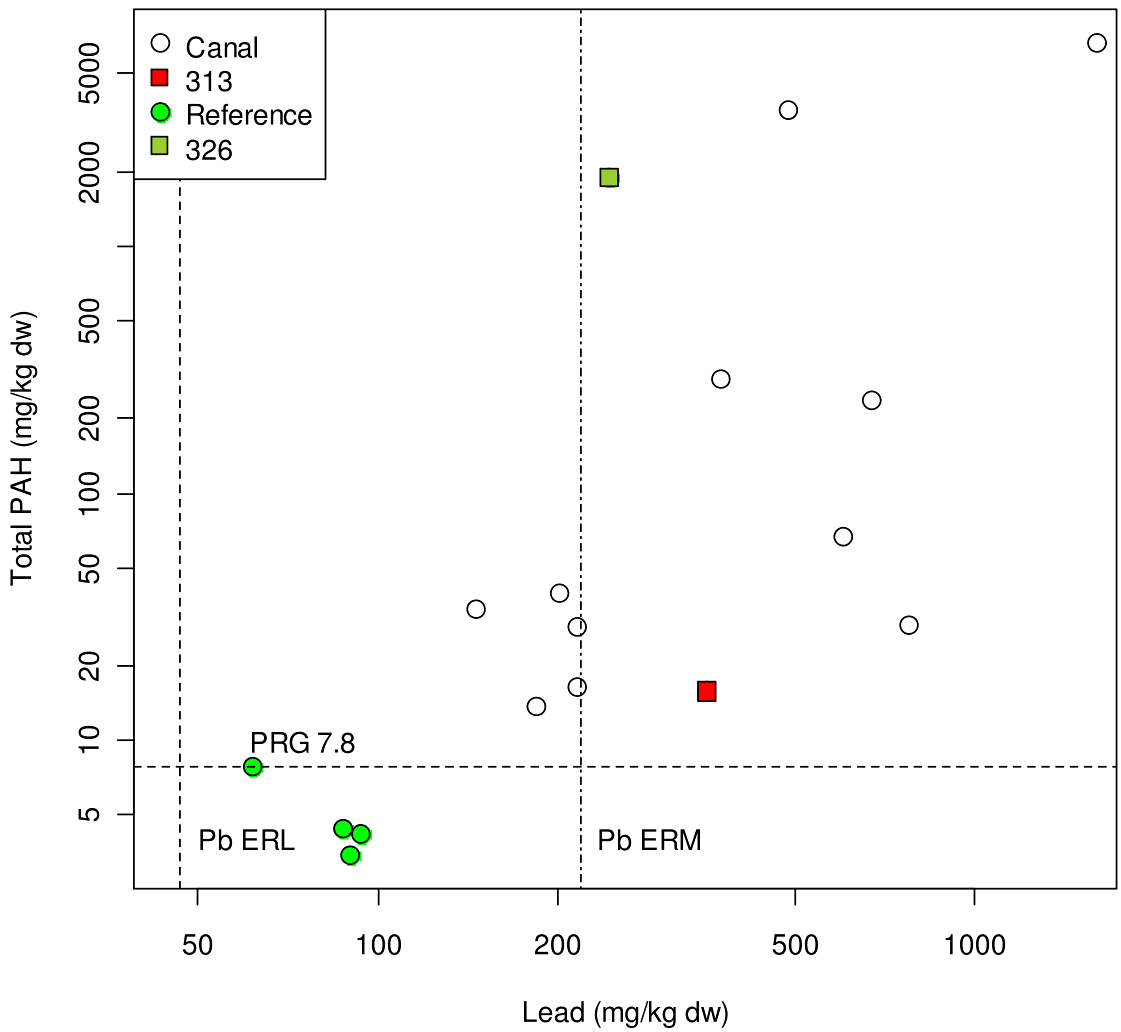

FIGURE 9
Comparison of Total PAH Concentrations and Lead Concentrations
Gowanus Canal Feasibility Study
Brooklyn, New York

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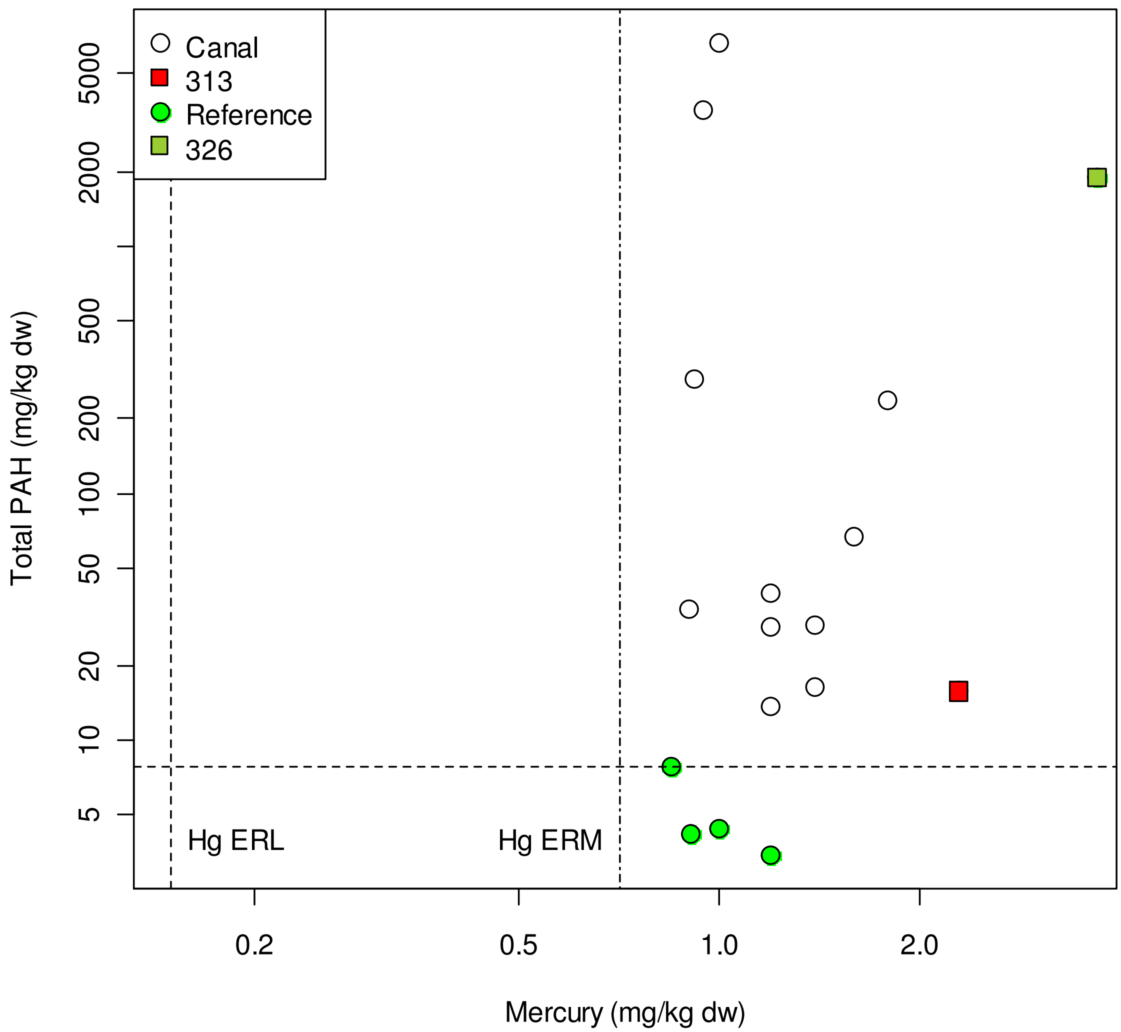

FIGURE 10
Comparison of Total PAH Concentrations and Mercury Concentrations
Gowanus Canal Feasibility Study
Brooklyn, New York

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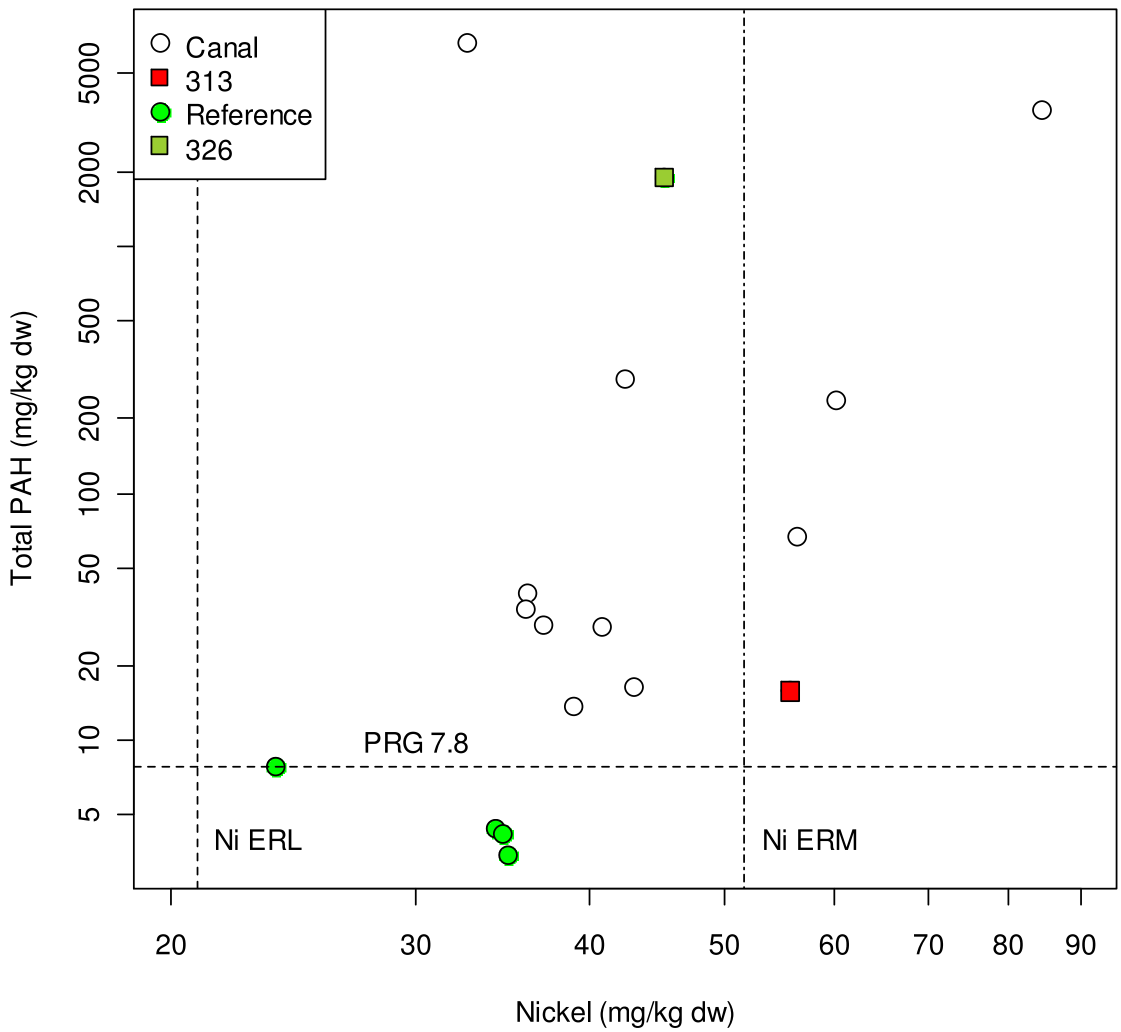

FIGURE 11
Comparison of Total PAH Concentrations and Nickel Concentrations
Gowanus Canal Feasibility Study
Brooklyn, New York

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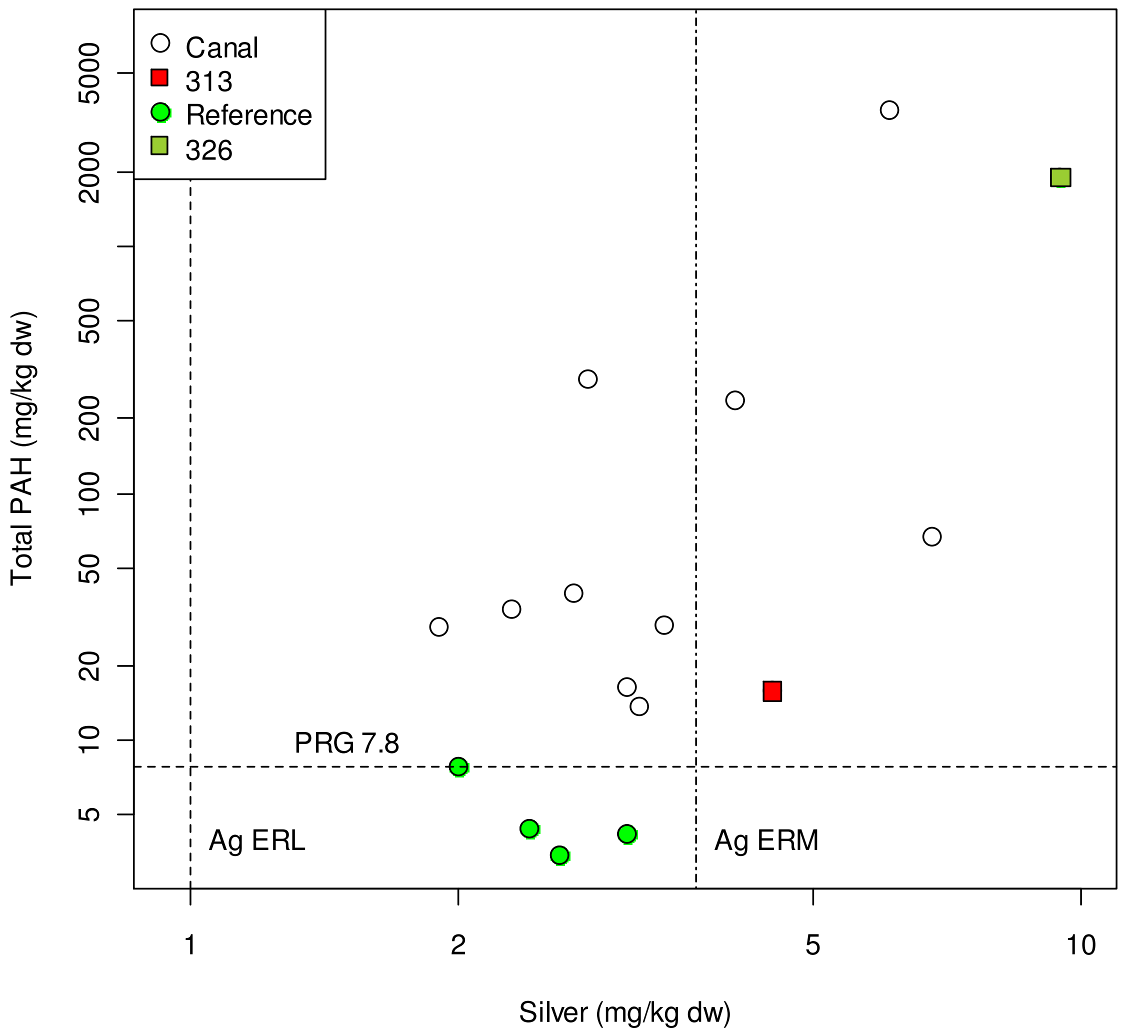

FIGURE 12
Comparison of Total PAH Concentrations and Silver Concentrations
Gowanus Canal Feasibility Study
Brooklyn, New York

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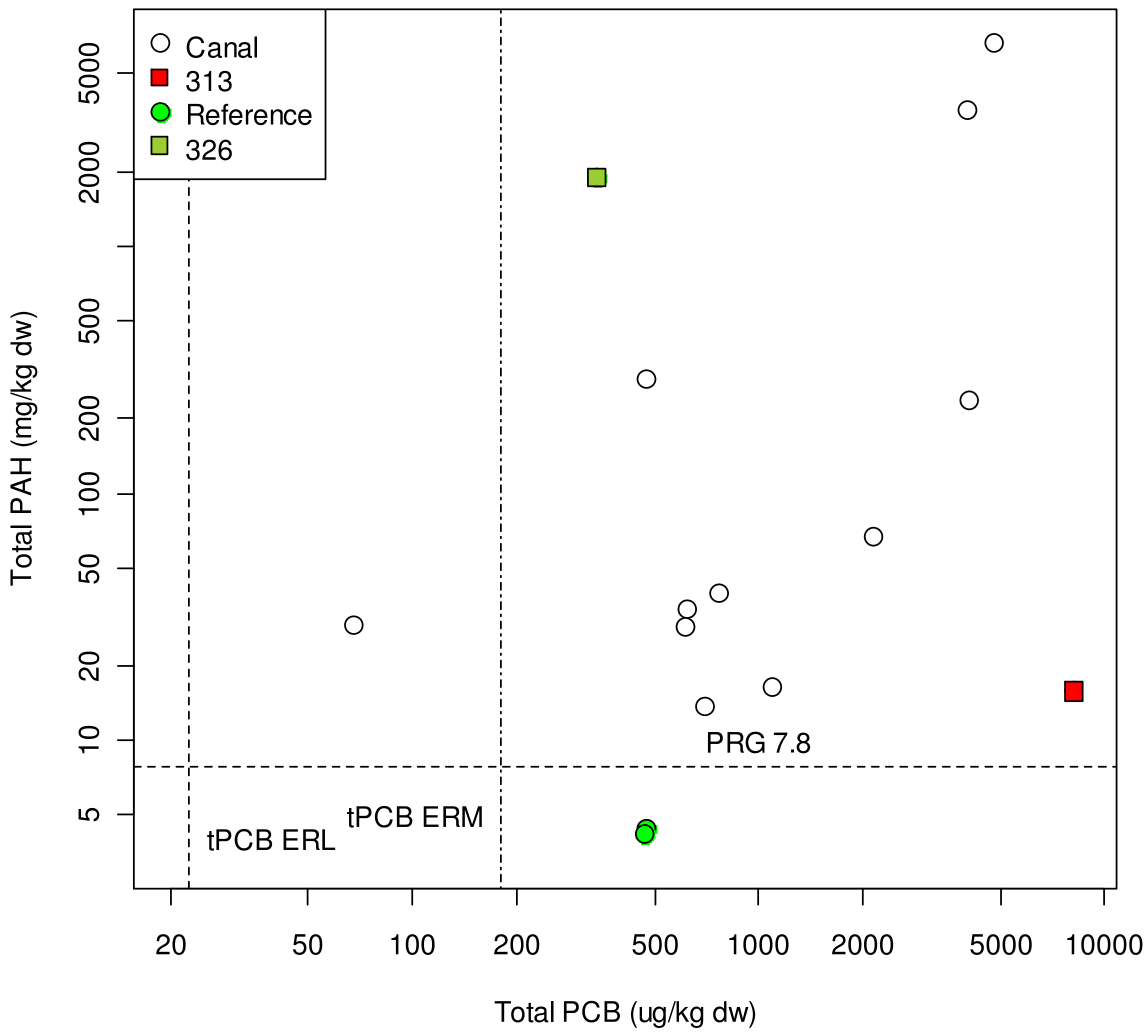

FIGURE 13
Comparison of Total PAH Concentrations and Total PCB Concentrations
Gowanus Canal Feasibility Study
Brooklyn, New York

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Appendix C.2
Comparison of Human Health Preliminary Remediation Goals to PAH Concentrations in CSO Solids

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TABLE C.2
Comparison of PAH Concentrations in Combined Sewer Overflow Solids to Human Health-Based Preliminary Remediation Goals
Gowanus Canal Feasibility Study
Brooklyn, New York

	Average Concentration in Wet Weather Solids (mg/kg)						Elevation above Recreational Use Preliminary Remediation Goal						
Location ID	**BAA**	**BAP**	**BBF**	**BKF**	**DA**	**ID**	**BAA**	**BAP**	**BBF**	**BKF**	**DA**	**ID**	**SUM** [1]
PRG - recreational use	24	2.4	24	240	2.4	24							
PRG - canal overflow	53	5.3	53	530	5.3	53							
OH-005	9.1	12.8	13.3	12.3	9.4	9.6	0.4	5.3	0.6	0.1	3.9	0.4	**10.6**
OH-006	3.8	3.8	3.8	3.8	3.8	9.8	0.2	1.6	0.2	0.0	1.6	0.4	3.9
OH-007	3.8	1.3	7.3	6.3	4.0	3.8	0.2	0.5	0.3	0.0	1.7	0.2	2.8
RH-031	3.4	5.5	7.4	2.9	4.1	3.0	0.1	2.3	0.3	0.0	1.7	0.1	4.6
RH-033	4.8	1.4	8.5	1.8	1.4	8.9	0.2	0.6	0.4	0.0	0.6	0.4	2.1
RH-034	6.9	6.9	12.4	4.5	7.6	13.6	0.3	2.9	0.5	0.0	3.2	0.6	7.4
RH-035	0.8	0.7	0.7	0.5	0.4	0.6	0.0	0.3	0.0	0.0	0.2	0.0	0.6
RH-036	6.9	6.9	8.6	6.9	6.9	6.1	0.3	2.9	0.4	0.0	2.9	0.3	6.7
RH-037	3.1	4.0	4.5	3.2	4.0	2.8	0.1	1.7	0.2	0.0	1.7	0.1	3.8
RH-038	2.1	0.8	3.7	2.4	1.5	3.3	0.1	0.4	0.2	0.0	0.6	0.1	1.4

Notes:
BAA - benzo(a)anthracene; BAP - benzo(a)pyrene; BBF - benzo(b)fluoranthene; BKF - benzo(k)fluoranthene; DA - dibenz(a,h)anthracene; ID - indeno(1,2,3-cd)pyrene
Individual preliminary remediation goals (PRGs) are based on 10^{-5} risk so that cumulative risk is less than 10^{-4}
Boldface - sum exceeds 10
Boldface italics - outfalls that account for 95 percent of the annual discharge
[1] Potential risk is greater than 10^{-4} if the sum of the exceedances exceeds 10

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Appendix C.3
Comparison of Human Health Preliminary Remediation Goals to PAH Concentrations in Soft Sediments

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TABLE C.3
Comparison of PAH Concentrations in Soft Sediment to Human Health-Based Preliminary Remediation Goals
Gowanus Canal Feasibility Study
Brooklyn, New York

	Sample	Top	Bottom	Distance from	Concentration in mg/kg						Elevation above Recreational Use Preliminary Remediation Goal						
Location ID	**Type**	**Depth**	**Depth**	**Head of Canal (ft)**	**BAA**	**BAP**	**BBF**	**BKF**	**DA**	**ID**	**BAA**	**BAP**	**BBF**	**BKF**	**DA**	**ID**	**SUM [1]**
	PRG - recreational use				24	2.4	24	240	2.4	24							
	PRG - canal overflow				53	5.3	53	530	5.3	53							
ERT1-1	N	0.0	0.5	23	6.5	5.8	3.8	4.9	0.8	3.1	0.3	2.4	0.2	0.0	0.4	0.1	3.3
ERT1-1	N	0.5	1.0	23	390	280	170	140	25	85	16	117	7.1	0.6	10	3.5	**155**
ERT1-1	N	1.0	2.0	23	79	64	30	45	6.5	23	3.3	27	1.3	0.2	2.7	1.0	**35**
ERT1-1	N	2.0	3.0	23	16	12	8.8	8.7	1.9	5.9	0.7	5.0	0.4	0.0	0.8	0.2	7.1
ERT1-1	N	3.0	4.0	23	17	13	9.2	9.6	1.8	6.0	0.7	5.4	0.4	0.0	0.8	0.3	7.5
ERT1-1	N	4.0	5.4	23	14	12	10	11	1.8	6.1	0.6	5.0	0.4	0.0	0.8	0.3	7.1
ERT1-2	N	0.0	0.5	19	15	12	8.0	8.8	1.9	6.3	0.6	5.0	0.3	0.0	0.8	0.3	7.0
ERT1-2	N	0.5	1.0	19	4.8	3.7	3.0	2.3	0.6	2.0	0.2	1.5	0.1	0.0	0.3	0.1	2.2
ERT1-2	N	1.0	2.0	19	1.6	1.2	1.1	1.2	*0.6*	0.8	0.1	0.5	0.0	0.0	0.2	0.0	0.9
ERT1-2	N	2.0	3.0	19	7.9	6.4	7.4	7.1	1.3	4.5	0.3	2.7	0.3	0.0	0.5	0.2	4.1
ERT1-2	N	3.0	4.0	19	6.8	6.2	6.1	5.6	1.2	4.3	0.3	2.6	0.3	0.0	0.5	0.2	3.8
ERT1-2	N	4.0	5.0	19	15	11	9.2	8.3	*9.0*	5.6	0.6	4.6	0.4	0.0	3.8	0.2	9.6
ERT1-2	N	5.0	6.0	19	220	210	210	170	35	120	9.2	88	8.8	0.7	15	5.0	**126**
ERT1-2	N	6.0	6.8	19	89	87	81	63	14	47	3.7	36	3.4	0.3	5.8	2.0	**51**
ERT1-3	N	0.0	0.5	19	17	11	7.9	9.0	*2.6*	4.9	0.7	4.6	0.3	0.0	1.1	0.2	6.9
ERT1-3	N	0.5	1.0	19	15	10	8.1	6.6	*2.6*	4.3	0.6	4.2	0.3	0.0	1.1	0.2	6.4
ERT1-3	N	1.0	2.0	19	27	18	12	12	2.2	6.6	1.1	7.5	0.5	0.1	0.9	0.3	**10**
ERT1-3	N	2.0	3.0	19	45	27	23	15	2.8	9.6	1.9	11	1.0	0.1	1.2	0.4	**16**
ERT1-3	N	3.0	4.0	19	51	41	19	31	*14*	15	2.1	17	0.8	0.1	5.6	0.6	**26**
ERT1-3	N	4.0	5.0	19	17	11	8.6	7.8	*4.9*	4.3	0.7	4.6	0.4	0.0	2.0	0.2	7.9
ERT1-3	N	5.0	6.0	19	20	14	9.2	11	2.0	6.2	0.8	5.8	0.4	0.0	0.8	0.3	8.2
ERT1-3	N	6.0	7.0	19	42	29	23	23	4.5	15	1.8	12	1.0	0.1	1.9	0.6	**17**
ERT1-3	N	7.0	7.7	19	24	21	18	13	3.0	10	1.0	8.8	0.8	0.1	1.3	0.4	**12**
ERT2-1	N	0.0	0.5	179	86	71	31	41	6.7	25	3.6	30	1.3	0.2	2.8	1.0	**38**
ERT2-1	N	0.5	1.0	179	36	28	13	17	*15*	10	1.5	12	0.5	0.1	6.0	0.4	**20**
ERT2-1	N	1.0	2.0	179	41	33	14	22	4.1	13	1.7	14	0.6	0.1	1.7	0.5	**18**
ERT2-1	N	2.0	3.0	179	110	86	47	45	9.0	31	4.6	36	2.0	0.2	3.8	1.3	**48**
ERT2-1	N	3.0	4.0	179	62	48	25	35	5.1	18	2.6	20	1.0	0.1	2.1	0.8	**27**
ERT2-1	N	4.0	5.0	179	61	47	24	37	5.8	17	2.5	20	1.0	0.2	2.4	0.7	**26**
ERT2-1	FD	4.0	5.0	179	75	52	31	35	6.1	21	3.1	22	1.3	0.1	2.5	0.9	**30**
ERT2-1	N	5.0	6.0	179	17	12	8.3	8.5	*5.5*	5.2	0.7	5.0	0.3	0.0	2.3	0.2	8.6
ERT2-1	N	6.0	7.0	179	60	47	30	33	4.8	17	2.5	20	1.3	0.1	2.0	0.7	**26**
ERT2-2	N	0.0	0.5	170	8.8	7.0	3.4	4.6	*2.4*	2.8	0.4	2.9	0.1	0.0	1.0	0.1	4.5
ERT2-2	N	0.5	1.0	170	11	9.0	4.1	5.8	1.1	3.8	0.5	3.8	0.2	0.0	0.5	0.2	5.0
ERT2-2	N	1.0	2.0	170	26	20	9.4	14	*6.5*	8.3	1.1	8.3	0.4	0.1	2.7	0.3	**13**
ERT2-2	N	2.0	3.0	170	40	31	15	19	3.7	11	1.7	13	0.6	0.1	1.5	0.5	**17**
ERT2-2	N	3.0	4.0	170	35	31	19	20	4.1	13	1.5	13	0.8	0.1	1.7	0.5	**18**
ERT2-2	N	4.0	5.0	170	16	13	7.1	9.7	1.7	5.6	0.7	5.4	0.3	0.0	0.7	0.2	7.4
ERT2-2	N	5.0	6.0	170	160	120	60	67	12	39	6.7	50	2.5	0.3	5.0	1.6	**66**
ERT2-2	FD	5.0	6.0	170	370	270	93	190	*240*	80	15	113	3.9	0.8	100	3.3	**236**
ERT2-2	N	6.0	7.0	170	32	27	14	20	3.1	12	1.3	11	0.6	0.1	1.3	0.5	**15**
ERT2-2	N	7.0	8.0	170	67	58	27	33	6.2	20	2.8	24	1.1	0.1	2.6	0.8	**32**
ERT2-3	N	0.0	0.5	170	7.7	5.6	4.2	3.5	0.6	2.1	0.3	2.3	0.2	0.0	0.3	0.1	3.2
ERT2-3	N	0.5	1.0	170	4.7	3.2	2.5	2.3	0.4	1.4	0.2	1.3	0.1	0.0	0.2	0.1	1.9
ERT2-3	N	1.0	2.0	170	4.0	3.5	2.7	2.7	0.5	1.6	0.2	1.5	0.1	0.0	0.2	0.1	2.0
ERT2-3	N	2.0	3.0	170	5.7	4.5	3.6	3.8	*1.4*	1.8	0.2	1.9	0.2	0.0	0.6	0.1	2.9
ERT2-3	N	3.0	4.0	170	19	16	12	12	2.9	7.6	0.8	6.7	0.5	0.1	1.2	0.3	9.5
ERT2-3	N	4.0	5.0	170	18	14	11	9.9	*4.2*	6.4	0.8	5.8	0.5	0.0	1.7	0.3	9.1
ERT2-3	N	5.0	6.0	170	19	14	8.6	10	1.7	5.7	0.8	5.8	0.4	0.0	0.7	0.2	8.0
ERT2-3	N	6.0	7.0	170	16	12	15	15	1.7	5.2	0.7	5.0	0.6	0.1	0.7	0.2	7.3

TABLE C.3
Comparison of PAH Concentrations in Soft Sediment to Human Health-Based Preliminary Remediation Goals
Gowanus Canal Feasibility Study
Brooklyn, New York

					Concentration in mg/kg						Elevation above Recreational Use Preliminary Remediation Goal						
Location ID	**Sample Type**	**Top Depth**	**Bottom Depth**	**Distance from Head of Canal (ft)**	**BAA**	**BAP**	**BBF**	**BKF**	**DA**	**ID**	**BAA**	**BAP**	**BBF**	**BKF**	**DA**	**ID**	**SUM [1]**
		PRG - recreational use			24	2.4	24	240	2.4	24							
		PRG - canal overflow			53	5.3	53	530	5.3	53							
ERT2-3	N	8.0	9.4	170	24	18	14	13	2.4	7.5	1.0	7.5	0.6	0.1	1.0	0.3	**10**
ERT3-1	N	0.0	0.5	554	26	22	21	22	2.8	7.6	1.1	9.2	0.9	0.1	1.2	0.3	**13**
ERT3-1	N	0.5	1.0	554	22	16	9.1	10	1.8	6.0	0.9	6.7	0.4	0.0	0.8	0.3	9.0
ERT3-1	N	1.0	2.0	554	21	19	12	12	1.8	6.4	0.9	7.9	0.5	0.1	0.8	0.3	**10**
ERT3-1	N	2.0	3.0	554	12	9.5	6.2	5.3	1.1	3.8	0.5	4.0	0.3	0.0	0.5	0.2	5.4
ERT3-1	N	3.0	4.0	554	6.3	5.7	2.7	4.0	0.6	2.2	0.3	2.4	0.1	0.0	0.3	0.1	3.1
ERT3-1	N	4.0	5.0	554	57	9.5	55	58	5.6	19	2.4	4.0	2.3	0.2	2.3	0.8	**12**
ERT3-1	N	5.0	6.0	554	25	20	13	14	3.0	7.7	1.0	8.3	0.5	0.1	1.3	0.3	**12**
ERT3-1	N	6.0	7.0	554	29	23	27	28	3.2	9.7	1.2	9.6	1.1	0.1	1.3	0.4	**14**
ERT3-2	N	0.0	0.5	554	13	11	6.2	7.8	1.5	4.7	0.5	4.6	0.3	0.0	0.6	0.2	6.2
ERT3-2	N	0.5	1.0	554	11	4.9	4.6	6.4	1.0	3.0	0.5	2.0	0.2	0.0	0.4	0.1	3.3
ERT3-2	N	1.0	2.0	554	22	19	12	12	2.1	6.8	0.9	7.9	0.5	0.1	0.9	0.3	**11**
ERT3-2	N	2.0	3.0	554	57	52	48	51	6.2	22	2.4	22	2.0	0.2	2.6	0.9	**30**
ERT3-2	N	3.0	4.0	554	25	22	23	24	2.5	9.0	1.0	9.2	1.0	0.1	1.0	0.4	**13**
ERT3-2	N	4.0	5.0	554	36	32	17	23	3.5	12	1.5	13	0.7	0.1	1.5	0.5	**18**
ERT3-2	N	5.0	6.0	554	24	19	18	19	2.5	7.2	1.0	7.9	0.8	0.1	1.0	0.3	**11**
ERT3-2	N	6.0	7.4	554	19	17	6.4	14	*6.0*	5.9	0.8	7.1	0.3	0.1	2.5	0.2	**11**
ERT3-3	N	0.0	0.5	554	2.7	2.2	1.7	1.6	0.4	1.2	0.1	0.9	0.1	0.0	0.2	0.1	1.3
ERT3-3	N	0.5	1.0	554	2.4	2.3	1.9	1.6	0.5	1.3	0.1	1.0	0.1	0.0	0.2	0.1	1.4
ERT3-3	N	1.0	2.0	554	4.9	4.4	3.2	2.7	0.7	2.1	0.2	1.8	0.1	0.0	0.3	0.1	2.5
ERT3-3	N	2.0	3.0	554	35	26	16	17	3.8	12	1.5	11	0.7	0.1	1.6	0.5	**15**
ERT3-3	N	3.0	4.0	554	22	16	11	10	2.4	8.1	0.9	6.7	0.5	0.0	1.0	0.3	9.4
ERT3-3	FD	3.0	4.0	554	15	11	13	13	1.4	4.0	0.6	4.6	0.5	0.1	0.6	0.2	6.6
ERT3-3	N	4.0	5.0	554	25	19	10	15	2.2	7.3	1.0	7.9	0.4	0.1	0.9	0.3	**11**
ERT3-3	N	5.0	6.0	554	35	28	16	19	2.9	11	1.5	12	0.7	0.1	1.2	0.5	**16**
ERT3-3	N	6.0	7.0	554	43	40	18	27	4.2	15	1.8	17	0.8	0.1	1.8	0.6	**22**
ERT3-3	N	7.0	8.0	554	40	31	29	32	3.0	11	1.7	13	1.2	0.1	1.3	0.5	**18**
ERT3-3	N	8.0	8.6	554	90	66	62	65	6.4	21	3.8	28	2.6	0.3	2.7	0.9	**38**
ERT4-3	N	0.0	0.5	970	2.9	2.7	2.0	2.1	0.3	1.0	0.1	1.1	0.1	0.0	0.1	0.0	1.5
ERT4-3	N	0.5	1.0	970	1.9	2.0	1.7	1.4	0.3	0.8	0.1	0.8	0.1	0.0	0.1	0.0	1.1
ERT4-3	N	1.0	2.0	970	6.5	5.4	5.9	6.2	0.6	1.9	0.3	2.3	0.2	0.0	0.3	0.1	3.1
ERT4-3	N	2.0	3.0	970	14	10	10	11	1.0	3.1	0.6	4.2	0.4	0.0	0.4	0.1	5.8
ERT4-3	N	3.0	4.0	970	53	40	41	43	4.1	14	2.2	17	1.7	0.2	1.7	0.6	**23**
ERT4-3	N	4.0	5.0	970	30	25	15	17	2.6	8.0	1.3	10	0.6	0.1	1.1	0.3	**14**
ERT4-3	N	5.0	6.0	970	26	22	13	15	2.1	7.1	1.1	9.2	0.5	0.1	0.9	0.3	**12**
ERT4-3	N	6.0	7.3	970	36	27	21	13	3.7	12	1.5	11	0.9	0.1	1.5	0.5	**16**
GC-SD107	N	0.0	2.0	25	7.7	5.8	3.5	3.8	*3.3*	2.3	0.3	2.4	0.1	0.0	1.4	0.1	4.3
GC-SD107	N	2.0	4.0	25	1.5	*3.4*	*3.4*	*3.4*	*3.4*	*3.4*	0.1	1.4	0.1	0.0	1.4	0.1	3.2
GC-SD107	N	4.0	6.0	25	14	12	9.7	11	2.0	7.7	0.6	5.0	0.4	0.0	0.8	0.3	7.2
GC-SD107	N	6.0	8.0	25	11	9.1	8.7	8.9	1.5	6.6	0.5	3.8	0.4	0.0	0.6	0.3	5.5
GC-SD108	N	0.0	2.0	495	11	8.9	3.9	6.0	*6.5*	3.8	0.5	3.7	0.2	0.0	2.7	0.2	7.2
GC-SD108	N	2.0	4.0	495	37	30	17	19	3.4	13	1.5	13	0.7	0.1	1.4	0.5	**17**
GC-SD108	FD	4.0	6.0	495	36	28	17	21	4.1	16	1.5	12	0.7	0.1	1.7	0.7	**16**
GC-SD108	N	4.0	6.0	495	57	47	25	36	4.8	21	2.4	20	1.0	0.2	2.0	0.9	**26**
GC-SD108	N	6.0	8.0	495	24	18	11	14	2.4	9.9	1.0	7.5	0.5	0.1	1.0	0.4	**10**
GC-SD109	N	0.0	2.0	1178	10	8.2	4.5	6.3	*8.5*	3.4	0.4	3.4	0.2	0.0	3.5	0.1	7.7
GC-SD109	N	2.0	4.0	1178	9.9	7.7	5.1	5.1	*6.5*	3.3	0.4	3.2	0.2	0.0	2.7	0.1	6.7
GC-SD110	N	0.0	2.0	1913	13	11	7.7	6.0	*7.0*	4.9	0.5	4.6	0.3	0.0	2.9	0.2	8.6
GC-SD110	N	2.0	4.0	1913	44	34	18	25	4.4	15	1.8	14	0.8	0.1	1.8	0.6	**19**
GC-SD110	N	4.0	5.0	1913	45	33	18	21	3.2	13	1.9	14	0.8	0.1	1.3	0.5	**18**

TABLE C.3

Comparison of PAH Concentrations in Soft Sediment to Human Health-Based Preliminary Remediation Goals

Gowanus Canal Feasibility Study

Brooklyn, New York

	Sample	Top	Bottom	Distance from	Concentration in mg/kg						Elevation above Recreational Use Preliminary Remediation Goal						
Location ID	**Type**	**Depth**	**Depth**	**Head of Canal (ft)**	**BAA**	**BAP**	**BBF**	**BKF**	**DA**	**ID**	**BAA**	**BAP**	**BBF**	**BKF**	**DA**	**ID**	**SUM [1]**
		PRG - recreational use			24	2.4	24	240	2.4	24							
		PRG - canal overflow			53	5.3	53	530	5.3	53							
GC-SD111	N	0.0	2.0	2469	120	83	54	53	14	55	5.0	35	2.3	0.2	5.8	2.3	**50**
GC-SD111	FD	2.0	4.0	2469	41	31	15	23	4.4	14	1.7	13	0.6	0.1	1.8	0.6	**18**
GC-SD111	N	2.0	4.0	2469	66	44	27	30	6.9	24	2.8	18	1.1	0.1	2.9	1.0	**26**
GC-SD111	N	4.0	6.0	2469	69	45	32	29	8.3	27	2.9	19	1.3	0.1	3.5	1.1	**28**
GC-SD111	N	6.0	8.0	2469	80	48	27	31	7.5	23	3.3	20	1.1	0.1	3.1	1.0	**29**
GC-SD112	N	0.0	2.0	2558	2.8	2.1	1.5	1.7	*3.2*	1.4	0.1	0.9	0.1	0.0	1.3	0.1	2.4
GC-SD112	FD	2.0	4.0	2558	20	13	11	9.6	2.2	8.3	0.8	5.4	0.5	0.0	0.9	0.3	8.0
GC-SD112	N	2.0	4.0	2558	32	31	30	30	8.3	25	1.3	13	1.3	0.1	3.5	1.0	**20**
GC-SD113	N	0.0	2.0	3018	20	14	10	10	2.0	7.5	0.8	5.8	0.4	0.0	0.8	0.3	8.3
GC-SD113	N	2.0	4.0	3018	35	24	16	16	4.1	14	1.5	10	0.7	0.1	1.7	0.6	**14**
GC-SD113	FD	4.0	6.0	3018	30	20	12	13	2.6	8.8	1.3	8.3	0.5	0.1	1.1	0.4	**12**
GC-SD113	N	4.0	6.0	3018	36	26	18	16	5.0	17	1.5	11	0.8	0.1	2.1	0.7	**16**
GC-SD113	N	6.0	8.0	3018	270	160	76	110	*90*	69	11	67	3.2	0.5	38	2.9	**122**
GC-SD113	N	8.0	9.0	3018	340	210	100	140	21	87	14	88	4.2	0.6	8.8	3.6	**119**
GC-SD115	N	0.0	1.5	4133	270	180	140	52	34	86	11	75	5.8	0.2	14	3.6	**110**
GC-SD116	N	0.0	2.0	3573	6.0	4.5	4.1	1.3	0.6	2.3	0.3	1.9	0.2	0.0	0.3	0.1	2.7
GC-SD116	N	2.0	4.0	3573	16	9.6	8.5	3.2	1.2	4.6	0.7	4.0	0.4	0.0	0.5	0.2	5.7
GC-SD116	N	4.0	6.0	3573	66	50	41	12	9.1	24	2.8	21	1.7	0.1	3.8	1.0	**30**
GC-SD117	N	0.0	2.0	3961	10	7.0	6.1	2.0	1.0	3.8	0.4	2.9	0.3	0.0	0.4	0.2	4.2
GC-SD117	N	2.0	4.0	3961	9.7	6.3	5.1	2.1	1.1	3.6	0.4	2.6	0.2	0.0	0.5	0.2	3.9
GC-SD117	FD	4.0	6.0	3961	59	37	30	13	7.0	18	2.5	15	1.3	0.1	2.9	0.8	**23**
GC-SD117	N	4.0	6.0	3961	40	27	24	5.6	4.3	13	1.7	11	1.0	0.0	1.8	0.5	**16**
GC-SD117	N	6.0	7.6	3961	310	200	170	53	37	81	13	83	7.1	0.2	15	3.4	**122**
GC-SD118	N	0.2	0.7	4604	280	190	170	54	36	86	12	79	7.1	0.2	15	3.6	**117**
GC-SD119	N	0.0	1.2	4961	220	190	84	120	25	67	9.2	79	3.5	0.5	10	2.8	**106**
GC-SD119	N	4.5	6.0	4961	45	33	15	21	4.7	10	1.9	14	0.6	0.1	2.0	0.4	**19**
GC-SD119	FD	6.0	8.0	4961	170	110	48	69	16	40	7.1	46	2.0	0.3	6.7	1.7	**64**
GC-SD119	N	6.0	8.0	4961	110	76	35	54	8.8	20	4.6	32	1.5	0.2	3.7	0.8	**42**
GC-SD119	N	8.0	10.0	4961	420	290	110	220	41	94	18	121	4.6	0.9	17	3.9	**165**
GC-SD119	N	10.0	12.0	4961	50	34	13	24	4.4	12	2.1	14	0.5	0.1	1.8	0.5	**19**
GC-SD119	N	12.0	13.0	4961	25	17	6.6	12	1.8	6.0	1.0	7.1	0.3	0.1	0.8	0.3	9.5
GC-SD120	N	0.0	1.3	5068	150	110	41	68	14	32	6.3	46	1.7	0.3	5.8	1.3	**61**
GC-SD122	N	0.0	0.7	5908	44	22	24	17	14	20	1.8	9.2	1.0	0.1	5.8	0.8	**19**
GC-SD123	N	0.0	2.0	6719	2.2	2.4	1.4	1.3	*6.5*	1.3	0.1	1.0	0.1	0.0	2.7	0.1	3.9
GC-SD123	N	2.0	4.0	6719	5.9	5.7	2.3	3.1	1.0	2.2	0.2	2.4	0.1	0.0	0.4	0.1	3.2
GC-SD123	N	4.0	6.0	6719	9.0	5.6	2.7	3.5	*6.5*	1.5	0.4	2.3	0.1	0.0	2.7	0.1	5.6
GC-SD123	N	6.0	6.8	6719	15	13	6.4	7.4	2.2	4.2	0.6	5.4	0.3	0.0	0.9	0.2	7.4
GC-SD124	N	0.0	2.0	114	76	58	32	44	*30*	26	3.2	24	1.3	0.2	13	1.1	**42**
GC-SD124	N	2.0	4.0	114	300	220	94	150	22	84	13	92	3.9	0.6	9.2	3.5	**121**
GC-SD124	N	4.0	6.0	114	270	210	110	120	22	68	11	88	4.6	0.5	9.2	2.8	**116**
GC-SD124	N	6.0	7.5	114	220	160	100	90	19	56	9.2	67	4.2	0.4	7.9	2.3	**91**
GC-SD125	N	0.0	2.0	114	2.8	2.6	2.5	2.2	*3.6*	1.7	0.1	1.1	0.1	0.0	1.5	0.1	2.9
GC-SD125	N	2.0	4.0	114	7.7	5.7	4.2	4.3	*4.7*	2.7	0.3	2.4	0.2	0.0	1.9	0.1	4.9
GC-SD125	N	4.0	6.0	114	10	8.0	5.7	7.1	*4.9*	3.9	0.4	3.3	0.2	0.0	2.0	0.2	6.2
GC-SD125	N	6.0	8.0	114	13	11	11	9.4	*5.0*	6.5	0.5	4.6	0.5	0.0	2.1	0.3	8.0
GC-SD125	FD	8.0	10.0	114	51	35	24	27	6.6	22	2.1	15	1.0	0.1	2.8	0.9	**21**
GC-SD125	N	8.0	10.0	114	140	120	120	95	20	83	5.8	50	5.0	0.4	8.3	3.5	**73**
GC-SD126	N	0.0	2.0	114	9.1	8.1	6.3	6.0	*5.0*	4.0	0.4	3.4	0.3	0.0	2.1	0.2	6.3
GC-SD126	FD	2.0	4.0	114	19	15	8.9	11	*6.5*	7.1	0.8	6.3	0.4	0.0	2.7	0.3	**10**
GC-SD126	N	2.0	4.0	114	18	15	8.8	11	1.9	6.9	0.8	6.3	0.4	0.0	0.8	0.3	8.5

TABLE C.3
Comparison of PAH Concentrations in Soft Sediment to Human Health-Based Preliminary Remediation Goals
Gowanus Canal Feasibility Study
Brooklyn, New York

Location ID	Sample Type	Top Depth	Bottom Depth	Distance from Head of Canal (ft)	Concentration in mg/kg BAA	BAP	BBF	BKF	DA	ID	Elevation above Recreational Use Preliminary Remediation Goal BAA	BAP	BBF	BKF	DA	ID	SUM[1]
PRG - recreational use					24	2.4	24	240	2.4	24							
PRG - canal overflow					53	5.3	53	530	5.3	53							
GC-SD126	N	4.0	6.0	114	21	17	12	11	2.2	8.2	0.9	7.1	0.5	0.0	0.9	0.3	9.8
GC-SD126	N	6.0	6.6	114	10	8.4	5.7	6.5	*4.2*	4.0	0.4	3.5	0.2	0.0	1.7	0.2	6.1
GC-SD127	N	0.0	2.0	2116	14	12	7.5	8.6	*5.5*	5.9	0.6	5.0	0.3	0.0	2.3	0.2	8.5
GC-SD127	N	2.0	4.0	2116	36	28	20	17	2.9	11	1.5	12	0.8	0.1	1.2	0.5	**16**
GC-SD127	FD	4.0	6.0	2116	640	420	200	280	36	130	27	175	8.3	1.2	15	5.4	**232**
GC-SD127	N	4.0	6.0	2116	630	410	250	250	50	140	26	171	10	1.0	21	5.8	**235**
GC-SD128	N	0.0	2.0	2116	25	20	11	15	2.5	9.8	1.0	8.3	0.5	0.1	1.0	0.4	**11**
GC-SD128	N	2.0	2.5	2116	280	240	220	190	37	140	12	100	9.2	0.8	15	5.8	**143**
GC-SD129	N	0.0	2.0	2116	25	17	19	*6.0*	2.2	10.0	1.0	7.1	0.8	0.0	0.9	0.4	**10**
GC-SD129	N	2.0	4.0	2116	72	48	44	*15*	6.7	23	3.0	20	1.8	0.1	2.8	1.0	**29**
GC-SD129	N	4.0	6.0	2116	590	420	390	*195*	63	150	25	175	16	0.8	26	6.3	**249**
GC-SD129	N	6.0	6.5	2116	190	*65*	*65*	*65*	15	54	7.9	27	2.7	0.3	6.3	2.3	**46**
GC-SD130	N	0.0	2.0	4383	21	15	7.9	9.8	1.8	4.3	0.9	6.3	0.3	0.0	0.8	0.2	8.4
GC-SD130	FD	2.0	4.0	4383	230	160	68	110	27	55	9.6	67	2.8	0.5	11	2.3	**93**
GC-SD130	N	2.0	4.0	4383	240	160	72	110	*105*	53	10	67	3.0	0.5	44	2.2	**126**
GC-SD130	N	4.0	6.0	4383	300	190	81	140	*115*	68	13	79	3.4	0.6	48	2.8	**146**
GC-SD130	N	6.0	7.0	4383	240	160	66	100	*205*	*205*	10	67	2.8	0.4	85	8.5	**174**
GC-SD131	N	0.0	1.3	4383	66	44	42	6.9	*23*	18	2.8	18	1.8	0.0	9.6	0.8	**33**
GC-SD132	N	0.0	2.0	4383	40	29	15	19	3.4	8.2	1.7	12	0.6	0.1	1.4	0.3	**16**
GC-SD132	N	2.0	4.0	4383	280	180	96	110	*135*	56	12	75	4.0	0.5	56	2.3	**150**
GC-SD132	N	4.0	4.7	4383	400	260	120	150	*265*	70	17	108	5.0	0.6	110	2.9	**244**
GC-SD133	N	0.0	2.0	5542	15	9.1	10.0	2.0	1.3	3.9	0.6	3.8	0.4	0.0	0.5	0.2	5.5
GC-SD133	N	2.0	4.0	5542	15	10	11	3.3	1.8	7.1	0.6	4.2	0.5	0.0	0.8	0.3	6.3
GC-SD133	N	4.0	6.0	5542	70	30	16	27	*31*	15	2.9	13	0.7	0.1	13	0.6	**30**
GC-SD133	N	6.0	7.8	5542	160	53	80	26	*105*	38	6.7	22	3.3	0.1	44	1.6	**78**
GC-SD134	N	0.0	2.0	5542	11	12	5.6	8.3	1.5	3.9	0.5	5.0	0.2	0.0	0.6	0.2	6.5
GC-SD134	N	2.0	4.0	5542	130	110	45	47	*70*	40	5.4	46	1.9	0.2	29	1.7	**84**
GC-SD134	N	4.0	4.4	5542	190	170	69	120	22	58	7.9	71	2.9	0.5	9.2	2.4	**94**
GC-SD135	N	0.0	2.0	5542	8.4	8.1	3.5	5.6	1.2	3.3	0.4	3.4	0.1	0.0	0.5	0.1	4.5
GC-SD135	FD	2.0	4.0	5542	17	13	7.0	9.3	1.0	3.4	0.7	5.4	0.3	0.0	0.4	0.1	7.0
GC-SD135	N	2.0	4.0	5542	23	19	10	14	2.0	5.7	1.0	7.9	0.4	0.1	0.8	0.2	**10**
GC-SD135	N	4.0	6.0	5542	7.5	9.3	3.8	6.9	*4.5*	2.5	0.3	3.9	0.2	0.0	1.9	0.1	6.3
GC-SD135	N	6.0	8.0	5542	28	23	12	15	2.5	6.3	1.2	9.6	0.5	0.1	1.0	0.3	**13**
GC-SD135	N	8.0	10.0	5542	37	37	19	26	*12*	12	1.5	15	0.8	0.1	5.0	0.5	**23**
GC-SD136	N	0.0	2.0	6075	7.8	5.5	4.0	4.6	*4.4*	2.8	0.3	2.3	0.2	0.0	1.8	0.1	4.8
GC-SD138	N	0.0	1.7	6075	2.0	1.8	0.9	1.2	*2.8*	0.9	0.1	0.8	0.0	0.0	1.2	0.0	2.1
GC-SD139	N	0.0	2.0	7079	0.2	*0.1*	*0.1*	*0.1*	*0.1*	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1
GC-SD139	N	2.0	4.0	7079	32	23	23	*8.0*	3.8	12	1.3	9.6	1.0	0.0	1.6	0.5	**14**
GC-SD139	N	4.0	6.0	7079	27	21	17	*8.0*	3.0	12	1.1	8.8	0.7	0.0	1.3	0.5	**12**
GC-SD139	N	6.0	8.0	7079	65	*65*	*65*	*65*	*65*	29	2.7	27	2.7	0.3	27	1.2	**61**
GC-SD139	N	8.0	10.0	7079	220	*110*	*110*	*110*	35	89	9.2	46	4.6	0.5	15	3.7	**78**
GC-SD139	FD	10.0	12.0	7079	240	*125*	*125*	*125*	*125*	63	10	52	5.2	0.5	52	2.6	**123**
GC-SD139	N	10.0	12.0	7079	260	*90*	*90*	*90*	*90*	74	11	38	3.8	0.4	38	3.1	**93**
GC-SD139	N	12.0	12.8	7079	130	*65*	*65*	*65*	*65*	47	5.4	27	2.7	0.3	27	2.0	**65**
GC-SD140	N	0.0	2.0	7079	7.8	*4.7*	*4.7*	*4.7*	1.2	3.0	0.3	1.9	0.2	0.0	0.5	0.1	3.1
GC-SD140	N	2.0	4.0	7079	0.2	*0.2*	*0.2*	*0.2*	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.2
GC-SD140	N	4.0	6.0	7079	11	*6.0*	*6.0*	*6.0*	1.0	3.0	0.5	2.5	0.3	0.0	0.4	0.1	3.8
GC-SD141	N	0.0	2.0	7079	0.6	0.6	*0.2*	*0.2*	0.0	0.1	0.0	0.2	0.0	0.0	0.0	0.0	0.3
GC-SD141	N	2.0	4.0	7079	1.8	1.6	0.8	0.9	0.2	0.4	0.1	0.7	0.0	0.0	0.1	0.0	0.9
GC-SD141	N	4.0	5.7	7079	12	10	*4.4*	*4.4*	1.5	3.6	0.5	4.2	0.2	0.0	0.6	0.2	5.6

TABLE C.3
Comparison of PAH Concentrations in Soft Sediment to Human Health-Based Preliminary Remediation Goals
Gowanus Canal Feasibility Study
Brooklyn, New York

	Sample	Top	Bottom	Distance from	Concentration in mg/kg						Elevation above Recreational Use Preliminary Remediation Goal						
Location ID	**Type**	**Depth**	**Depth**	**Head of Canal (ft)**	**BAA**	**BAP**	**BBF**	**BKF**	**DA**	**ID**	**BAA**	**BAP**	**BBF**	**BKF**	**DA**	**ID**	**SUM[1]**
		PRG - recreational use			24	2.4	24	240	2.4	24							
		PRG - canal overflow			53	5.3	53	530	5.3	53							
GC-SD142	N	0.0	2.0	7519	0.7	*0.4*	*0.4*	*0.4*	0.2	0.3	0.0	0.2	0.0	0.0	0.1	0.0	0.3
GC-SD142	N	2.0	3.8	7519	0.7	*0.3*	*0.3*	*0.3*	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.2
GC-SD143	N	0.0	2.0	7519	0.6	0.6	0.3	0.4	0.1	0.1	0.0	0.2	0.0	0.0	0.0	0.0	0.3
GC-SD143	N	2.0	2.9	7519	0.3	0.3	0.2	0.2	*0.2*	0.1	0.0	0.1	0.0	0.0	0.1	0.0	0.2
GC-SD144C	N	0.0	2.0	7519	75	46	*21*	*21*	6.6	23	3.1	19	0.9	0.1	2.8	1.0	**27**
GC-SD144C	N	2.0	3.3	7519	100	*37*	*37*	*37*	12	29	4.2	15	1.5	0.2	5.0	1.2	**27**
GC-SD145	N	0.0	2.0	1490	12	11	4.5	5.6	1.4	3.6	0.5	4.6	0.2	0.0	0.6	0.2	6.0
GC-SD145	N	2.0	3.5	1490	81	45	22	29	4.9	12	3.4	19	0.9	0.1	2.0	0.5	**26**
GC-SD146	N	0.0	2.0	1773	0.6	0.7	*0.2*	*0.2*	0.1	0.1	0.0	0.3	0.0	0.0	0.0	0.0	0.4
GC-SD146	N	2.0	4.0	1773	14	15	*6.5*	*6.5*	2.0	5.2	0.6	6.3	0.3	0.0	0.8	0.2	8.2
GC-SD146	N	4.0	6.0	1773	37	*12*	*12*	*12*	2.2	6.7	1.5	5.0	0.5	0.1	0.9	0.3	8.3
GC-SD146	N	6.0	6.6	1773	59	*30*	*30*	*30*	11	25	2.5	13	1.3	0.1	4.6	1.0	**22**
GC-SD147	N	0.0	2.0	1773	*6.5*	4.3	1.7	2.5	0.7	1.5	0.3	1.8	0.1	0.0	0.3	0.1	2.5
GC-SD147	N	2.0	3.1	1773	38	31	15	18	1.9	5.9	1.6	13	0.6	0.1	0.8	0.2	**16**
GC-SD148	N	0.0	2.0	1773	0.3	*0.2*	*0.2*	*0.2*	*0.2*	0.1	0.0	0.1	0.0	0.0	0.1	0.0	0.2
GC-SD148	N	2.0	4.0	1773	48	35	30	*10.0*	4.3	18	2.0	15	1.3	0.0	1.8	0.8	**20**
GC-SD148	N	4.0	5.5	1773	330	230	*80*	*80*	25	85	14	96	3.3	0.3	10	3.5	**127**
GC-SD149	N	0.0	2.0	4961	35	27	12	14	3.6	7.6	1.5	11	0.5	0.1	1.5	0.3	**15**
GC-SD149	N	2.0	4.0	4961	110	81	32	46	6.8	17	4.6	34	1.3	0.2	2.8	0.7	**43**
GC-SD149	N	4.0	4.7	4961	110	69	21	41	6.8	17	4.6	29	0.9	0.2	2.8	0.7	**38**
GC-SD150	N	0.0	2.0	6380	2.7	2.7	1.3	1.5	0.3	0.7	0.1	1.1	0.1	0.0	0.1	0.0	1.5
GC-SD150	N	2.0	4.0	6380	1.4	*0.8*	*0.8*	*0.8*	0.2	0.6	0.1	0.3	0.0	0.0	0.1	0.0	0.5
GC-SD150	N	4.0	6.0	6380	1.3	*1.1*	*1.1*	*1.1*	*1.1*	0.4	0.1	0.4	0.0	0.0	0.4	0.0	1.0
GC-SD150	N	6.0	8.2	6380	52	*15*	*15*	*15*	4.0	7.3	2.2	6.0	0.6	0.1	1.7	0.3	**11**
GC-SD151	N	0.0	2.0	6380	0.5	0.6	0.4	0.4	0.1	0.2	0.0	0.3	0.0	0.0	0.0	0.0	0.3
GC-SD151	N	2.0	4.0	6380	0.5	0.6	0.3	0.4	0.1	0.2	0.0	0.2	0.0	0.0	0.0	0.0	0.3
GC-SD151	N	4.0	4.8	6380	2.1	1.8	1.6	1.2	0.2	0.7	0.1	0.8	0.1	0.0	0.1	0.0	1.0
GC-SD152	N	0.0	2.0	394	21	18	14	*6.5*	1.8	9.5	0.9	7.5	0.6	0.0	0.8	0.4	**10**
GC-SD152	N	2.0	4.0	394	11	*5.0*	*5.0*	*5.0*	1.4	5.3	0.5	2.1	0.2	0.0	0.6	0.2	3.6
GC-SD152	N	4.0	6.0	394	71	52	48	*15*	6.0	26	3.0	22	2.0	0.1	2.5	1.1	**30**
GC-SD152	N	6.0	7.3	394	290	*160*	*160*	*160*	*160*	98	12	67	6.7	0.7	67	4.1	**157**
GC-SD153	N	0.0	2.0	1404	4.7	*2.6*	*2.6*	*2.6*	*2.6*	1.7	0.2	1.1	0.1	0.0	1.1	0.1	2.5
GC-SD153	N	2.0	3.2	1404	16	12	*6.0*	*6.0*	2.2	6.3	0.7	5.0	0.3	0.0	0.9	0.3	7.1
GC-SD37B	N	0.0	0.5	3278	23	17	*7.0*	*7.0*	2.2	7.6	1.0	7.1	0.3	0.0	0.9	0.3	9.6
GC-SD37B	N	1.4	1.9	3278	37	27	24	*3.9*	3.5	12	1.5	11	1.0	0.0	1.5	0.5	**16**
GC-SD37B	N	2.5	4.2	3278	170	*90*	*90*	*90*	22	49	7.1	38	3.8	0.4	9.2	2.0	**60**
GC-SD38A	N	2.1	2.6	3278	400	270	*115*	*115*	*115*	110	17	113	4.8	0.5	48	4.6	**187**
GC-SD38A	N	2.6	4.4	3278	290	190	170	*85*	33	83	12	79	7.1	0.4	14	3.5	**116**
GC-SED-01	N	1.0	2.5	67	1.9	1.5	1.7	0.4	0.4	1.1	0.1	0.6	0.1	0.0	0.2	0.0	1.0
GC-SED-01	N	16.0	17.0	67	47	39	41	20	6.2	18	2.0	16	1.7	0.1	2.6	0.8	**23**
GC-SED-02	N	1.0	2.0	67	2.4	1.7	2.1	0.6	*1.9*	1.3	0.1	0.7	0.1	0.0	0.8	0.1	1.7
GC-SED-02	N	9.6	10.6	67	24	14	14	4.4	2.2	6.1	1.0	5.8	0.6	0.0	0.9	0.3	8.6
GC-SED-03	N	0.0	1.5	67	1.4	1.1	1.1	0.4	0.1	0.4	0.1	0.5	0.0	0.0	0.1	0.0	0.6
GC-SED-03	N	7.5	9.3	67	8.3	7.1	7.5	2.5	1.7	4.6	0.3	3.0	0.3	0.0	0.7	0.2	4.5
GC-SED-04	N	0.0	2.0	252	20	17	7.0	7.9	2.5	6.5	0.8	7.1	0.3	0.0	1.0	0.3	9.6
GC-SED-04	N	10.3	11.3	252	150	110	42	61	17	39	6.3	46	1.8	0.3	7.1	1.6	**63**
GC-SED-05	N	0.0	2.0	252	14	11	4.8	5.6	1.9	5.3	0.6	4.6	0.2	0.0	0.8	0.2	6.4
GC-SED-07	N	0.0	2.5	412	81	74	51	26	7.9	23	3.4	31	2.1	0.1	3.3	1.0	**41**
GC-SED-07	N	7.5	8.5	412	35	24	23	6.3	*9.0*	8.8	1.5	10	1.0	0.0	3.8	0.4	**17**
GC-SED-08	N	1.0	2.0	412	51	45	20	28	5.8	17	2.1	19	0.8	0.1	2.4	0.7	**25**

TABLE C.3
Comparison of PAH Concentrations in Soft Sediment to Human Health-Based Preliminary Remediation Goals
Gowanus Canal Feasibility Study
Brooklyn, New York

					Concentration in mg/kg						Elevation above Recreational Use Preliminary Remediation Goal						
Location ID	**Sample Type**	**Top Depth**	**Bottom Depth**	**Distance from Head of Canal (ft)**	**BAA**	**BAP**	**BBF**	**BKF**	**DA**	**ID**	**BAA**	**BAP**	**BBF**	**BKF**	**DA**	**ID**	**SUM[1]**
		PRG - recreational use			24	2.4	24	240	2.4	24							
		PRG - canal overflow			53	5.3	53	530	5.3	53							
GC-SED-09B	N	6.0	7.0	412	390	360	*290*	*290*	*290*	180	16	150	12	1.2	121	7.5	**308**
GC-SED-10	N	0.0	1.5	760	18	12	9.8	3.9	2.3	6.6	0.8	5.0	0.4	0.0	1.0	0.3	7.4
GC-SED-100	N	5.0	6.0	3492	150	130	100	33	85	31	6.3	54	4.2	0.1	35	1.3	**101**
GC-SED-101	N	4.0	7.0	3808	210	150	100	36	110	56	8.8	63	4.2	0.2	46	2.3	**124**
GC-SED-102	N	2.0	4.0	3957	630	440	*600*	260	600	240	26	183	25	1.1	250	10	**496**
GC-SED-102	N	6.5	8.5	3957	510	390	*500*	*500*	500	220	21	163	21	2.1	208	9.2	**424**
GC-SED-103	N	1.0	2.0	4151	59	50	40	19	5.0	9.2	2.5	21	1.7	0.1	2.1	0.4	**28**
GC-SED-103	N	8.1	9.1	4151	190	140	130	*140*	*140*	*140*	7.9	58	5.4	0.6	58	5.8	**136**
GC-SED-105	N	2.5	4.0	5304	270	180	140	56	*90*	71	11	75	5.8	0.2	38	3.0	**133**
GC-SED-11	N	1.0	3.0	760	43	36	14	20	4.3	11	1.8	15	0.6	0.1	1.8	0.5	**20**
GC-SED-11	N	11.0	13.0	760	43	32	16	21	3.1	8.9	1.8	13	0.7	0.1	1.3	0.4	**18**
GC-SED-12	N	0.0	2.0	760	16	13	9.6	4.9	2.4	7.0	0.7	5.4	0.4	0.0	1.0	0.3	7.8
GC-SED-12	N	13.0	14.0	760	58	43	26	14	5.5	18	2.4	18	1.1	0.1	2.3	0.8	**25**
GC-SED-13B	N	0.0	2.0	978	5.4	4.7	4.1	1.9	0.5	1.9	0.2	2.0	0.2	0.0	0.2	0.1	2.6
GC-SED-14	N	0.0	1.5	978	23	18	16	4.6	1.2	4.8	1.0	7.5	0.7	0.0	0.5	0.2	9.8
GC-SED-14	N	5.5	6.5	978	530	380	270	97	*270*	96	22	158	11	0.4	113	4.0	**309**
GC-SED-15	N	0.0	0.8	978	6.0	5.2	4.5	2.1	0.4	2.5	0.3	2.2	0.2	0.0	0.2	0.1	2.9
GC-SED-16	N	0.0	2.0	1259	10.0	8.4	7.8	2.2	0.8	3.3	0.4	3.5	0.3	0.0	0.3	0.1	4.7
GC-SED-17	N	0.0	2.0	1259	13	11	11	2.7	1.2	3.6	0.5	4.6	0.5	0.0	0.5	0.2	6.2
GC-SED-18	N	0.0	1.0	1259	6.3	5.1	4.5	1.6	0.5	2.1	0.3	2.1	0.2	0.0	0.2	0.1	2.9
GC-SED-19C	N	1.5	2.0	1603	22	18	16	5.3	1.4	5.8	0.9	7.5	0.7	0.0	0.6	0.2	10
GC-SED-19C	N	5.8	6.8	1603	55	42	39	18	*14*	19	2.3	18	1.6	0.1	5.6	0.8	**28**
GC-SED-20	N	0.0	1.5	1603	5.1	4.4	5.5	1.4	0.5	1.5	0.2	1.8	0.2	0.0	0.2	0.1	2.6
GC-SED-20	N	4.0	5.0	1603	21	19	16	5.6	1.1	5.4	0.9	7.9	0.7	0.0	0.5	0.2	**10**
GC-SED-21B	N	1.5	3.0	1603	43	35	32	13	2.8	13	1.8	15	1.3	0.1	1.2	0.5	**19**
GC-SED-21B	N	7.0	8.0	1603	15	12	11	3.1	0.9	3.5	0.6	5.0	0.5	0.0	0.4	0.1	6.6
GC-SED-22B	N	0.0	1.0	1921	7.2	6.2	6.1	1.9	0.6	2.6	0.3	2.6	0.3	0.0	0.3	0.1	3.5
GC-SED-22B	N	7.0	8.0	1921	50	40	30	10	3.4	12	2.1	17	1.3	0.0	1.4	0.5	**22**
GC-SED-23	N	0.0	2.0	1921	5.3	4.6	5.2	1.2	0.6	1.5	0.2	1.9	0.2	0.0	0.2	0.1	2.7
GC-SED-24B	N	3.0	5.0	1921	7.6	7.1	7.3	2.2	0.6	1.9	0.3	3.0	0.3	0.0	0.3	0.1	3.9
GC-SED-25B	N	1.0	4.0	2348	13	11	5.5	7.7	2.1	6.0	0.5	4.6	0.2	0.0	0.9	0.3	6.5
GC-SED-26	N	1.0	2.0	2348	14	12	11	3.2	0.9	3.4	0.6	5.0	0.5	0.0	0.4	0.1	6.6
GC-SED-27	N	0.5	1.0	2348	3.3	2.9	3.4	1.0	*1.6*	1.7	0.1	1.2	0.1	0.0	0.6	0.1	2.2
GC-SED-27	N	4.9	5.4	2348	100	67	61	24	*60*	*60*	4.2	28	2.5	0.1	25	2.5	**62**
GC-SED-28	N	1.5	2.5	2608	9.4	8.4	5.0	4.7	2.1	5.5	0.4	3.5	0.2	0.0	0.9	0.2	5.2
GC-SED-28	N	4.9	5.8	2608	8.9	6.8	3.1	3.3	1.3	2.6	0.4	2.8	0.1	0.0	0.5	0.1	4.0
GC-SED-29	N	2.3	4.6	2608	6.0	5.6	3.4	3.3	1.1	2.8	0.3	2.3	0.1	0.0	0.5	0.1	3.3
GC-SED-30	N	3.5	5.5	2608	12	11	5.3	6.0	2.7	6.9	0.5	4.6	0.2	0.0	1.1	0.3	6.7
GC-SED-31	N	2.5	4.5	2799	25	20	11	11	4.3	9.9	1.0	8.3	0.5	0.0	1.8	0.4	**12**
GC-SED-31	N	11.5	12.5	2799	550	380	*550*	260	*550*	*550*	23	158	23	1.1	229	23	**457**
GC-SED-32	N	0.5	1.5	2799	3.4	3.4	2.4	2.1	0.7	2.1	0.1	1.4	0.1	0.0	0.3	0.1	2.1
GC-SED-32	N	5.9	6.9	2799	54	43	21	21	8.1	20	2.3	18	0.9	0.1	3.4	0.8	**25**
GC-SED-33	N	1.5	3.0	2799	18	15	7.5	11	3.3	8.7	0.8	6.3	0.3	0.0	1.4	0.4	9.1
GC-SED-34B	N	2.0	3.0	3054	46	39	18	21	7.5	17	1.9	16	0.8	0.1	3.1	0.7	**23**
GC-SED-34B	N	5.8	6.8	3054	56	46	23	22	8.2	20	2.3	19	1.0	0.1	3.4	0.8	**27**
GC-SED-35	N	0.0	4.5	3054	26	20	*19*	11	*19*	8.4	1.1	8.3	0.8	0.0	7.9	0.4	**19**
GC-SED-35	N	8.8	10.8	3054	220	150	*195*	79	*195*	64	9.2	63	8.1	0.3	81	2.7	**164**
GC-SED-36	N	2.5	4.5	3054	33	30	12	21	5.8	14	1.4	13	0.5	0.1	2.4	0.6	**17**
GC-SED-36	N	8.0	9.0	3054	520	320	*280*	*280*	*280*	100	22	133	12	1.2	117	4.2	**289**
GC-SED-37B	N	7.0	8.0	3278	650	510	270	270	110	280	27	213	11	1.1	46	12	**309**

TABLE C.3
Comparison of PAH Concentrations in Soft Sediment to Human Health-Based Preliminary Remediation Goals
Gowanus Canal Feasibility Study
Brooklyn, New York

	Sample	Top	Bottom	Distance from	Concentration in mg/kg						Elevation above Recreational Use Preliminary Remediation Goal						
Location ID	**Type**	**Depth**	**Depth**	**Head of Canal (ft)**	**BAA**	**BAP**	**BBF**	**BKF**	**DA**	**ID**	**BAA**	**BAP**	**BBF**	**BKF**	**DA**	**ID**	**SUM[1]**
		PRG - recreational use			24	2.4	24	240	2.4	24							
		PRG - canal overflow			53	5.3	53	530	5.3	53							
GC-SED-38	N	5.1	6.1	3278	130	100	41	50	19	47	5.4	42	1.7	0.2	7.9	2.0	**59**
GC-SED-39	N	1.0	2.0	3278	54	43	18	25	11	25	2.3	18	0.8	0.1	4.6	1.0	**27**
GC-SED-39	N	4.5	5.5	3278	410	230	220	*230*	*230*	84	17	96	9.2	1.0	96	3.5	**222**
GC-SED-40	N	2.5	3.5	3444	9.2	6.9	2.4	4.4	1.2	3.0	0.4	2.9	0.1	0.0	0.5	0.1	4.0
GC-SED-41	N	0.0	4.5	3444	0.9	0.7	0.3	0.3	0.1	0.2	0.0	0.3	0.0	0.0	0.0	0.0	0.4
GC-SED-43	N	2.0	3.0	3540	400	260	*195*	*195*	*195*	100	17	108	8.1	0.8	81	4.2	**219**
GC-SED-43	N	7.3	8.3	3540	470	370	260	100	*270*	99	20	154	11	0.4	113	4.1	**302**
GC-SED-44	N	0.5	2.5	3540	220	130	100	40	*155*	47	9.2	54	4.2	0.2	65	2.0	**134**
GC-SED-44	N	5.6	6.1	3540	460	320	220	94	*290*	82	19	133	9.2	0.4	121	3.4	**286**
GC-SED-45C	N	1.0	1.5	3540	690	460	320	150	*490*	100	29	192	13	0.6	204	4.2	**443**
GC-SED-46C	N	1.5	2.5	3740	210	130	100	37	13	41	8.8	54	4.2	0.2	5.4	1.7	**74**
GC-SED-46C	N	5.0	5.5	3740	590	400	310	*460*	*460*	110	25	167	13	1.9	192	4.6	**402**
GC-SED-47	N	1.5	2.5	3740	170	110	78	28	*110*	37	7.1	46	3.3	0.1	46	1.5	**104**
GC-SED-48	N	0.5	1.5	3740	230	140	120	39	*95*	49	9.6	58	5.0	0.2	40	2.0	**115**
GC-SED-48	N	5.0	5.8	3740	410	250	270	*305*	*305*	*305*	17	104	11	1.3	127	13	**274**
GC-SED-49	N	2.5	3.5	3875	670	370	270	100	62	110	28	154	11	0.4	26	4.6	**224**
GC-SED-49	N	5.4	5.9	3875	140	110	85	32	*110*	32	5.8	46	3.5	0.1	46	1.3	**103**
GC-SED-50B	N	2.0	5.0	3875	630	480	*495*	290	*495*	170	26	200	21	1.2	206	7.1	**461**
GC-SED-51	N	0.0	1.5	3875	190	130	120	30	17	51	7.9	54	5.0	0.1	7.1	2.1	**76**
GC-SED-51	N	6.7	7.2	3875	880	630	*550*	380	*550*	180	37	263	23	1.6	229	7.5	**560**
GC-SED-52	N	3.0	6.0	4038	480	320	240	84	*230*	95	20	133	10	0.4	96	4.0	**263**
GC-SED-53	N	0.5	1.5	4038	160	110	94	29	13	30	6.7	46	3.9	0.1	5.4	1.3	**63**
GC-SED-54B	N	0.0	2.0	4038	52	38	31	12	3.7	13	2.2	16	1.3	0.1	1.5	0.5	**21**
GC-SED-54B	N	4.5	5.7	4038	560	390	280	*455*	*455*	130	23	163	12	1.9	190	5.4	**394**
GC-SED-55	N	1.5	2.5	4264	88	66	52	18	15	33	3.7	28	2.2	0.1	6.3	1.4	**41**
GC-SED-55	N	10.0	11.0	4264	38	28	19	8.9	5.8	12	1.6	12	0.8	0.0	2.4	0.5	**17**
GC-SED-57	N	7.0	9.0	4264	77	59	48	16	6.3	21	3.2	25	2.0	0.1	2.6	0.9	**33**
GC-SED-58C	N	0.0	5.0	4604	200	120	110	*165*	*165*	34	8.3	50	4.6	0.7	69	1.4	**134**
GC-SED-59	N	0.5	1.0	4604	450	340	*200*	*200*	*200*	90	19	142	8.3	0.8	83	3.8	**257**
GC-SED-60B	N	0.0	2.5	4604	200	140	110	44	*44*	48	8.3	58	4.6	0.2	18	2.0	**92**
GC-SED-62C	N	0.0	2.0	4819	52	38	30	11	4.0	13	2.2	16	1.3	0.0	1.7	0.5	**22**
GC-SED-62C	N	3.0	4.0	4819	270	190	140	71	*220*	*220*	11	79	5.8	0.3	92	9.2	**197**
GC-SED-63	N	3.0	3.5	4819	56	40	33	10.0	*23*	14	2.3	17	1.4	0.0	9.4	0.6	**30**
GC-SED-64D	N	2.0	4.0	5161	260	190	150	*155*	*155*	47	11	79	6.3	0.6	65	2.0	**163**
GC-SED-65	N	0.5	1.3	5161	200	140	130	*150*	*150*	45	8.3	58	5.4	0.6	63	1.9	**137**
GC-SED-67B	N	0.0	1.0	5730	8.7	8.0	8.5	*0.9*	1.3	3.3	0.4	3.3	0.4	0.0	0.5	0.1	4.7
GC-SED-67B	N	7.0	8.0	5730	350	240	190	62	*205*	69	15	100	7.9	0.3	85	2.9	**211**
GC-SED-68	N	0.0	1.0	5730	19	16	15	4.6	1.9	6.1	0.8	6.7	0.6	0.0	0.8	0.3	9.1
GC-SED-68	N	2.2	3.1	5730	210	110	*200*	*200*	*200*	55	8.8	46	8.3	0.8	83	2.3	**149**
GC-SED-69C	N	0.0	1.0	5730	18	17	10.0	8.9	3.6	9.9	0.8	7.1	0.4	0.0	1.5	0.4	**10**
GC-SED-69C	N	6.0	7.0	5730	13	10.0	4.6	5.1	2.1	4.6	0.5	4.2	0.2	0.0	0.9	0.2	6.0
GC-SED-71C	N	1.5	2.5	5908	23	16	14	4.0	*10.0*	6.3	1.0	6.7	0.6	0.0	4.2	0.3	**13**
GC-SED-71C	N	2.5	4.0	5908	51	38	*40*	*40*	9.2	19	2.1	16	1.6	0.2	3.8	0.8	**24**
GC-SED-72B	N	0.0	2.0	5908	0.3	0.3	0.3	0.1	*0.2*	0.1	0.0	0.1	0.0	0.0	0.1	0.0	0.2
GC-SED-72B	N	5.5	7.0	5908	33	26	22	8.3	2.5	11	1.4	11	0.9	0.0	1.0	0.5	**15**
GC-SED-73E	N	1.0	2.5	6256	17	14	11	3.6	1.9	5.9	0.7	5.8	0.5	0.0	0.8	0.2	8.1
GC-SED-74	N	5.3	6.3	6256	47	40	33	11	*41*	17	2.0	17	1.4	0.0	17	0.7	**38**
GC-SED-75C	N	0.0	0.7	6256	5.1	4.2	3.6	1.9	0.8	2.2	0.2	1.8	0.2	0.0	0.3	0.1	2.5
GC-SED-75C	N	0.7	1.5	6256	0.3	0.5	0.4	0.2	0.1	0.2	0.0	0.2	0.0	0.0	0.0	0.0	0.3
GC-SED-76C	N	2.5	3.4	6649	11	9.8	9.8	3.4	1.3	4.7	0.5	4.1	0.4	0.0	0.5	0.2	5.7

TABLE C.3

Comparison of PAH Concentrations in Soft Sediment to Human Health-Based Preliminary Remediation Goals

Gowanus Canal Feasibility Study

Brooklyn, New York

	Sample	Top	Bottom	Distance from	Concentration in mg/kg						Elevation above Recreational Use Preliminary Remediation Goal						
Location ID	**Type**	**Depth**	**Depth**	**Head of Canal (ft)**	**BAA**	**BAP**	**BBF**	**BKF**	**DA**	**ID**	**BAA**	**BAP**	**BBF**	**BKF**	**DA**	**ID**	**SUM [1]**
		PRG - recreational use			24	2.4	24	240	2.4	24							
		PRG - canal overflow			53	5.3	53	530	5.3	53							
GC-SED-77	N	0.0	3.0	6649	5.6	6.3	6.0	1.9	0.9	2.7	0.2	2.6	0.3	0.0	0.4	0.1	3.6
GC-SED-77	N	14.5	15.4	6649	97	75	60	19	8.6	27	4.0	31	2.5	0.1	3.6	1.1	**43**
GC-SED-78B	N	0.0	1.0	6649	7.0	5.3	6.3	2.4	0.7	2.6	0.3	2.2	0.3	0.0	0.3	0.1	3.2
GC-SED-78B	N	2.5	5.0	6649	22	14	15	5.2	*7.0*	5.7	0.9	5.8	0.6	0.0	2.9	0.2	**11**
GC-SED-79	N	2.5	3.5	7596	34	26	21	6.3	3.2	8.5	1.4	11	0.9	0.0	1.3	0.4	**15**
GC-SED-80	N	0.0	2.0	7596	12	8.7	7.4	3.3	1.1	4.0	0.5	3.6	0.3	0.0	0.5	0.2	5.1
GC-SED-81	N	8.0	11.0	7596	39	31	23	7.7	*9.5*	9.8	1.6	13	1.0	0.0	4.0	0.4	**20**
GC-SED-81	N	13.0	13.5	7596	*0.2*	*0.2*	*0.2*	*0.2*	*0.2*	*0.2*	0.0	0.1	0.0	0.0	0.1	0.0	0.2
GC-SED-82	N	0.0	2.0	7596	96	65	54	19	11	31	4.0	27	2.3	0.1	4.6	1.3	**39**
GC-SED-82	N	12.0	12.8	7596	83	65	46	16	8.3	21	3.5	27	1.9	0.1	3.5	0.9	**37**
GC-SED-83	N	0.0	2.0	7596	9.8	7.9	6.8	2.8	1.4	5.0	0.4	3.3	0.3	0.0	0.6	0.2	4.8
GC-SED-83	N	11.0	11.9	7596	14	9.7	7.9	2.7	1.5	4.7	0.6	4.0	0.3	0.0	0.6	0.2	5.8
GC-SED-84	N	1.0	2.0	2469	15	13	13	3.7	1.4	4.8	0.6	5.4	0.5	0.0	0.6	0.2	7.4
GC-SED-85B	N	0.0	1.0	2469	15	12	10.0	3.0	1.2	3.4	0.6	5.0	0.4	0.0	0.5	0.1	6.7
GC-SED-85B	N	8.5	9.3	2469	100	71	63	26	7.7	27	4.2	30	2.6	0.1	3.2	1.1	**41**
GC-SED-86	N	0.0	1.0	2469	61	53	40	26	8.9	28	2.5	22	1.7	0.1	3.7	1.2	**31**
GC-SED-87	N	4.4	6.2	2469	67	40	33	16	8.5	17	2.8	17	1.4	0.1	3.5	0.7	**25**
GC-SED-88	N	0.5	1.0	3573	50	34	26	12	6.3	14	2.1	14	1.1	0.1	2.6	0.6	**21**
GC-SED-89B	N	1.8	2.3	3573	54	40	31	11	5.7	16	2.3	17	1.3	0.0	2.4	0.7	**23**
GC-SED-90B	N	0.0	1.0	3573	170	140	100	40	16	55	7.1	58	4.2	0.2	6.7	2.3	**79**
GC-SED-91	N	4.7	6.2	3961	47	29	29	8.8	*9.5*	9.9	2.0	12	1.2	0.0	4.0	0.4	**20**
GC-SED-92	N	0.0	2.0	3961	46	32	29	10.0	3.7	13	1.9	13	1.2	0.0	1.5	0.5	**19**
GC-SED-93	N	0.0	1.0	3961	68	*230*	*230*	*230*	*230*	*230*	2.8	96	9.6	1.0	96	9.6	**215**
GC-SED-94	N	0.5	1.3	4961	88	55	42	13	9.7	28	3.7	23	1.8	0.1	4.0	1.2	**34**
GC-SED-95	N	3.5	4.5	2478	26	18	11	5.8	2.1	7.0	1.1	7.5	0.5	0.0	0.9	0.3	**10**
GC-SED-96	N	0.0	1.0	2704	5.5	4.5	4.8	1.6	0.6	2.1	0.2	1.9	0.2	0.0	0.3	0.1	2.7
GC-SED-97	N	0.5	2.0	2952	36	29	22	6.9	3.7	11	1.5	12	0.9	0.0	1.5	0.5	**17**
GC-SED-97	N	8.5	9.0	2952	200	110	130	*125*	*125*	*125*	8.3	46	5.4	0.5	52	5.2	**117**
GC-SED-98	N	1.0	2.0	3144	29	25	19	5.4	3.4	9.8	1.2	10	0.8	0.0	1.4	0.4	**14**
GC-SED-98	N	8.5	9.5	3144	520	310	*650*	*650*	*650*	*650*	22	129	27	2.7	271	27	**479**
GC-SED-99B	N	3.5	4.5	3361	200	160	67	81	26	77	8.3	67	2.8	0.3	11	3.2	**92**
GC-SED-99B	N	7.2	8.7	3361	630	440	300	*430*	*430*	120	26	183	13	1.8	179	5.0	**408**

Notes:

BAA - benzo(a)anthracene; BAP - benzo(a)pyrene; BBF - benzo(b)fluoranthene; BKF - benzo(k)fluoranthene; DA - dibenz(a,h)anthracene; ID - indeno(1,2,3-cd)pyrene

Individual preliminary remediation goals (PRGs) are based on 10^{-5} risk so that cumulative risk is less than 10^{-4}

Italics - constituent not detected; value is one-half the detection limit

Boldface - sum exceeds 10

[1] Potential risk is greater than 10^{-4} if the sum of the exceedances exceeds 10

Appendix D
Propeller Wash and Cap Armor Thickness Calculations

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Propeller Wash and Cap Armor Thickness Calculations

1. Objective

The potential effects of propeller wash on sediments in the Gowanus Canal in Brooklyn, New York, were evaluated to support the development and evaluation of remedial alternatives in the Gowanus Canal feasibility study (FS). In situ capping is one component of the remedial alternatives in the FS. The objectives of this report are as follows:

- Present preliminary calculations that estimate bottom flow velocities and bottom shear from propeller wash due to barge operations in the Gowanus Canal
- Determine the conceptual sizing of sediment cap armor layer material required to prevent scour of the cap from continued barge operations

The sizing for a sediment cap armor layer to withstand currents from the operation of a flushing tunnel in the upper reach of the canal was also determined.

2. Approach

Information about tug boat properties was obtained through discussions with tug operators on the Gowanus Canal. A range of water depths was defined based on bathymetry in the canal and tidal ranges under which the tugs would operate.

Near-bed velocities and bottom shear from a propeller jet are calculated based on methods presented in Verhey (1983) and earlier work performed by Blaauw and Kaa (1978). Resulting propeller-induced water velocities and shear stresses are presented in tabular and graphical formats as a function of water depth.

The characteristics of the armor layer for the sediment cap in the middle canal (remediation target area [RTA] 2, between 3rd Street and Hamilton Street) and lower canal (RTA 3, below Hamilton Avenue) were determined using the methods presented in *Guidance for In Situ Subaqueous Capping of Contaminated Sediments: Appendix A: Armor Layer Design* (Palermo et al., 1998).

3. Tug and Canal Properties

Table 1 presents the information about tug boat properties relevant to the propeller wash and scour calculations that was obtained during telephone conversations with representatives from the identified tug operators (Mathews, 2011; Vane Brothers, 2011). For the purposes of this report, it is assumed that the maximum vessel draft for tugs operating in the lower canal is 11 feet. This assumption is based on the vessel characteristics provided by a representative of Vane Brothers (Table 1).

Canal bottom elevations in the middle canal are between -14 and -18 feet North American Vertical Datum 1988 (NAVD88). The preliminary conceptual design elevation is -18 feet NAVD88. The mean lower low water (MLLW) tidal datum is at approximately -3 feet NAVD88, with a mean higher high water (MHHW) datum at +2.0 feet NAVD88. A range of water depths, from 11 to 23 feet, was used to calculate bottom velocities and bottom shear within the Middle Canal, which approximates the range corresponding to the shallowest areas at MLLW and the deepest areas at MHHW. Tug operators indicated that they operate only in the Middle Canal during high tides, so calculations for canal depths at MLW may be overly conservative; however, values over the entire range were calculated to determine potential conditions in the event of operations at lower tides and to observe the sensitivity of the calculated values to changes in water depth.

TABLE 1
Tugboat Properties Used for Propeller Wash Calculations
Gowanus Canal Feasibility Study, Brooklyn, New York

Property	Middle and Lower Canal	Lower Canal	
Tug operator	Buchanan Marine (Tug #1)	Vane Brothers (Tug #2)	Vane Brothers (Tug #3)
Rated horsepower (hp) (per propeller)	2,200	3,000	4,200
Number of propellers	2	2	2
Propeller diameter (inches)	88	36	42
Type of propeller	Nonducted	Ducted (Kort nozzles)	Nonducted
Rudder?	Yes	Yes	Yes
Maximum vessel draft (feet)	9	8 to 11	8 to 11

Canal bottom elevations in the lower canal range from -20 to -38 feet NAVD88. Because of greater water depths in this portion of the canal, operations are not constrained to high tide, and water depths can range from about 17 feet at MLW in areas close to Hamilton Bridge to greater than 40 feet near the mouth of Gowanus Bay at high tides. Here, a range of water depths from 15 to 40 feet was used to calculate bottom velocities and bottom shear within the lower canal.

4. Calculation of Bottom Velocities

Calculation of bottom velocities caused by ship propellers requires the following:

- Definition of power delivered to the propulsion system
- Distance of the propeller above the seabed
- Dimensions of propellers for each vessel
- Calculation of the flow field behind the jet

4.1 Power Used for Maneuvering

The amount of power supplied to the tug propeller to execute various barge maneuvers determines the thrust generated and velocity of the flow in the jet. The amount of thrust required from the tug to handle a barge will vary with the size and load condition of the barge. For the purposes of these initial calculations, it is assumed that the tug may be required to generate full thrust while maneuvering a barge. This is likely a conservative assumption, one made for the purposes of conceptual planning. Actual power required from the tugs may be less, and a more detailed study of design vessel characteristics should be performed if refinement to the cap material sizing is desired in the preliminary design phase.

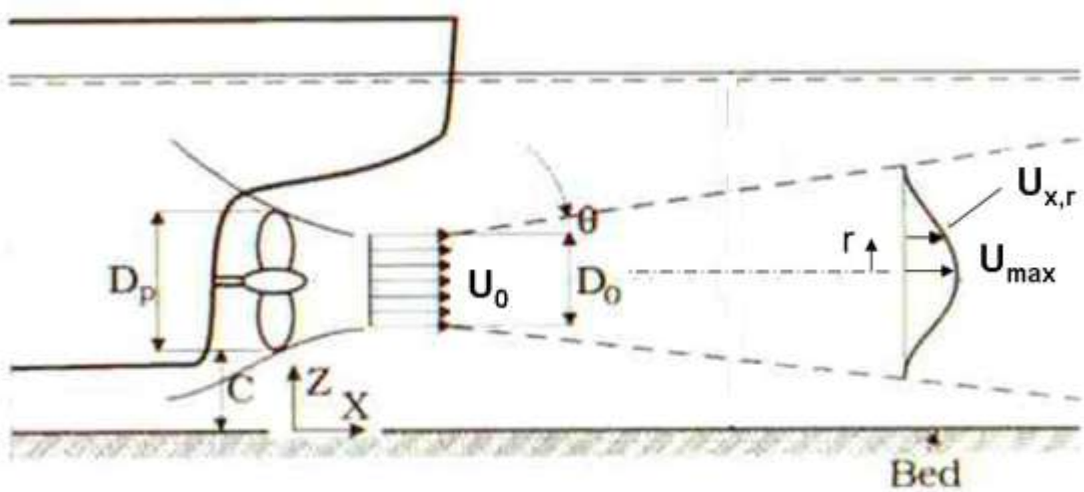
4.2 Distance Above the Bottom

The distance of the propeller above the seabed was estimated by assuming that the tip of the propeller was at approximately the depth of the maximum draft of the vessel; that is, the elevation of the propeller shaft above the bottom was calculated as the water depth minus the maximum vessel draft plus half the propeller diameter.

4.3 Propeller Calculations

A definition sketch for the jet generated behind a tug's propeller is shown in Figure 1. The flow field is broken down into a zone of flow establishment and the zone of established flow. The dividing line between these two zones is at the point of maximum contraction of the jet, at which point the jet has a diameter of D_0 and a flow velocity of u_0.

FIGURE 1
Definition Sketch for Propeller Jet Calculations
Gowanus Canal Feasibility Study, Brooklyn, New York



The maximum velocity, u_{max}, at a distance, x, from the propeller is located along the centerline of the jet. $u_{x,r}$ is the velocity distribution radially from the centerline of the jet. Equations 1 through 3 can be used to calculate these variables for a jet produced by a propeller.

The initial velocity in the zone of established flow, u_0, can be calculated as a function of the power delivered to the propeller, P_d, and the corresponding diameter of the jet, D_0, as:

$$u_0 = 1.15\left[\frac{P_d}{\left(\rho_w D_0^2\right)}\right]^{0.33} \qquad \text{(Eq. 1)}$$

where ρ_w is the water density.

The velocity distribution in the flow field behind a propeller can be described using the following equations (Verheij and Stolker, 2007):

$$u_{max} = 2.8 u_0 D_0 x^{-1.0} \qquad \text{(Eq. 2)}$$

$$u_{x,r} = u_{max} e^{-15.4 r^2 / x^2} \qquad \text{(Eq. 3)}$$

For a propeller with a horizontal axis, the bottom velocities can be calculated using Equation 3 by setting r equal to the distance from the propeller axis to the bottom.

Verhey (1983) presents the following relations for D_0 related to the propeller diameter, D_P:

$D_0 = 0.71 D_P$	(for nonducted propellers)
$D_0 = D_P$	(for ducted propellers)
$D_0 = 0.85 D_P$	(for propellers in tunnels)

For the purposes of this study, a D_0 of $0.71D_P$ was assumed for nonducted propellers and a D_0 of D_P was assumed for ducted propellers (i.e., propellers with Kort nozzles).

5. Calculation of Bottom Shear

Bottom shear was calculated as:

$$\tau_b = \frac{1}{2} \rho f_c u^2 \qquad \text{(Eq. 4)}$$

where:

ρ = water density

f_c = friction factor

u = velocity at the bed

Blaauw and Kaa (1978) recommend using a friction factor of between 0.06 and 0.11 for calculation of bottom shear induced by flow from ship propellers and these values were used to calculate bottom shear that would accompany the estimated near-bottom propeller jet velocities.

6. Armor Stone Sizing

The stone sizing was calculated based on the navigation effects (tug usage) within the canal using the following equation:

$$D_{50} = \left(\frac{Vb(\text{max})}{C_3}\right)^2 / (\text{g} \times \text{Ä}) \quad \text{(Eq. 5)}$$

Where:

D_{50} = median stone size

Vb(max) = maximum bottom velocity

C_3 = coefficient for armor movement

g = gravitational constant

$\text{Ä} = (\text{ã}s - \text{ã}w)/\text{ã}w$

ãs = unit weight of stone, typically 165 lb/ft^3

ãw = unit weight of water, 62.4 lb/ ft^3

The maximum bottom velocity was determined using Equation 3 to calculate bottom velocities along a range of distances behind the propeller.

Capping guidance (Palermo et al., 1998) recommends values for C_3 between 0.6 and 0.7 for cap design in areas where infrequent propeller wash is expected at any given location in the channel, and 0.55 in areas such as harbors where propeller wash will be more persistent and scour holes more likely to form. Armor stone was sized for the FS using a C_3 value of 0.6. The cap thickness was determined to be two times the median stone size (i.e., 2 × D_{50}), which is consistent with guidance from Palermo et al (1998) for thickness of a cap under the influence of propeller wash.

7. Results

Results of the bottom velocity and bottom shear based on the calculations described above are presented in Tables 2 through 4, with plots of bottom shear versus water depth following each table (Figures 2 through 4).

Table 5 presents the range of stone sizes and cap thicknesses calculated for the middle and lower canal (RTA 2 and RTA 3) based on the bottom velocities presented in Tables 2 through 4.

TABLE 2
Bottom Velocities and Bottom Shear for Tug #1 Operating in the Middle Canal
Gowanus Canal Feasibility Study, Brooklyn, New York

		Bottom Shear, lb/ft2	
Water Depth, ft	**Water Velocity, ft/s**	f_c **= 0.06**	f_c **= 0.11**
11	7.2	3.1	5.7
12	6.1	2.3	4.1
13	5.3	1.7	3.1
14	4.7	1.3	2.4
15	4.2	1.1	2.0
16	3.8	0.88	1.6
17	3.5	0.74	1.4
18	3.2	0.63	1.1
19	3.0	0.54	0.98
20	2.8	0.47	0.86
21	2.6	0.41	0.75
22	2.5	0.36	0.66
23	2.3	0.32	0.59

FIGURE 2
Calculated Bottom Velocities and Bottom Shear, Middle Canal, Tug #1
Gowanus Canal Feasibility Study, Brooklyn, New York

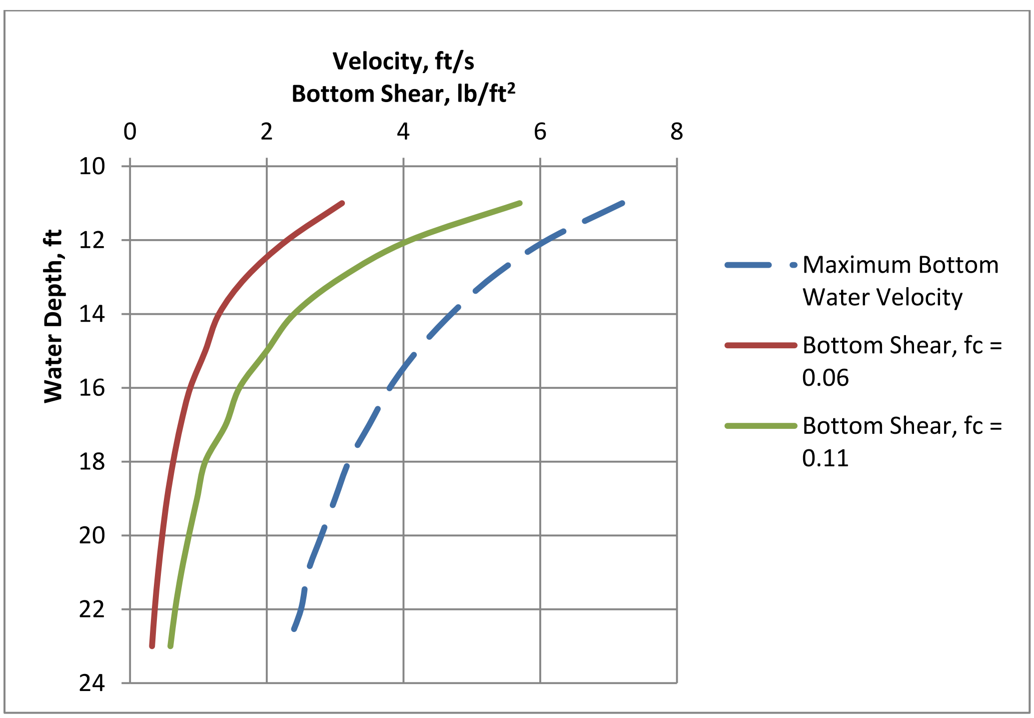


TABLE 3
Bottom Velocities and Bottom Shear for Tug #2 Operating in the Lower Canal
Gowanus Canal Feasibility Study, Brooklyn, New York

		Bottom Shear, lb/ft2	
Water Depth, ft	**Water Velocity, ft/s**	**f_c = 0.06**	**f_c = 0.11**
15	6.9	2.8	5.2
17	5.0	1.5	2.8
19	4.0	0.95	1.7
21	3.3	0.65	1.2
23	2.8	0.47	0.86
25	2.4	0.36	0.65
27	2.2	0.28	0.51
29	1.9	0.22	0.41
31	1.8	0.18	0.34
34	1.5	0.14	0.26
37	1.4	0.11	0.21
40	1.2	0.09	0.17

FIGURE 3
Calculated Bottom Velocities and Shear, Lower Canal, Tug #2
Gowanus Canal Feasibility Study, Brooklyn, New York

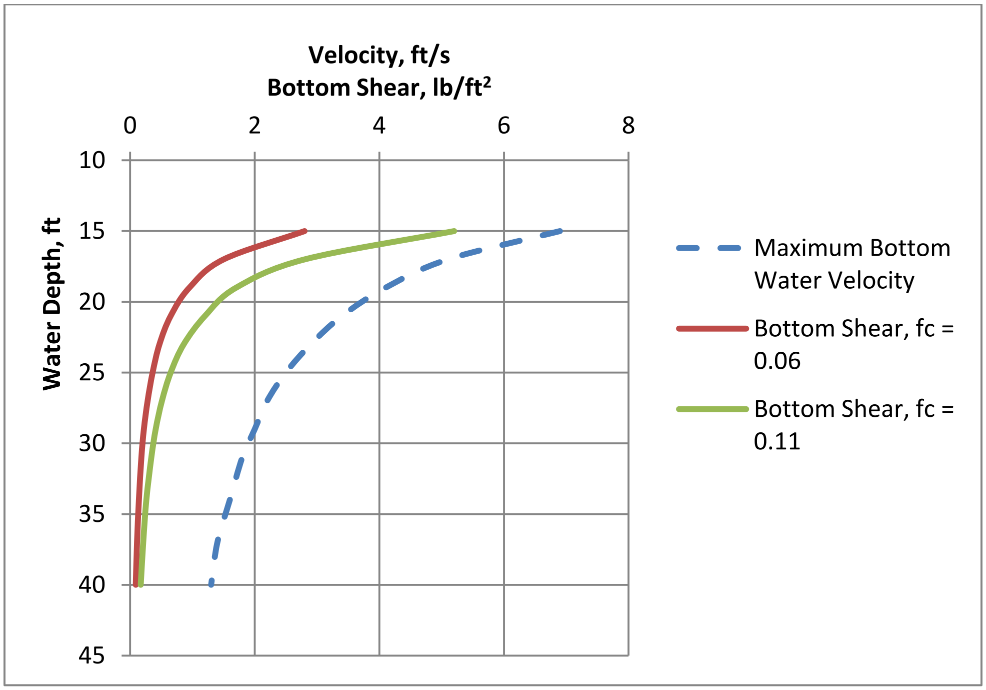


TABLE 4
Bottom Velocities and Bottom Shear for Tug #3 Operating in the Lower Canal
Gowanus Canal Feasibility Study, Brooklyn, New York

		Bottom Shear, lb/ft2	
Water Depth, ft	**Water Velocity, ft/s**	f_c **= 0.06**	f_c **= 0.11**
15	6.9	2.9	5.2
17	5.1	1.6	2.9
19	4.1	1.0	1.8
21	3.4	0.68	1.2
23	2.9	0.50	0.91
25	2.5	0.38	0.70
27	2.2	0.30	0.55
29	2.0	0.24	0.44
31	1.8	0.20	0.37
34	1.6	0.15	0.28
37	1.4	0.12	0.22
40	1.3	0.10	0.18

FIGURE 4
Calculated Bottom Velocities and Shear, Lower Canal, Tug #3
Gowanus Canal Feasibility Study, Brooklyn, New York

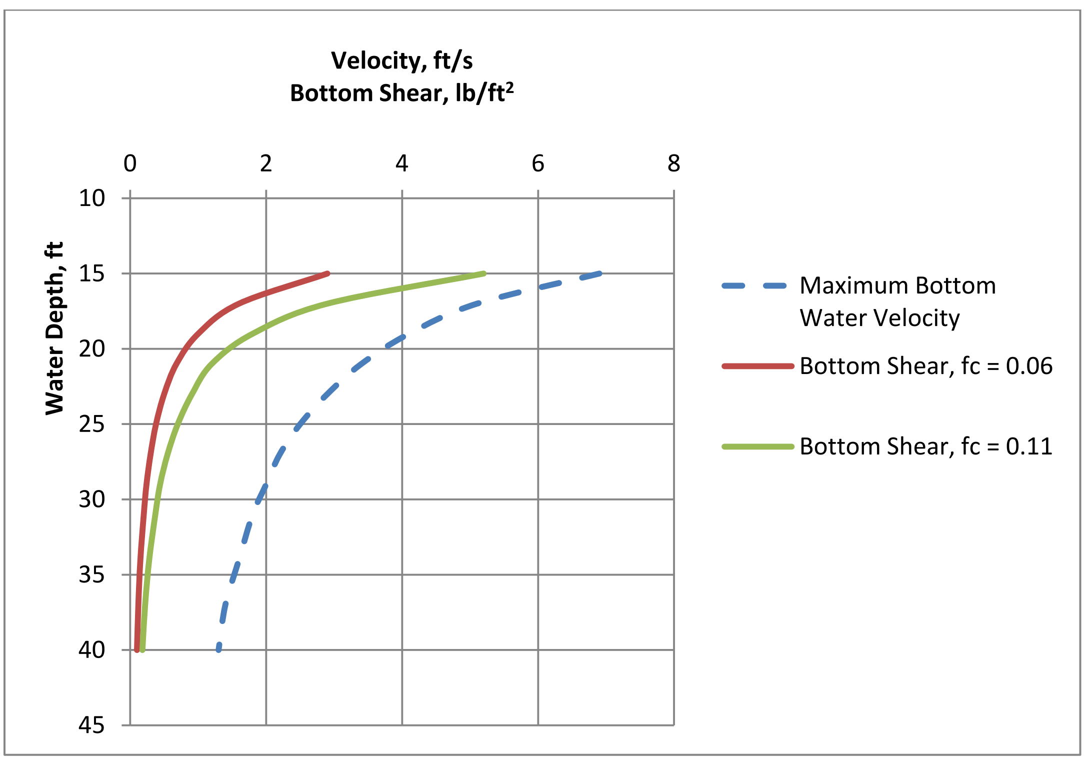


TABLE 5
Summary of Armor Sizes and Armor Layer Thicknesses for Middle and Lower Canal (RTA 1 and 2)
Gowanus Canal Feasibility Study, Brooklyn, New York

Water Velocity (ft/s)	D_{50} (ft)	Armor Layer Thickness (ft)
Middle Canal (RTA 2)		
7.2	2.72	5.4
6.1	1.95	3.9
5.3	1.47	2.9
4.7	1.16	2.3
4.2	0.93	1.9
3.8	**0.76**	**1.5**
3.5	0.64	1.3
3.2	0.54	1.1
3.0	0.47	0.9
2.8	0.41	0.8
Lower Canal (RTA 3)		
6.9	2.50	5.0
5.0	1.31	2.6
4.0	**0.84**	**1.7**
3.3	**0.57**	**1.1**
2.8	0.41	0.8
2.4	0.30	0.6
2.2	0.25	0.5
1.9	0.19	0.4
1.8	0.17	0.3
1.5	0.12	0.2
1.4	0.10	0.2
1.2	0.08	0.2

Boldface values indicate stone sizing assumptions used for feasibility study conceptual cap design.

8. Discussion

Assumptions associated with the conceptual-level sizing of the sediment cap material are discussed below.

8.1 Bed Velocity Estimates

Procedures used for estimating bed velocity estimates are consistent with the approach provided in Palermo et al. (1998) and are appropriate for conceptual level design of the sediment cap. There are a number of simplifications and assumptions implicit in this approach, including the following:

- **Power Delivered to Propellers.** It was assumed that full power of the tug was delivered to the propeller. This is a conservative assumption. A vessel under way will typically require a fraction of its power to maintain its speed. Maneuvering and berthing of a vessel require a greater percentage of its engine power. The power used by a tug will depend on operations that are being performed and the size of the barge it is handling.
- **Number of Propellers.** Water velocities were calculated based on jet theory for a single jet. Tug boats identified and used for the analysis in this TM each had two propellers, and the jets behind the two propellers would merge at some point, resulting in different flow fields and potentially larger maximum velocities.
- **Propeller Shaft Angle with Horizontal.** Tug boat characteristics were based on available information from tug boat operators in the canal. Although there was no indication from the tug boat operators that the tugs currently operating in the canal have propeller shafts that are not oriented horizontally, some tug boats have propeller shafts that are at an angle with respect to horizontal, resulting in a downward angle of the propeller jet. Operating boats which have propellers that have a downward angle can have a significantly greater impact on bottom sediments, especially in shallow water.
- **Influence of Rudders.** Rudders have an effect on the flow behind a propeller by splitting the wash into two streams, one directed upward and the other toward the bottom as shown in Figure 5 (Sumer and Fredsøe, 2002); however, literature describing the flow field sufficiently to determine the impact of a rudder on bottom velocities was not identified. Model studies do show that the presence of a rudder can increase the scour depth by 25 percent or more, depending on the rudder angle.

A site-specific, detailed study of tug boats and operations in the canal was not performed. However, the assumptions made for calculating near-bottom velocities and bottom shear stresses are consistent with guidance given in Palermo et al. (1998).

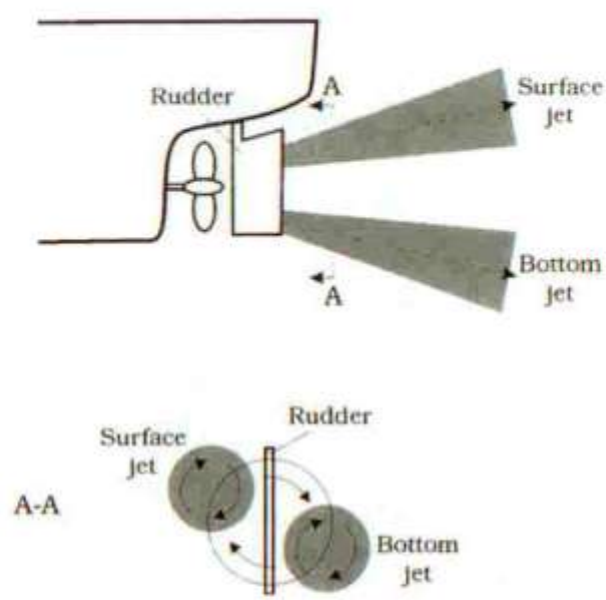
8.2 Armor Stone Sizing

As shown in Table 5, required armor stone size is sensitive to water depth in which the tugs operate, as reflected by the varying propeller wash velocities.

8.2.1 Middle Canal (RTA 2)

In the middle reach of the canal

FIGURE 5
Effect of Rudders on Propeller Wash (from Sumer and Fredsøe, 2002)
Gowanus Canal Feasibility Study, Brooklyn, New York



(RTA 2), the U.S. Army Corps of Engineers (USACE) estimated an elevation of -16 feet NAVD88 to facilitate commercial use of the canal (USACE, 2007, 2009). The final cap design will have a surface elevation of -18 feet NAVD88 to accommodate commercial use of the canal and allow a 2-foot buffer for sediment deposition on top of the cap. The MLLW elevation is approximately -3 feet NAVD88, resulting in a water depth over the cap of about 15 feet at low tide.

Commercial tugs that currently utilize the middle canal to move gravel barges to and from the concrete plant use the canal only during the flood tide cycle (Mathews, 2011). Assuming barges will be limited to operations during higher tides only, a minimum water depth of 16 feet was assumed to be conservative for the purposes of conceptual-level sizing of the cap material.

The selected median stone size for the conceptual cap design in the middle canal (RTA 2) is 0.76 feet, and a 1.5-foot armor layer is assumed.

8.2.2 Lower Canal (RTA 3)

The same cap stone size and armor layer thickness is assumed for the lower canal (RTA 3). The most frequent large tug activity (with respect to maneuvering) is in the lower canal, near the Amerada Hess oil terminal, where water depths are much deeper (25 feet or greater). However, the New York City asphalt plant is in a shallower area, as are the oil barges periodically moored on the eastern side of the canal; therefore, the more conservative stone size of 0.76 feet and a 1.5-foot armor layer is assumed for this reach.

8.2.3 Upper Canal (RTA 1)

The upper reach of the canal (RTA 1, between the head of the canal and 3rd Street) is not currently used for commercial navigation; however, future use requirements may include navigation by small work vessels to monitor and repair the sediment cap or to perform maintenance on the New York City sewer system infrastructure at the head of the canal. Further, the ongoing flushing tunnel upgrades are expected to result higher water velocities. The predicted (modeled) water velocities resulting from the upgraded flushing tunnel are expected to range from approximately 0.3 to 0.75 feet per second in the upper reach of the canal (USACE, undated).

A surficial layer of sand was determined to be sufficient to armor against flushing tunnel flows; however, this would not be expected to be protective against propeller wash from work vessels accessing the upper reach of the canal. As a result, the feasibility study also assumes that the cap placed in RTA 1 would include an armor layer that has a median stone size of 0.76 feet and is 1.5 feet thick. This assumption that requires this level of armor protection for RTA 1 should be re-evaluated during design.

The final cap designs will be determined during the remedial design. The assumptions and calculations herein are intended to provide realistic material volumes and thickness estimates for the purposes of the evaluating the alternatives in the FS.

9. References

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Appendix E
Dredge Volume Estimates

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Dredge Volume Estimates

This appendix describes the rationale and methods used to develop estimates for the sediment volumes that would be removed from each remediation target area (RTA) under Alternatives 5 and 7 developed for evaluation in the Gowanus Canal Feasibility Study (FS).

1. Summary of Alternatives

The following three alternatives are evaluated in the FS:

- Alternative 1: No Action.
- Alternative 5: Dredge entire soft-sediment column and cap with treatment layer, isolation layer, and armor layer.
- Alternative 7: Dredge entire soft-sediment column, solidify top 3–5 feet of native sediment in targeted areas, and cap with treatment layer, isolation layer, and armor layer.

In order to facilitate the development of these different alternatives, the removal volumes were calculated for each RTA. A removal elevation was specified for RTA 2 in order to identify areas where native sediments would require removal in order to accommodate a cap and still allow commercial vessels to traverse the canal. The final target sediment surface elevation for RTA 2 is -16 feet NAVD88, which will allow commercial vessels to traverse the canal. A 2-foot buffer and a 3.5-foot cap thickness are assumed; therefore, the dredge elevation is -21.5 feet NAVD88.

2. Method for Estimating Dredge Volumes

The dredge volumes were estimated using the soft-sediment thickness values and soft- and native-sediment surface elevation values presented in Table E-1. The volumes of soft and native sediment to be removed were determined separately for each RTA as applicable. Removal volumes for the four turning basins within RTA 2 were also calculated individually. These volume estimates do not include any type of offset for bulkhead stability, because the FS assumes that significant bulkhead repair and replacement will be required before sediment removal is performed. These volume estimates also do not include an over-dredge allowance. The volume estimates will be refined during remedial design.

To determine the total volume of soft and native sediment in each RTA, the soft sediment thickness values and native surface elevations were plotted and contoured in Spatial Analyst (an extension of ESRI ArcGIS). Two raster files were created, one that represented the surface and the other that represented the soft sediment thickness. Volume calculations were determined using the cut/fill operation within Spatial Analyst.

The same process was used to determine the volume of native sediment requiring removal in RTA 2. However, instead of contouring the entire soft-sediment thickness, only the required removal thickness was plotted and contoured; in instances where the difference between the removal elevation and the existing elevation was negative, these areas were treated as areas of “zero-removal.” Table E-2 provides the thickness of native sediment that would require removal in RTA 2 to allow for the cap thickness.

3. Results

The volume determinations for each RTA for each alternative are summarized in Table E-3.

TABLE E-1

Sediment Thickness and Elevation Data Used for Dredge Volume Calculations

Gowanus Canal Feasibility Study

Brooklyn, New York

RTA	Station ID	Easting (X)[a]	Northing (Y)	Native Surface Elevation (NAVD88)[b]	Soft Sediment Thickness (ft)	Sediment Surface Elevation (NAVD88)	Note
RTA 1	ERT1-2	634427.77	673633.99	-14.30	10.50	-3.80	
	ERT1-3	634460.51	673617.49	-11.84	9.80	-2.04	
	ERT1-1	634391.77	673647.37	-13.61	10.20	-3.41	
	GC-SD107	634413.11	673635.16	-16.08	12.00	-4.08	
	GC-SD01A	634371.28	673607.91	-21.13	16.90	-4.23	
	GC-SD02A	634402.00	673599.74	-20.02	16.80	-3.22	
	GC-SD03	634429.69	673583.80	-17.47	15.00	-2.47	
	GC-SD124	634340.71	673564.39	-25.58	14.00	-11.58	
	GC-SD125	634384.68	673554.68	-18.75	16.10	-2.65	
	GC-SD126	634429.84	673537.65	-13.24	11.00	-2.24	
	ERT2-2	634354.87	673503.25	-15.71	12.00	-3.71	
	ERT2-3	634390.82	673483.31	-17.04	14.10	-2.94	
	ERT2-1	634318.78	673510.00	-16.44	10.50	-5.94	
	GC-SD04A	634285.63	673438.09	-17.63	12.60	-5.03	
	GC-SD05A	634313.60	673432.78	-18.20	13.50	-4.70	
	GC-SD06A	634355.13	673411.90	-20.01	15.00	-5.01	
	GC-SD152	634280.01	673289.33	-18.15	14.00	-4.15	
	GC-SD07A	634227.22	673298.55	-19.15	12.60	-6.55	
	GC-SD08A	634255.69	673285.30	-18.97	14.80	-4.17	
	GC-SD108	634231.95	673200.67	-14.72	11.00	-3.72	
	ERT3-1	634149.54	673176.18	-13.68	8.80	-4.88	
	ERT3-2	634182.23	673159.58	-13.46	9.00	-4.46	
	ERT3-3	634215.00	673142.97	-14.48	11.20	-3.28	
	GC-SD10A	634066.63	672981.11	-20.45	13.80	-6.65	
	GC-SD11A	634086.74	672969.35	-19.41	12.50	-6.91	
	ERT4-3	634029.10	672770.00	-12.16	9.50	-2.66	
	GC-SD13B	633963.58	672791.88	-14.35	9.30	-5.05	
	GC-SD14A	633983.67	672782.48	-21.69	13.30	-8.39	
	GC-SD109	633912.23	672596.42	-15.13	5.70	-9.43	
	GC-SD16A	633828.90	672521.70	-21.09	11.40	-9.69	
	GC-SD17A	633864.93	672537.54	-19.76	9.00	-10.76	
	GC-SD18A	633887.21	672526.66	-16.03	6.50	-9.53	
	GC-SD153	633803.36	672395.30	-18.59	6.60	-11.99	
	GC-SD145	633791.00	672310.37	-20.09	6.30	-13.79	
	GC-SD19C	633769.29	672227.64	-18.73	11.00	-7.73	
	GC-SD146	633748.24	672058.48	-22.60	13.40	-9.20	
	GC-SD147	633772.00	672024.10	-17.72	6.10	-11.62	
	GC-SD148	633781.90	672022.77	-23.94	13.10	-10.84	
	GC-SD110	633682.91	671922.23	-20.70	10.80	-9.90	
	GC-SD22B	633669.58	671925.90	-17.61	9.70	-7.91	
	GC-SD24B	633709.15	671891.11	-18.71	8.80	-9.91	
	GC-SD127	633549.75	671757.01	-17.18	9.70	-7.48	
	GC-SD128	633588.78	671742.60	-19.07	7.20	-11.87	
	GC-SD129	633604.51	671726.39	-20.64	11.40	-9.24	

TABLE E-1

Sediment Thickness and Elevation Data Used for Dredge Volume Calculations

Gowanus Canal Feasibility Study

Brooklyn, New York

RTA	Station ID	Easting (X)[a]	Northing (Y)	Native Surface Elevation (NAVD88)[b]	Soft Sediment Thickness (ft)	Sediment Surface Elevation (NAVD88)	Note
RTA 2	GC-SD111	633530.99	671127.28	-14.75	10.10	-4.65	4th St Turning Basin
	GC-SD87A	633828.02	670945.84	-18.14	13.40	-4.74	
	GC-SD116	632576.11	671370.26	-18.73	10.20	-8.53	6th Street Turning Basin
	GC-SD88A	632491.15	671401.95	-19.42	13.40	-6.02	
	GC-SD89B	632648.18	671340.80	-19.74	11.20	-8.54	
	GC-SD90B	632902.28	671142.33	-14.30	6.60	-7.70	
	GC-SD117	632254.29	671107.65	-19.10	11.90	-7.20	7th Street Turning Basin
	GC-SD91A	632084.13	671200.88	-20.77	13.80	-6.97	
	GC-SD93A	632378.16	671029.44	-13.40	7.80	-5.60	
	GC-SD149	631543.92	670396.66	-22.79	11.80	-10.99	11th St Turning Basin
	GC-SD119	631673.79	670324.35	-21.71	20.00	-1.71	
	GC-SD25B	633439.12	671567.17	-24.07	12.80	-11.27	
	GC-SD26A	633459.11	671551.88	-19.72	7.30	-12.42	
	GC-SD27A	633475.29	671533.17	-20.62	8.10	-12.52	
	GC-SD112	633293.14	671426.76	-14.22	7.00	-7.22	
	GC-SD28B	633252.49	671513.18	-19.39	11.50	-7.89	
	GC-SD29A	633238.84	671471.48	-16.21	5.70	-10.51	
	GC-SD30A	633256.91	671442.92	-16.89	8.00	-8.89	
	GC-SD31A	633077.08	671550.03	-17.79	12.80	-4.99	
	GC-SD32A	633065.62	671517.73	-20.94	11.60	-9.34	
	GC-SD33A	633040.16	671481.39	-14.51	9.50	-5.01	
	GC-SD113	632853.82	671583.41	-22.63	14.00	-8.63	
	GC-SD34B	632847.79	671583.78	-21.85	12.90	-8.95	
	GC-SD35A	632813.58	671555.55	-20.33	10.40	-9.93	
	GC-SD36A	632801.03	671551.43	-19.84	10.50	-9.34	
	GC-SD37B	632570.52	671612.79	-16.52	7.00	-9.52	
	GC-SD38A	632604.82	671597.43	-16.59	7.30	-9.29	
	GC-SD39B	632606.80	671562.72	-19.93	9.60	-10.33	
	GC-SD40A	632418.04	671609.70	-19.65	8.90	-10.75	
	GC-SD41A	632427.12	671589.20	-18.35	2.90	-15.45	
	GC-SD42B	632444.55	671564.57	-18.39	4.20	-14.19	
	GC-SD114	632380.38	671570.77	-19.09	4.50	-14.59	
	GC-SD43A	632339.02	671583.64	-20.29	6.10	-14.19	
	GC-SD44A	632346.46	671536.55	-21.63	5.20	-16.43	
	GC-SD45C	632368.25	671518.38	-20.07	4.90	-15.17	
	GC-SD46C	632153.90	671463.18	-22.73	8.20	-14.53	
	GC-SD47A	632188.77	671431.56	-17.15	1.00	-16.15	
	GC-SD49A	632071.13	671373.45	-21.86	8.70	-13.16	
	GC-SD50B	632097.35	671342.44	-23.78	6.20	-17.58	
	GC-SD51A	632123.73	671326.02	-24.07	9.80	-14.27	
	GC-SD53A	632005.69	671215.51	-20.52	6.20	-14.32	
	GC-SD54B	632018.62	671172.68	-20.69	9.30	-11.39	
	GC-SD115	631941.75	671126.10	-20.07	6.70	-13.37	

TABLE E-1

Sediment Thickness and Elevation Data Used for Dredge Volume Calculations

Gowanus Canal Feasibility Study

Brooklyn, New York

RTA	Station ID	Easting (X)[a]	Northing (Y)	Native Surface Elevation (NAVD88)[b]	Soft Sediment Thickness (ft)	Sediment Surface Elevation (NAVD88)	Note
RTA 2	GC-SD56A	631870.43	671009.89	-17.69	5.00	-12.69	
	GC-SD57A	631915.69	671003.16	-20.99	11.50	-9.49	
	GC-SD130	631791.88	670940.52	-20.81	9.00	-11.81	
	GC-SD131	631816.20	670908.85	-18.24	3.30	-14.94	
	GC-SD132	631839.49	670884.45	-22.40	10.10	-12.30	
	GC-SD118	631655.17	670727.45	-17.92	3.90	-14.02	
	GC-SD59A	631695.70	670730.43	-22.63	7.20	-15.43	
	GC-SD60B	631721.71	670707.73	-20.11	8.30	-11.81	
	GC-SD61C	631545.57	670562.15	-24.45	13.30	-11.15	
	GC-SD62C	631578.01	670549.78	-25.80	10.80	-15.00	
	GC-SD63A	631609.30	670524.84	-23.94	10.70	-13.24	
	GC-SD120	631478.12	670312.41	-22.88	8.20	-14.68	
	GC-SD64D	631371.64	670275.67	-20.35	6.40	-13.95	
	GC-SD65A	631402.71	670251.90	-24.81	8.20	-16.61	
	GC-SD66C	631420.77	670216.81	-22.72	9.10	-13.62	
	GC-SD121	631388.08	670187.49	-20.17	7.40	-12.77	
	GC-SD105A	631316.58	670129.25	-21.94	6.90	-15.04	
	GC-SD133	631140.69	669954.75	-17.70	13.30	-4.40	
	GC-SD134	631180.93	669936.52	-24.70	11.00	-13.70	
	GC-SD135	631228.33	669926.54	-16.90	12.10	-4.80	
RTA 3a	GC-SD67B	631090.06	669777.71	-22.30	9.00	-13.30	
	GC-SD122	631068.00	669589.58	-24.76	2.80	-21.96	
	GC-SD70B	631030.37	669605.64	-24.78	6.40	-18.38	
	GC-SD72B	631097.91	669582.54	-28.00	8.60	-19.40	
	GC-SD136	631002.60	669474.21	-26.60	3.50	-23.10	
	GC-SD137	631029.88	669430.53	-32.64	7.20	-25.44	
	GC-SD138	631106.13	669389.68	-18.88	4.00	-14.88	
RTA 3b	GC-SD74E	630997.67	669253.05	-39.11	9.00	-30.11	
	GC-SD75C	631102.91	669231.38	-32.78	8.20	-24.58	
	GC-SD150	630894.44	669169.28	-38.87	12.35	-26.52	
	GC-SD151	631050.33	669093.74	-35.28	8.20	-27.08	
	GC-SD76C	630782.93	668936.19	-36.12	11.20	-24.92	
	GC-SD77A	630891.31	668861.10	-41.75	13.20	-28.55	
	GC-SD123	630858.12	668785.32	-44.24	15.80	-28.44	
	GC-SD139	630435.96	668733.58	-30.87	15.60	-15.27	
	GC-SD140	630526.94	668625.44	-42.58	11.40	-31.18	
	GC-SD141	630591.52	668510.65	-37.63	8.80	-28.83	
	GC-SD142	630022.58	668390.50	-38.11	11.60	-26.51	
	GC-SD143	630211.16	668362.60	-42.47	8.10	-34.37	
	GC-SD144B	630407.60	668352.52	-37.81	8.00	-29.81	
	GC-SD144C	630404.83	668362.00	-33.93	4.00	-29.93	
	GC-SD79A	630266.08	668735.70	-40.15	10.40	-29.75	
	GC-SD81A	630209.73	668620.52	-41.29	10.50	-30.79	
	GC-SD83A	630139.54	668432.01	-43.71	11.60	-32.11	

Notes:

[a] New York State Plane East Zone NAD83

[b] North American Vertical Datum 1988

RTA - Remediation Target Area

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TABLE E-2

Native Sediment Removal Thicknesses in Remediation Target Area 2

Gowanus Canal Feasibility Study

Brooklyn, New York

Station ID	Easting (X)[a]	Northing (Y)	Native Surface Elevation (NAVD88)[b]	Soft Sediment Thickness (ft)	Sediment Surface Elevation (NAVD88)	Removal Elevation (NAVD88)	Removal Thickness (ft)[c]	Note
GC-SD111	633530.99	671127.28	-14.75	10.10	-4.65	-21.5	6.75	4th St Turning Basin
GC-SD87A	633828.02	670945.84	-18.14	13.40	-4.74	-21.5	3.36	4th St Turning Basin
GC-SD116	632576.11	671370.26	-18.73	10.20	-8.53	-21.5	2.77	6th Street Turning Basin
GC-SD88A	632491.15	671401.95	-19.42	13.40	-6.02	-21.5	2.08	6th Street Turning Basin
GC-SD89B	632648.18	671340.80	-19.74	11.20	-8.54	-21.5	1.76	6th Street Turning Basin
GC-SD90B	632902.28	671142.33	-14.30	6.60	-7.70	-21.5	7.20	6th Street Turning Basin
GC-SD117	632254.29	671107.65	-19.10	11.90	-7.20	-21.5	2.40	7th Street Turning Basin
GC-SD91A	632084.13	671200.88	-20.77	13.80	-6.97	-21.5	0.73	7th Street Turning Basin
GC-SD93A	632378.16	671029.44	-13.40	7.80	-5.60	-21.5	8.10	7th Street Turning Basin
GC-SD149	631543.92	670396.66	-22.79	11.80	-10.99	-21.5	0.00	11th St Turning Basin
GC-SD119	631673.79	670324.35	-21.71	20.00	-1.71	-21.5	0.00	11th St Turning Basin
GC-SD25B	633439.12	671567.17	-24.07	12.80	-11.27	-21.5	0.00	
GC-SD26A	633459.11	671551.88	-19.72	7.30	-12.42	-21.5	1.78	
GC-SD27A	633475.29	671533.17	-20.62	8.10	-12.52	-21.5	0.88	
GC-SD112	633293.14	671426.76	-14.22	7.00	-7.22	-21.5	7.28	
GC-SD28B	633252.49	671513.18	-19.39	11.50	-7.89	-21.5	2.11	
GC-SD29A	633238.84	671471.48	-16.21	5.70	-10.51	-21.5	5.29	
GC-SD30A	633256.91	671442.92	-16.89	8.00	-8.89	-21.5	4.61	
GC-SD31A	633077.08	671550.03	-17.79	12.80	-4.99	-21.5	3.71	
GC-SD32A	633065.62	671517.73	-20.94	11.60	-9.34	-21.5	0.56	
GC-SD33A	633040.16	671481.39	-14.51	9.50	-5.01	-21.5	6.99	
GC-SD113	632853.82	671583.41	-22.63	14.00	-8.63	-21.5	0.00	
GC-SD34B	632847.79	671583.78	-21.85	12.90	-8.95	-21.5	0.00	
GC-SD35A	632813.58	671555.55	-20.33	10.40	-9.93	-21.5	1.17	
GC-SD36A	632801.03	671551.43	-19.84	10.50	-9.34	-21.5	1.66	
GC-SD37B	632570.52	671612.79	-16.52	7.00	-9.52	-21.5	4.98	
GC-SD38A	632604.82	671597.43	-16.59	7.30	-9.29	-21.5	4.91	
GC-SD39B	632606.80	671562.72	-19.93	9.60	-10.33	-21.5	1.57	
GC-SD40A	632418.04	671609.70	-19.65	8.90	-10.75	-21.5	1.85	
GC-SD41A	632427.12	671589.20	-18.35	2.90	-15.45	-21.5	3.15	
GC-SD42B	632444.55	671564.57	-18.39	4.20	-14.19	-21.5	3.11	
GC-SD114	632380.38	671570.77	-19.09	4.50	-14.59	-21.5	2.41	
GC-SD43A	632339.02	671583.64	-20.29	6.10	-14.19	-21.5	1.21	
GC-SD44A	632346.46	671536.55	-21.63	5.20	-16.43	-21.5	0.00	
GC-SD45C	632368.25	671518.38	-20.07	4.90	-15.17	-21.5	1.43	
GC-SD46C	632153.90	671463.18	-22.73	8.20	-14.53	-21.5	0.00	
GC-SD47A	632188.77	671431.56	-17.15	1.00	-16.15	-21.5	4.35	
GC-SD49A	632071.13	671373.45	-21.86	8.70	-13.16	-21.5	0.00	
GC-SD50B	632097.35	671342.44	-23.78	6.20	-17.58	-21.5	0.00	
GC-SD51A	632123.73	671326.02	-24.07	9.80	-14.27	-21.5	0.00	
GC-SD53A	632005.69	671215.51	-20.52	6.20	-14.32	-21.5	0.98	
GC-SD54B	632018.62	671172.68	-20.69	9.30	-11.39	-21.5	0.81	
GC-SD115	631941.75	671126.10	-20.07	6.70	-13.37	-21.5	1.43	

TABLE E-2

Native Sediment Removal Thicknesses in Remediation Target Area 2

Gowanus Canal Feasibility Study

Brooklyn, New York

Station ID	Easting (X)[a]	Northing (Y)	Native Surface Elevation (NAVD88)[b]	Soft Sediment Thickness (ft)	Sediment Surface Elevation (NAVD88)	Removal Elevation (NAVD88)	Removal Thickness (ft)[c]	Note
GC-SD56A	631870.43	671009.89	-17.69	5.00	-12.69	-21.5	3.81	
GC-SD57A	631915.69	671003.16	-20.99	11.50	-9.49	-21.5	0.51	
GC-SD130	631791.88	670940.52	-20.81	9.00	-11.81	-21.5	0.69	
GC-SD131	631816.20	670908.85	-18.24	3.30	-14.94	-21.5	3.26	
GC-SD132	631839.49	670884.45	-22.40	10.10	-12.30	-21.5	0.00	
GC-SD118	631655.17	670727.45	-17.92	3.90	-14.02	-21.5	3.58	
GC-SD59A	631695.70	670730.43	-22.63	7.20	-15.43	-21.5	0.00	
GC-SD60B	631721.71	670707.73	-20.11	8.30	-11.81	-21.5	1.39	
GC-SD61C	631545.57	670562.15	-24.45	13.30	-11.15	-21.5	0.00	
GC-SD62C	631578.01	670549.78	-25.80	10.80	-15.00	-21.5	0.00	
GC-SD63A	631609.30	670524.84	-23.94	10.70	-13.24	-21.5	0.00	
GC-SD120	631478.12	670312.41	-22.88	8.20	-14.68	-21.5	0.00	
GC-SD64D	631371.64	670275.67	-20.35	6.40	-13.95	-21.5	1.15	
GC-SD65A	631402.71	670251.90	-24.81	8.20	-16.61	-21.5	0.00	
GC-SD66C	631420.77	670216.81	-22.72	9.10	-13.62	-21.5	0.00	
GC-SD121	631388.08	670187.49	-20.17	7.40	-12.77	-21.5	1.33	
GC-SD105A	631316.58	670129.25	-21.94	6.90	-15.04	-21.5	0.00	
GC-SD133	631140.69	669954.75	-17.70	13.30	-4.40	-21.5	3.80	
GC-SD134	631180.93	669936.52	-24.70	11.00	-13.70	-21.5	0.00	
GC-SD135	631228.33	669926.54	-16.90	12.10	-4.80	-21.5	4.60	

Notes:

[a] New York State Plane East Zone NAD83

[b] North American Vertical Datum 1988

[c] Negative removal thicknesses are treated as "0" for data-contouring purposes.

TABLE E-3

Summary of Sediment Volumes Removed in Alternatives 5 and 7 (Cubic Yards)

Gowanus Canal Feasibility Study

Brooklyn, New York

Area	Sediment Type	Alternatives 5 and 7: Removal of All Soft Sediment in RTAs 1, 2, and 3
RTA 1	Soft	82,000
RTA 2	Soft	174,000
	Native[a]	51,000
RTA 3	Soft	281,000
Total Sediment Removed		**588,000**

Notes:

[a] Some native sediment may require removal in order to meet navigation depth requirements after cap is placed.

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Appendix F
Estimated Costs

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Estimated Costs

This appendix presents the detailed cost estimates developed for the Gowanus Canal Feasibility Study (FS).

1. Introduction

The estimates presented herein are order-of-magnitude cost estimates that provide an accuracy of +50 percent to -30 percent. They are based on the assumptions outlined in Section 4 of the FS Report (specifically, Table 4-4) and were prepared using USEPA's *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study* (USEPA, 2000). All present worth values are based on real discount rates from Appendix C of the Office of Management and Budget (OMB) Circular A-94, Appendix C (revised December 2010). The 30-year value of 2.3 percent was selected since any operations and maintenance (O&M) durations are assumed to be over 30 years. This estimate is limited to the conditions existing at its issuance and is not a guaranty of actual price or cost. Uncertain market conditions such as, but not limited to, local labor or contractor availability, wages, other work, material market fluctuations, price escalations, force majeure events, and developing bidding conditions, may affect the accuracy of this estimate.

The cost summary tables include capital costs and O&M costs. Capital costs consist of direct and indirect costs. Direct costs include the cost of construction, equipment, land and site development, treatment, transportation, and disposal. Indirect costs include engineering expenses, license or permit costs, and contingency allowances. Annual O&M costs are the postconstruction costs required for the continued effectiveness of the remedy. Components of annual O&M costs include the cost of maintenance materials and labor, monitoring, and periodic site reviews.

Expenditures that occur over different periods were analyzed using present-worth, which discounts all future costs to a base year. Present-worth analysis allows the cost of remedial action alternatives to be compared on the basis of a single figure representing the amount of money that, if invested in the base year and disbursed as needed, would be sufficient to cover all costs associated with the life of the remedial project. Assumptions associated with the present-worth calculations include a discount rate of 2.3 percent before taxes and after inflation, cost estimates in the planning years in constant dollars, a 30-year period for O&M, and 5 years of construction to implement the remedy.

The cost estimates are in 2011 dollars and were prepared on the basis of the site information available at the time of preparation of this report and the components of the conceptual remedial alternatives presented herein. Additional investigation activities and evaluations will be performed during the remedial design. On the basis of the collected additional information, it the volume of sediment requiring removal and treatment or disposal may be refined and the cap designs will be finalized. Emerging technologies will also be evaluated during the remedial design and may be incorporated if they are determined to be effective and implementable at this site.

The cost estimates were prepared using vendor quotes, technology reference documents, and actual costs from other sediment remediation projects available at the time of preparation of this report. Labor costs have been estimated by using prevailing wages for Kings County that have been adjusted to a union scale. Table F-4 contains the prevailing wage information, as well as the scaled values that are used herein.

In summary, the cost estimates were prepared in order to compare the different remedial alternatives and disposal options by RTA. The actual cost of the selected remedial alternative will depend on a number of factors, including:

- Final sediment volumes removed
- Final cap design and associated material volumes
- Inclusion of additional emerging technologies that are not currently proposed within the alternatives presented herein
- Extent of bulkhead repair, stabilization, and replacement required
- Selected alternative and disposal option(s) utilized within each RTA
- Competitive market conditions
- Actual labor and material costs

Although these factors will affect the cost of each remedial action alternative, they are not expected to affect the relative cost differences between alternatives for the purpose of comparing alternatives. The final costs will, however, likely vary from the estimates presented in this report, so funding needs must be carefully reviewed before specific financial decisions are made or final budget is established.

2. Summary of Contents

This appendix contains the following tables:

3. Key Assumptions

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

Additionally, to ensure that the sediment remedy achieves the RAOs and is sustainable, source control measures will need to be implemented. Source control implementation is the first underlying component of all alternatives (other than the No Action alternative). Source control measures are in the process of being developed, and therefore the costs for these are not available for this FS. The source control measures that will be developed are included by reference in this FS.

4. References

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

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

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

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

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

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

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

Base Component and Sequence	Key Differences Between Alternatives 5 and 7
Debris Removal	
Debris removal will be performed as part of the sediment removal; additional detail is presented in that section.	NA
Upgrading/Restoration of Existing Bulkheads	
Existing bulkheads identified as degraded during predesign surveys would require replacement, repair, or reinforcement prior to remedy implementation to prevent failure during sediment removal.	NA
Total canal shoreline is approximately 21,000 LF (RTA 1: 4,600 ft; RTA 2 and turning basins: 11,100 ft; and RTA 3: 5,200 ft).	
Assume bulkhead installation would include targeted debris removal, installation of sheet piling, installation of tieback anchors, and backfill behind the sheet piling with crushed stone. In RTAs 1 and 2, the sheet piling would be installed to a depth of 10 feet into native sediment (cap thickness of 3 feet would result in ~13 feet of sediment at the base of the sheet piling). For purposes of the FS, assume that sheet piles would be 35 feet long. In RTA 3, assume that 50-ft-long sheets are required. Assume 80% of the bulkheads require replacement in each RTA.	
Assume two sheet piling installation operations proceed simultaneously and can install 30 LF/day each, for a total of 60 LF/day. Estimated duration is 280 days to install 16,800 LF (80% of 21,000 LF).	
Installation and Removal of Sheet Pile Cells	
Sheet piling would be installed down the middle of RTA 1 and would extend to the sides of the canal to create remedial cells.	NA
Six separate cells would be used to remediate RTA 1—one cell at a time would be remediated. Each cell would be approximately 750 ft long; after the southeast side of the canal is remediated, the sheet piling dividing the middle of the canal would be left in place, and the northwest side of the canal would be remediated. Sheet piling would then be extracted and installed further down the canal.	
Within RTA 1, due to the shallow water depths at the head of the canal, work may be sequenced to progress from the downstream to upstream to allow work to proceed throughout the tidal cycle.	

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

Base Component and Sequence	Key Differences Between Alternatives 5 and 7
Sheet pile cells would be installed within RTA 2 using the same means and methods as described for RTA 1, with the following differences: – The turning basins each are treated as an individual remedial cell and would be created by installing sheet piling at the confluence of the basin(s) with the canal. – A total of 12 separate cells are assumed to be used for RTA 2 for the purposes of this FS: four turning basin cells and eight cells along the canal (four on each side). – The turning basins would be remediated first, followed by the southeast side of the canal, and then the northwest side of the canal. – The remedial design would address management of the gas line crossing in RTA 2. Installation and extraction of sheet piling would be performed using a vibratory hammer/extractor; no impact driving would be necessary. Sheet piling would be used to contain turbidity and NAPL release during remedial activities, but would not be designed to withstand differential head pressures created by lowering water within the cell (except for up to 5 feet differential due to tidal fluctuation). Sheet pile wall joints would not need to be completely watertight because no significant pressure differential would exist. Overflow weirs would be cut into the top of the sheet pile wall to allow water to flow from the remedial cell during times of extreme flow to prevent upland flooding. Overflow weirs would be designed to trap oil sheens and allow them to be captured during remedial activities. Sheet piling would not be utilized or installed in RTA 3 because the potential for NAPL release is much lower and sheet piling would interfere with the federal navigation channel. Turbidity concerns would be managed with silt curtains. It is assumed that RTA 3 would be divided into three dredge units or dredge management areas. For the purposes of this FS, it is assumed that 1,500 LF of silt curtain to a depth of 30 ft would be used to control turbidity in RTA 3.	
Sediment Removal Large debris and obstructions would be removed from sediment using mechanical means (e.g., barge-mounted long-reach excavators). Larger debris, such as the sunken barge in the 6th Street turning basin, may require removal using a crane and clamshell bucket. Debris removal would be done within each enclosed remedial cell in order to control sheens and turbidity. All soft sediment would be removed using mechanical dredging (e.g., dredge to native sediment surface). A standard clamshell dredge bucket is assumed to be used in RTAs 1 and 2 because the work would be done inside an enclosed remedial cell. Scows for material transport would be staged outside of the remedial cell, and the dredge bucket would be swung over the sheet pile wall to place the dredged material in the material scow. RTA 3 would be dredged using an environmental bucket because enclosed sheet pile cells would not be used.	NA

Base Component and Sequence	Key Differences Between Alternatives 5 and 7
In the turning basins, a two-step sediment transfer process would be performed. Dredged sediment would be placed in a scow within the turning basin; when full, it would be pushed over to the sheet pile wall, and dredged material would be hydraulically pumped into an empty scow on the canal side of the sheet piling. The sediment removal volumes and durations are estimated to be: RTA 1—82,000 yd^3/3.5 months; RTA 2—225,000 yd^3/ 9.5 months; and RTA 3—281,000 yd^3/ 12 months. The removal durations were determined using the assumption that work would be performed 12 hours/day, 7 days/week, and that a production rate of 800 yd^3/day would be achieved.	
Sediment Dewatering Dredged sediment would be transported in the scow over to the onsite staging area. Free water on top of the sediment would be pumped out of the scow and treated at the onsite temporary water treatment system before being discharged to Gowanus Canal or Gowanus Bay. Eighty gallons of free water are assumed to be generated per cubic yard of sediment removed (or 64,000 gallons of water per day). This assumption is applied to all three RTAs. For the disposal options that include offsite stabilization, the dewatered sediment would then be transported in the same barge to a commercial dredge material transfer / treatment facility in New Jersey for stabilization prior to transport by barge back to the site for placement in the onsite CDF, or transport by truck to offsite landfill and treatment facilities, or to beneficial-use locations. If disposal options utilizing an onsite stabilization facility are selected, the dewatered sediment would be transferred to the temporary onsite facility for stabilization prior to placement in the onsite CDF or onsite beneficial use.	NA
In Situ Stabilization After the soft sediment has been removed and prior to cap placement, ISS would be performed on the remaining native sediment in targeted areas. The reagents would be delivered using barge-mounted deep-soil augers. Reagents would be delivered to a depth of 5 ft below the dredge surface. Pilot testing is needed to determine the appropriate reagents and dosage for the canal, but for purposes of this FS it is assumed 15% by weight reagent would be used for solidification, and the reagent itself would be 75% blast furnace slag (BFS120) and 25% portland cement.	ISS is only a component in Alternative 7. This component is not included in Alternative 5.

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

Base Component and Sequence	Key Differences Between Alternatives 5 and 7
The proposed areas to be treated with ISS are: – RTA 1—60,000 ft^2 – RTA 2—190,000 ft^2 – RTA 2—4th Street and 6th Street turning basins—50,000 ft^2 – RTA 2—7th Street turning basin—30,000 ft^2 A production rate of approximately 1,400 ft^2 per day has been assumed for this cost estimate. The cost estimate assumes two delivery platforms will be working simultaneously, 12 hours/day, 7 days/week.	
Sediment Capping Upon completion of the removal of the soft sediment (Alternative 5) or upon completion of ISS (Alternative 7), a three-layer cap would be placed in RTAs 1, 2, and 3. The conceptual cap design consists of 1 ft of granular oleophilic clay material, 6 inches of sand, 6 inches of gravel, and 1.5 ft of riprap armoring (9-inch average diameter) to prevent direct contact and NAPL migration from native sediments. In order to facilitate establishment of a benthic community, the FS assumes that approximately 6 inches of sand will be placed on top of the armor layer and allowed to fill the gaps between the stones. Based on conceptual cap design, approximately 8,000 yd^3 of clay (treatment layer), 4,000 yd^3 each of sand and gravel (isolation layer), and 12,000 yd^3 of riprap and 4,000 yd^3 of sand (armor layer) would be used for the cap in RTA 1; placement is expected to take approximately 80 days. Based on conceptual cap design, approximately 19,100 yd^3 of clay (treatment layer), 9,600 yd^3 each of sand and gravel (isolation layer), and 28,800 yd^3 of riprap and 9,600 yd^3 of sand (armor layer) would be used for the cap in RTA 2; placement is expected to take approximately 6 months. Conceptual cap design for RTA 3 consists of a 6-inch clay treatment layer, a 6-inch sand layer, a 6-inch gravel layer, and 1.5 ft armor layer. Based on conceptual design, approximately 13,600 yd^3 each of clay, sand, and gravel would make up the treatment and isolation layers. Approximately 40,700 yd^3 of riprap and 13,600 yd^3 of sand would be used for the armor layer; cap placement in RTA 3 expected to take approximately 8 months. Capping materials would be transported to the canal by barge. Capping materials would be placed using a broadcast spreader.	Cap would be placed after dredging in Alternative 5. In Alternative 7, the cap would be placed after ISS is implemented.

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

Base Component and Sequence	Key Differences Between Alternatives 5 and 7
A production rate of 400 yd^3 per 12-hour workday is assumed. Final cap design will be determined during remedial design.	
Dredge Cell Water Treatment After sediment and cap placement is completed, the water within the dredge unit would be pumped out, treated at the onsite water treatment system, and discharged to the canal. It is assumed that two volumes of water would be pumped and treated from each dredge cell. Water would be pumped to the temporary water treatment facility through high-density polyethylene piping. Estimated treatment rate is 750 gpm. In RTA 1, approximately 63 million gallons of water would require treatment. This would be expected to take approximately 60 days. In RTA 2, approximately 160 million gallons of water would require treatment. This would be expected to take approximately 150 days. Dredge cells would not be constructed for RTA 3; therefore, this step is not applicable.	NA
Short-Term Monitoring (During Construction) Down-current turbidity monitoring would be performed with readings collected within the water column down-current of the work cell manually once every 3 hours (use of an automatic recording station may not be feasible due to concerns about vandalism). Sheens would be monitored visually. Assume collection of air samples for volatiles, semivolatiles, and PM_{10} (particulate matter with diameter greater than or equal to 10 µm) concentrations. Samples collected from four monitoring stations once per week.	NA
Confirmation Sampling Confirmation field surveys would be performed after dredging and before either cap placement or ISS implementation to verify that all soft sediment has been removed. Final bathymetric survey would be completed following verification of dredging completion via confirmation sampling to assure that all soft sediment has been removed. ISS confirmation sampling would consist of collecting sediment from within the ISS areas in Shelby tubes after stabilization and prior to cap placement. A collection frequency of one sample for approximately every 500–1000 yd^3 of treated material would be used. Samples would be analyzed for compressive strength, hydraulic conductivity, and leachability.	Since ISS will not be implemented under Alternative5, ISS confirmation sampling is not included in Alternative 5.

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

Base Component and Sequence	Key Differences Between Alternatives 5 and 7
Physical surveys would be performed after placement of each of the cap layers to confirm that cap is placed to design elevation/thickness and covers entire area (assume four surveys for each dredge cell in RTAs 1 and 2 and three surveys per dredge area in RTA 3) Sampling would also be performed after placement to verify that no contaminated sediment was deposited on top of the cap surface during installation.	
Long-Term Monitoring and Operation and Maintenance [a]	
Long term monitoring would include evaluating cap integrity every five years. Sediment deposited on top of the cap would also be sampled to assess recontamination. Maintenance costs are assumed to include replacement of 5% of the cap footprint (entire cap thickness) every ten years. Maintenance dredging may be required to maintain depths required for navigation purposes; however, this is not considered as part of this FS. For purposes of this FS, costs for a bathymetric survey and sediment sampling and analysis every 5 years are assumed. Perform 5 year reviews.	NA
Dredged Material Treatment and Disposal Options for Alternatives 5 and 7	
Option A: Thermal Desorption, Offsite Beneficial Use • Dredged sediment would be treated at an offsite commercial facility by mixing with a stabilization agent and then transported by truck to a thermal desorption facility. Depending on the selected thermal facility, transport could be by rail, but for the purposes of developing estimated costs, this FS assumes approximately 60 miles of transport by truck (the higher of the two costs). • For estimating purposes, it is assumed 7.5% by weight portland cement would be used to stabilize the material in order to pass the paint filter test prior to transport for further treatment. • Following thermal desorption, the treated sediment would be used either as daily cover for a landfill, elsewhere as backfill, or otherwise beneficially. • For cost estimating purposes, it is assumed that the material would be provided to the end user free of charge and would be transported approximately 60 miles via truck. • Predesign testing would need to be performed, including bench testing of composite samples to make sure that the material would be accepted for treatment.	NA

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

Base Component and Sequence	Key Differences Between Alternatives 5 and 7
Option B: Offsite Disposal (Landfill) • Dredged sediment would be treated at an offsite commercial facility by mixing with a stabilization agent and then be transported by truck to a Subtitle D disposal facility. • For estimating purposes, it is assumed 7.5% by weight portland cement would be used to stabilize the material in order to pass the paint filter test. • For estimating purposes, it is assumed that the sediment would be transported approximately 110 miles by truck for disposal. • Based on TCLP data collected during the RI, it is assumed that the sediment is not a characteristic hazardous waste under RCRA and would be accepted at a Subtitle D disposal facility; however, predesign testing needs to be performed using composite samples to confirm waste characteristics and obtain preapproval/preacceptance from disposal facilities. The costs presented herein assume that sediment from the canal would not be classified as PCB-remediation waste.	NA
Option C: Cogeneration, Offsite Beneficial Use • Dredged sediment would be treated at an offsite commercial facility by mixing with a stabilization agent and then transported by truck to a cogeneration facility (350 mile trip assumed; Jersey City, NJ, to Clarion, PA). Depending on the selected cogeneration facility, transport could be by rail, but for the purposes of developing estimated costs, this FS assumes transport by truck (the higher of the two costs). • For estimating purposes, it is assumed 7.5% by weight portland cement would be used to stabilize the material to pass the paint filter test prior to transport for further treatment. • Following treatment, the treated sediment would be used either as daily cover for a landfill, elsewhere as clean backfill, or otherwise beneficially. • For cost estimating purposes, the material would be provided to the end user free of charge and would be transported 60 miles via truck. • Predesign testing would need to be performed including testing of composite samples to make sure that the material would be accepted for treatment.	NA
Option D: Offsite Stabilization and Offsite Beneficial Use • This FS assumes the stabilized material would be used as daily cover at a landfill; however, an end use has not yet been identified and other beneficial uses may be considered.	—

Base Component and Sequence	Key Differences Between Alternatives 5 and 7
• Dredged sediment would be dewatered onsite and then transported via barge to an offsite commercial stabilization facility. After treatment, the sediment would be transported by truck to the end use location. Transport could potentially occur via rail, but for the purposes of developing estimated costs, this FS assumes transport by truck (the higher of the two costs). • Dredged sediment would be treated at the offsite dredge-material-processing facility by mixing with a stabilization agent. The sediment would then be transported to the final use location. • For estimating purposes, it is assumed 15% by weight reagent would be used for stabilization, and the reagent itself would be 75% blast furnace slag (BFS120) and 25% portland cement. • For cost estimating purposes, the material would be provided to the end user free of charge and would be transported 110 miles via truck. • No additional O&M costs are assumed for this disposal option. • Predesign testing would need to be performed to determine stabilization requirements based on beneficial use.	
Option E: Onsite Stabilization and Onsite Beneficial Use • Dewatered sediment would be stabilized at a temporary dredge material processing facility constructed onsite. • For estimating purposes, it is assumed 30% by weight reagent would be used for solidification, and the reagent itself would be 75% blast furnace slag (BFS120) and 25% portland cement. • Institutional controls would be required to limit exposures to stabilized material beneficially used onsite. • Long-term O&M activities would include periodic sampling of the stabilized material to assess leachability and periodic surveys to assure that exposure through direct contact is prevented. • Final disposition of the stabilized sediment is assumed to be adjacent to the canal and will be a net zero cost under this disposal option. • Predesign testing would need to be performed to determine stabilization requirements based on beneficial use.	
Option F: Offsite stabilization, Transport of Treated Material Back to Site, Placement in Onsite Constructed CDF • During preconstruction site work, a confined disposal facility (CDF) would be constructed. This FS assumes that space will be available to construct a CDF that will contain all the material from RTA 3, estimated to be 281,000 yd^3.	NA

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

Base Component and Sequence	Key Differences Between Alternatives 5 and 7
• An expansion factor of 1.15 is assumed to determine the CDF capacity, which will need to be approximately 323,000 yd^3. It has been assumed that the CDF will be constructed so that the dewatered, stabilized sediment will be placed in a layer 20 ft thick. The area required for a CDF of this size is 436,000 ft^2, or 10 acres. – The FS assumes that the CDF will be surrounded on three sides by land and that those sides of the CDF will consist of a single sheet pile wall. The fourth side of the CDF will consist of a double sheet pile wall, 3 ft apart, filled with bentonite-augmented soil. – A total of 5,400 LF of 45-ft-long sheet piles are estimated. • Dredged sediment would be treated at an offsite dredge-material-processing-facility by mixing with a stabilization agent. The sediment would then be transported back to the site by barge and placed in the CDF. • For estimating purposes, it is assumed 15% by weight reagent would be used for stabilization, and the reagent itself would be 75% blast furnace slag (BFS120) and 25% portland cement. • The CDF would be capped with asphalt pavement to allow use of the surface. • CDF O&M would include cap integrity surveys and periodic repairs. Predesign testing would need to be performed to determine stabilization requirements and contaminant leachability. The results would be used to determine the appropriate design for the CDF.	
Option G: Onsite Stabilization and Placement in Onsite Constructed CDF • The description of Option F is applicable to this disposal option. The only difference between Options F and G is that under Option G the dewatered sediment would be stabilized at the temporary onsite facility. This FS assumes that the onsite stabilization facility would be located adjacent to the CDF and that an additional transport step between stabilization and placement in the CDF would not be required.	NA

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

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

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TABLE F-2a

Summary of Alternative, Disposal, and O&M Cost by RTA

Gowanus Canal Feasibility Study

Brooklyn, New York

Alternative Description	Base Implementation Capital Cost[1]	Dredging, Capping, Treatment and Disposal Capital Cost by RTA[2,3]			Present Worth O&M Cost[4]	Estimated Total Cost
		RTA 1	RTA 2	RTA 3		
Dredging and Capping Alternatives						
No Action	$0	$0	$0	$0	$0	$0
Dredge entire column of soft sediment Cap with treatment layer, isolation sand layer, and armor layer	$93,000,000	$15,000,000	$35,000,000	$29,000,000	$3,300,000	$175,000,000
Dredge entire column of soft sediment Solidify top 3-5 feet of underlying native sediment in targeted areas Cap with treatment layer, isolation sand layer, and armor layer	$93,000,000	$18,000,000	$48,000,000	$29,000,000	$3,300,000	$191,000,000
Treatment and Disposal Options						
A - Offsite thermal desorption, beneficial use	NA	$30,000,000	$82,000,000	$102,000,000	NA	$214,000,000
B - Offsite disposal (landfill)	NA	$32,000,000	$87,000,000	$108,000,000	NA	$227,000,000
C - Offsite Co-gen	NA	$37,000,000	$101,000,000	$126,000,000	NA	$264,000,000
D - Offsite stabilization, beneficial use	NA	$30,000,000	NA	$104,000,000	NA	$104,000,000
E - Onsite stabilization, beneficial use	$5,400,000	$23,000,000	NA	$78,000,000	$2,900,000	$109,000,000
F - Offsite stabilization and disposal in on-site constructed CDF	NA	NA	NA	$74,000,000	$260,000	$74,000,000
G - Onsite stabilization and disposal in on-site constructed CDF	$5,400,000	NA	NA	$67,000,000	$260,000	$73,000,000

Notes:

1. Base implementation costs for the dredging and capping alternatives consist of the following cost items: remedial design and pre-design sampling and testing; pre-remediation site work, facility costs, bulkhead upgrade/stabilization, short term morning costs, and confirmation sampling costs. The base implementation cost for disposal options E and G includes setting up the onsite sediment stabilization facility.

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

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

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

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TABLE F-2b

Summary of Representative Total Cost Range

Gowanus Canal Feasibility Study

Brooklyn, New York

Alternative Description	Base Implementation Capital Cost[1]	Dredging, Capping, Treatment and Disposal Capital Cost by RTA[2,3]			Present Worth O&M Cost[4]	Estimated Total Cost
		RTA 1	RTA 2	RTA 3		
Lower End of Cost Range						
Dredge entire column of soft sediment Cap with treatment layer, isolation sand layer, and armor layer	$93,000,000	$15,000,000	$35,000,000	$29,000,000	$3,300,000	$351,000,000
Disposal Option (Lowest cost) RTA 1 and 2 - Offsite thermal desorption, beneficial use RTA 3 - Onsite stabilization and disposal in onsite CDF	$5,400,000	$23,000,000	$82,000,000	$67,000,000	$260,000	
Higher End of Cost Range						
Dredge entire column of soft sediment Solidify top 3-5 feet of underlying native sediment in targeted areas Cap with treatment layer, isolation sand layer, and armor layer	$93,000,000	$18,000,000	$48,000,000	$29,000,000	$3,300,000	$456,000,000
Disposal Option (highest cost) RTA 1, 2, and 3 - Offsite cogeneration	NA	$37,000,000	$101,000,000	$126,000,000	NA	

Notes:

1. Base implementation costs for the dredging and capping alternatives consist of the following cost items: remedial design and pre-design sampling and testing; pre-remediation site work, facility costs, bulkhead upgrade/stabilization, short term morning costs, and confirmation sampling costs. The base implementation cost for disposal options E and G includes setting up the onsite sediment stabilization facility.
2. Dredging and Capping costs consist of the following cost items: installation and removal of sheet pile cells (RTAs 1 and 2), silt curtain (RTA 3 only), sediment removal, cap placement, dewatering, and dewatering/dredge cell water treatment.
3. Treatment and Disposal costs are summarized by RTA and include the costs associated with transport to the stabilization facility, stabilization, treatment or disposal, and transport to end
4. O&M costs are included under the dredging and capping alternatives are for the cap. Costs included for the treatment and disposal options are for the CDF associated with options F and G and for monitoring associated with the onsite beneficial use in Option E. The present worth cost is determined using a discount rate of 2.3%.

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TABLE F-3

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

Gowanus Canal Feasibility Study

Brooklyn, New York

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

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

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

Summary of Areas Proposed For ISS Application

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

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TABLE F-4

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

Gowanus Canal Feasibility Study

Brooklyn, New York

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

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

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TABLE F5a

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

Gowanus Canal Feasibility Study

Brooklyn, New York

PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL	
BASE IMPLEMENTATION COSTS										
1	**Pre-Design Testing/Site Investigation//Design Costs**	**Remedial Design and Pre-Design Sampling & Testing**	**1**	**LS**	**$4,351,516.62**	**$3,626,263.85**	**$543,939.58**	**$181,313.19**	**$ 4,351,517**	
		Bathymetric Survey	3	DAY	$3,000.00	$9,000.00	$1,350.00	$450.00		
		Pre-Design Treatability/Pilot Studies	1	LS	$500,000.00	$500,000.00	$75,000.00	$25,000.00		
		Full-Scale Remedial Design (4% of Remediation Costs)	1	LS	$2,453,811.08	$2,453,811.08	$368,071.66	$122,690.55		
		Coordination With Agencies/Stakeholders/Permitting (1% of Remediation Costs)	1	LS	$613,452.77	$613,452.77	$92,017.92	$30,672.64		
		Geophysical Survey	20	DAY	$2,500.00	$50,000.00	$7,500.00	$2,500.00		
2	**Includes all labor, equipment, & odc costs to complete pre-remedial site work**	**Pre-Remediation Site Work**	**9,500**	**LF**	**$42.16**	**$333,805.40**	**$50,070.81**	**$16,690.27**	**$ 400,566**	
		Temporary Access Road Construction	23,464	SY	$11.35	$266,316.40	$39,947.46	$13,315.82		PER MEANS 01 55 23.50.0100
		Chain-Link Fence (Temporary)	2,000	LF	$7.13	$14,260.00	$2,139.00	$713.00		PER MEANS 01 56 26.50.0100
		Prepare Docking/Staging Area	933	SY	$11.80	$11,009.40	$1,651.41	$550.47		PER MEANS 31 22 16.10.0010
		Establish Required Vertical Control Points & Tide Gauges	1	LS	$10,000.00	$10,000.00	$1,500.00	$500.00		ALLOWANCE
		Set-Up Temporary Water Treatment System-Site Prep	1	LS	$32,219.60	$32,219.60	$4,832.94	$1,610.98		ALLOWANCE
3	**Includes all labor, equipment, & odc costs for Dewatering & Treating Dredge Cell Water**	**Dewatering/Dredge Cell Water Treatment**	**1**	**LS**	**$612,000.00**	**$510,000.00**	**$803,000.00**	**$803,000.00**	**$ 612,000**	
		Mobilization/Demobilization	1	LS	$ 150,000.00	$150,000.00	$22,500.00	$7,500.00		
		Installation of Surface water Treatment System	1	LS	$ 200,000.00	$200,000.00	$30,000.00	$10,000.00		
		Power Drop	1	LS	$ 75,000.00	$75,000.00	$11,250.00	$3,750.00		
		Instrumentation & Control Allowance	1	LS	$ 25,000.00	$25,000.00	$3,750.00	$1,250.00		
		Treatment System Building	1	LS	$ 60,000.00	$60,000.00	$9,000.00	$3,000.00		
4	**Includes all labor, equipment, & odc costs for project long facility costs**	**Facility Costs**	**72**	**MO**	**$139,020.00**	**$8,341,200.00**	**$1,251,180.00**	**$417,060.00**	**$ 10,009,440**	
		Office Facilities	72	MO	$5,200.00	$374,400.00	$56,160.00	$18,720.00		ALLOWANCE: (2) Trailers
		Jobsite Sanitation	72	MO	$750.00	$54,000.00	$8,100.00	$2,700.00		PER MEANS 01 56 26.50.0020
		Site Security	72	MO	$5,400.00	$388,800.00	$58,320.00	$19,440.00		PER MEANS 31 22 16.10.0010

TABLE F5a

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

Gowanus Canal Feasibility Study

Brooklyn, New York

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

TABLE F5a

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

Gowanus Canal Feasibility Study

Brooklyn, New York

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

TABLE F5a

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

Gowanus Canal Feasibility Study

Brooklyn, New York

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

TABLE F5a

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

Gowanus Canal Feasibility Study

Brooklyn, New York

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

TABLE F5a

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

Gowanus Canal Feasibility Study

Brooklyn, New York

BASE IMPLEMENTATION COSTS

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

REMEDIATION: RTA#2

PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL	
1	**Design Costs & Permitting Costs**	**Remedial Design and Pre-Design Sampling & Testing**	**1**	**LS**	**$1,388,252.74**	**$1,156,877.28**	**$173,531.59**	**$57,843.86**	**$ 1,388,253**	
		Full-Scale Remedial Design (4% of Remediation Costs)	1	LS	$925,501.83	$925,501.83	$138,825.27	$46,275.09		
		Coordination With Agencies/Stakeholders/Permitting (1% of Remediation Costs)	1	LS	$231,375.46	$231,375.46	$34,706.32	$11,568.77		
2	**Includes all labor, equipment, & odc costs for constructing Sheetpile Cells**	**Installation and Removal of Sheet Pile Cells**	**1,400**	**LF**	**$1,256.69**	**$1,466,140.00**	**$219,921.00**	**$73,307.00**	**$ 1,759,368**	
		Sheet Piling Installation	18,000	SF	$39.53	$711,540.00	$106,731.00	$35,577.00		PER MEANS 31 41 16.10.1800
		Sheet Piling Extraction/Reinstallation	44,000	SF	$17.15	$754,600.00	$113,190.00	$37,730.00		PER MEANS 31 41 16.10.1300
3	**Includes all labor, equipment, & odc costs for Cap Placement**	**Cap Placement**	**76,777**	**CY**	**$102.20**	**$6,538,516.59**	**$980,777.49**	**$326,925.83**	**$ 7,846,220**	
		Clay Import	19,194	CY	$200.00	$3,838,847.26	$575,827.09	$191,942.36		PER MEANS 31 23 23.15.6000
		Sand Import	9,597	CY	$23.00	$220,733.72	$33,110.06	$11,036.69		PER MEANS 04 05 13.95.0200
		Habitat Sand Import	9,597	CY	$23.00	$220,733.72	$33,110.06	$11,036.69		PER MEANS 04 05 13.95.0200
		Gravel Import	9,597	CY	$28.00	$268,719.31	$40,307.90	$13,435.97		
		Armor Import	28,791	CY	$31.50	$906,927.66	$136,039.15	$45,346.38		PER MEANS 31 37 13.10.0011
		Material Placement-Equipment	192	DAY	$2,580.00	$495,211.30	$74,281.69	$24,760.56		
		Material Placement-Labor	192	DAY	$3,060.00	$587,343.63	$88,101.54	$29,367.18		
4	**Includes all labor, equipment, & odc costs for Dewatering & Treating Dredge Cell Water**	**Dewatering/Dredge Cell Water Treatment**	**181,200,000**	**GAL**	**$0.04**	**$5,512,909.00**	**$826,936.35**	**$275,645.45**	**$ 6,615,491**	
		Power/Electric	9.38	MO	$10,000.00	$93,750.00	$14,062.50	$4,687.50		
		Treatment System Operation	6,750	HR	$0.00	$0.00	$0.00	$0.00		
		Treatment System Rental	9.38	MO	$75,000.00	$703,125.00	$105,468.75	$35,156.25		
		Treatment Chemicals	9.38	MO	$10,000.00	$93,750.00	$14,062.50	$4,687.50		
		Replacement Carbon	2,311,142	LBS	$2.00	$4,622,284.00	$693,342.60	$231,114.20		

TABLE F5a

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

Gowanus Canal Feasibility Study

Brooklyn, New York

BASE IMPLEMENTATION COSTS									
PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL
5	**Includes all labor, equipment, & odc costs for Sediment Removal via Mechanical Dredge**	**Dredging: Debris and Sediment Removal**	**225,000**	**CY**	**$29.31**	**$5,496,534.98**	**$824,480.25**	**$274,826.75**	**$ 6,595,842**
		Transfer Pump	281	DAY	$1,000.00	$281,250.00	$42,187.50	$14,062.50	
		Barge With Clamshell	281	DAY	$1,380.00	$388,125.00	$58,218.75	$19,406.25	
		Barge With Excavator	281	DAY	$800.00	$225,000.00	$33,750.00	$11,250.00	
		Scow	281	DAY	$180.00	$50,625.00	$7,593.75	$2,531.25	
		Scow	281	DAY	$180.00	$50,625.00	$7,593.75	$2,531.25	
		Scow	281	DAY	$180.00	$50,625.00	$7,593.75	$2,531.25	
		Superintendent	281	DAY	$1,566.45	$440,564.71	$66,084.71	$22,028.24	
		Tug Operator	281	DAY	$1,213.83	$341,389.81	$51,208.47	$17,069.49	
		Tug Operator	281	DAY	$1,213.83	$341,389.81	$51,208.47	$17,069.49	
		Tug Operator	281	DAY	$1,213.83	$341,389.81	$51,208.47	$17,069.49	
		Crane Operator	281	DAY	$1,362.13	$383,099.75	$57,464.96	$19,154.99	
		Equipment Operator	281	DAY	$1,362.13	$383,099.75	$57,464.96	$19,154.99	
		Dredge Laborer	281	DAY	$945.51	$265,925.66	$39,888.85	$13,296.28	
		Dredge Laborer	281	DAY	$945.51	$265,925.66	$39,888.85	$13,296.28	
		FOGM	281	DAY	$6,000.00	$1,687,500.00	$253,125.00	$84,375.00	
6	**Includes all labor, equipment, & odc costs for Dewatering Dredged Material**	**Dredging: Dewatering**	**1**	**LS**	**$320,625.00**	**$267,187.50**	**$40,078.13**	**$13,359.38**	**$ 320,625**
		Dewatering Pump	281	DAY	$750.00	$210,937.50	$31,640.63	$10,546.88	
		Pump Fuel	281	DAY	$200.00	$56,250.00	$8,437.50	$2,812.50	
		Pump Laborer	3,375	HR	$0.00	$0.00	$0.00	$0.00	
		ESTIMATED COST							**$ 24,525,798**
						Contingency	**30%**		**$ 7,357,740**
						Construction Management/Oversig	**6%**		**$ 1,471,548**
						Project Management	**5%**		**$ 1,226,290**
		TOTAL RTA#2 REMEDIATION							**$ 34,581,376**

TABLE F5a

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

Gowanus Canal Feasibility Study

Brooklyn, New York

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

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

TABLE F5a

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

Gowanus Canal Feasibility Study

Brooklyn, New York

BASE IMPLEMENTATION COSTS									
PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL
5	**Includes all labor, equipment, & odc costs for Dewatering & Treating Dredge Cell Water**	**Dewatering/Dredge Cell Water Treatment**	**22,480,000**	**GAL**	**$0.12**	**$2,314,016.48**	**$347,102.47**	**$115,700.82**	**$ 2,776,820**
		Power/Electric	11.71	MO	$10,000.00	$117,083.33	$17,562.50	$5,854.17	
		Treatment System Operation	8,430	HR	$74.53	$628,276.81	$94,241.52	$31,413.84	
		Treatment System Rental	11.71	MO	$75,000.00	$878,125.00	$131,718.75	$43,906.25	
		Treatment Chemicals	11.71	MO	$10,000.00	$117,083.33	$17,562.50	$5,854.17	
		Replacement Carbon	286,724	LBS	$2.00	$573,448.00	$86,017.20	$28,672.40	
6	**Includes all labor, equipment, & odc costs for Sediment Removal via Mechanical Dredge**	**Dredging: Debris and Sediment Removal**	**281,000**	**CY**	**$29.31**	**$6,864,561.46**	**$1,029,684.22**	**$343,228.07**	**$ 8,237,474**
		Transfer Pump	351	DAY	$1,000.00	$351,250.00	$52,687.50	$17,562.50	
		Barge With Clamshell	351	DAY	$1,380.00	$484,725.00	$72,708.75	$24,236.25	
		Barge With Excavator	351	DAY	$800.00	$281,000.00	$42,150.00	$14,050.00	
		Scow	351	DAY	$180.00	$63,225.00	$9,483.75	$3,161.25	
		Scow	351	DAY	$180.00	$63,225.00	$9,483.75	$3,161.25	
		Scow	351	DAY	$180.00	$63,225.00	$9,483.75	$3,161.25	
		Superintendent	351	DAY	$1,566.45	$550,216.38	$82,532.46	$27,510.82	
		Tug Operator	351	DAY	$1,213.83	$426,357.95	$63,953.69	$21,317.90	
		Tug Operator	351	DAY	$1,213.83	$426,357.95	$63,953.69	$21,317.90	
		Tug Operator	351	DAY	$1,213.83	$426,357.95	$63,953.69	$21,317.90	
		Crane Operator	351	DAY	$1,362.13	$478,449.02	$71,767.35	$23,922.45	
		Equipment Operator	351	DAY	$1,362.13	$478,449.02	$71,767.35	$23,922.45	
		Dredge Laborer	351	DAY	$945.51	$332,111.60	$49,816.74	$16,605.58	
		Dredge Laborer	351	DAY	$945.51	$332,111.60	$49,816.74	$16,605.58	
		FOGM	351	DAY	$6,000.00	$2,107,500.00	$316,125.00	$105,375.00	
7	**Includes all labor, equipment, & odc costs for Dewatering Dredged Material**	**Dredging: Dewatering**	**1**	**LS**	**$400,425.00**	**$333,687.50**	**$50,053.13**	**$16,684.38**	**$ 400,425**
		Dewatering Pump	351	DAY	$750.00	$263,437.50	$39,515.63	$13,171.88	
		Pump Fuel	351	DAY	$200.00	$70,250.00	$10,537.50	$3,512.50	
		Pump Laborer	4,215	HR	$0.00	$0.00	$0.00	$0.00	
		ESTIMATED COST							**$ 20,216,518**
						Contingency	**30%**		**$ 6,064,955**
						Construction Management/Oversig	**6%**		**$ 1,212,991**

TABLE F5a

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

Gowanus Canal Feasibility Study

Brooklyn, New York

BASE IMPLEMENTATION COSTS									
PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL
						Project Management	5%		$ 1,010,826
		TOTAL RTA#3 REMEDIATION							$ 28,505,290

TABLE F5b

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

Gowanus Canal Feasibility Study

Brooklyn, New York

BASE IMPLEMENTATION COSTS										
PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL	
1	Pre-Design Testing/Site Investigation//Design Costs	Remedial Design and Pre-Design Sampling & Testing	1	LS	$4,374,992.22	$3,645,826.85	$546,874.03	$182,291.34	$ 4,374,992	
		Bathymetric Survey	3	DAY	$3,000.00	$9,000.00	$1,350.00	$450.00		
		Pre-Design Treatability/Pilot Studies	1	LS	$500,000.00	$500,000.00	$75,000.00	$25,000.00		
		Full-Scale Remedial Design (4% of Remediation Costs)	1	LS	$2,469,461.48	$2,469,461.48	$370,419.22	$123,473.07		
		Coordination With Agencies/Stakeholders/Permitting (1% of Remediation Costs)	1	LS	$617,365.37	$617,365.37	$92,604.81	$30,868.27		
		Geophysical Survey	20	DAY	$2,500.00	$50,000.00	$7,500.00	$2,500.00		
2	Includes all labor, equipment, & odc costs to complete pre-remedial site work	Pre-Remediation Site Work	9,500	LF	$42.16	$333,805.40	$50,070.81	$16,690.27	$ 400,566	
		Temporary Access Road Construction	23,464	SY	$11.35	$266,316.40	$39,947.46	$13,315.82		PER MEANS 01 55 23.50.0100
		Chain-Link Fence (Temporary)	2,000	LF	$7.13	$14,260.00	$2,139.00	$713.00		PER MEANS 01 56 26.50.0100
		Prepare Docking/Staging Area	933	SY	$11.80	$11,009.40	$1,651.41	$550.47		PER MEANS 31 22 16.10.0010
		Establish Required Vertical Control Points & Tide Gauges	1	LS	$10,000.00	$10,000.00	$1,500.00	$500.00		ALLOWANCE
		Set-Up Temporary Water Treatment System-Site Prep	1	LS	$32,219.60	$32,219.60	$4,832.94	$1,610.98		ALLOWANCE
3	Includes all labor, equipment, & odc costs for Dewatering & Treating Dredge Cell Water	Dewatering/Dredge Cell Water Treatment	1	LS	$612,000.00	$510,000.00	$76,500.00	$25,500.00	$ 612,000	
		Mobilization/Demobilization	1	LS	$ 150,000.00	$150,000.00	$22,500.00	$7,500.00		
		Installation of Surface water Treatment System	1	LS	$ 200,000.00	$200,000.00	$30,000.00	$10,000.00		
		Power Drop	1	LS	$ 75,000.00	$75,000.00	$11,250.00	$3,750.00		
		Instrumentation & Control Allowance	1	LS	$ 25,000.00	$25,000.00	$3,750.00	$1,250.00		
		Treatment System Building	1	LS	$ 60,000.00	$60,000.00	$9,000.00	$3,000.00		
4	Includes all labor, equipment, & odc costs for project long facility costs	Facility Costs	72	MO	$139,020.00	$8,341,200.00	$1,251,180.00	$417,060.00	$ 10,009,440	
		Office Facilities	72	MO	$5,200.00	$374,400.00	$56,160.00	$18,720.00		ALLOWANCE: (2) Trailers
		Jobsite Sanitation	72	MO	$750.00	$54,000.00	$8,100.00	$2,700.00		PER MEANS 01 56 26.50.0020

TABLE F5b

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

Gowanus Canal Feasibility Study

Brooklyn, New York

BASE IMPLEMENTATION COSTS

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

TABLE F5b

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

Gowanus Canal Feasibility Study

Brooklyn, New York

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

TABLE F5b

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

Gowanus Canal Feasibility Study

Brooklyn, New York

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

TABLE F5b

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

Gowanus Canal Feasibility Study

Brooklyn, New York

BASE IMPLEMENTATION COSTS

PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL
5	**Includes all labor, equipment, & odc costs for Dewatering & Treating Dredge Cell Water**	**Dewatering/Dredge Cell Water Treatment**	**69,160,000**	**GAL**	**$0.04**	**$2,272,145.90**	**$340,821.88**	**$113,607.29**	**$ 2,726,575**
		Power/Electric	3.42	MO	$10,000.00	$34,166.67	$5,125.00	$1,708.33	
		Treatment System Operation	2,460	HR	$74.53	$183,340.57	$27,501.08	$9,167.03	
		Treatment System Rental	3.42	MO	$75,000.00	$256,250.00	$38,437.50	$12,812.50	
		Treatment Chemicals	3.42	MO	$10,000.00	$34,166.67	$5,125.00	$1,708.33	
		Replacement Carbon	882,111	LBS	$2.00	$1,764,222.00	$264,633.30	$88,211.10	
6	**Includes all labor, equipment, & odc costs for Sediment Removal via Mechanical Dredge**	**Dredging: Debris and Sediment Removal**	**82,000**	**CY**	**$29.31**	**$2,003,181.64**	**$300,477.25**	**$100,159.08**	**$ 2,403,818**
		Transfer Pump	103	DAY	$1,000.00	$102,500.00	$15,375.00	$5,125.00	
		Barge With Clamshell	103	DAY	$1,380.00	$141,450.00	$21,217.50	$7,072.50	
		Barge With Excavator	103	DAY	$800.00	$82,000.00	$12,300.00	$4,100.00	
		Scow	103	DAY	$180.00	$18,450.00	$2,767.50	$922.50	
		Scow	103	DAY	$180.00	$18,450.00	$2,767.50	$922.50	
		Scow	103	DAY	$180.00	$18,450.00	$2,767.50	$922.50	
		Superintendent	103	DAY	$1,566.45	$160,561.36	$24,084.20	$8,028.07	
		Tug Operator	103	DAY	$1,213.83	$124,417.62	$18,662.64	$6,220.88	
		Tug Operator	103	DAY	$1,213.83	$124,417.62	$18,662.64	$6,220.88	
		Tug Operator	103	DAY	$1,213.83	$124,417.62	$18,662.64	$6,220.88	
		Crane Operator	103	DAY	$1,362.13	$139,618.58	$20,942.79	$6,980.93	
		Equipment Operator	103	DAY	$1,362.13	$139,618.58	$20,942.79	$6,980.93	
		Dredge Laborer	103	DAY	$945.51	$96,915.13	$14,537.27	$4,845.76	
		Dredge Laborer	103	DAY	$945.51	$96,915.13	$14,537.27	$4,845.76	
		FOGM	103	DAY	$6,000.00	$615,000.00	$92,250.00	$30,750.00	
7	**Includes all labor, equipment, & odc costs for Dewatering Dredged Material**	**Dredging: Dewatering**	**1**	**LS**	**$226,854.34**	**$189,045.28**	**$28,356.79**	**$9,452.26**	**$ 226,854**
		Dewatering Pump	103	DAY	$750.00	$76,875.00	$11,531.25	$3,843.75	
		Pump Fuel	103	DAY	$200.00	$20,500.00	$3,075.00	$1,025.00	
		Pump Laborer	1,230	HR	$74.53	$91,670.28	$13,750.54	$4,583.51	
		ESTIMATED COST							**$ 10,589,075**
						Contingency	**30%**		**$ 3,176,723**
						Construction Management/Oversigh	**6%**		**$ 635,345**
						Project Management	**5%**		**$ 529,454**
		TOTAL RTA#1 REMEDIATION							**$ 14,930,596**

TABLE F5b

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

Gowanus Canal Feasibility Study

Brooklyn, New York

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

REMEDIATION: RTA#2										
PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL	
1	**Design Costs & Permitting Costs**	**Remedial Design and Pre-Design Sampling & Testing**	**1**	**LS**	**$1,424,473.68**	**$1,187,061.40**	**$178,059.21**	**$59,353.07**	**$ 1,424,474**	
		Full-Scale Remedial Design (4% of Remediation Costs)	1	LS	$949,649.12	$949,649.12	$142,447.37	$47,482.46		
		Coordination With Agencies/Stakeholders/Permitting (1% of Remediation Costs)	1	LS	$237,412.28	$237,412.28	$35,611.84	$11,870.61		
2	**Includes all labor, equipment, & odc costs for constructing Sheetpile Cells**	**Installation and Removal of Sheet Pile Cells**	**1,400**	**LF**	**$1,256.69**	**$1,466,140.00**	**$219,921.00**	**$73,307.00**	**$ 1,759,368**	
		Sheet Piling Installation	18,000	SF	$39.53	$711,540.00	$106,731.00	$35,577.00		PER MEANS 31 41 16.10.1800
		Sheet Piling Extraction/Reinstallation	44,000	SF	$17.15	$754,600.00	$113,190.00	$37,730.00		PER MEANS 31 41 16.10.1300
3	**Includes all labor, equipment, & odc costs for placing Silt Curtain in RTA 3**	**Silt Curtain**	**0**	**LF**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$ -**	
		Silt Curtain	0	SF	$1.00	$0.00	$0.00	$0.00		
4	**Includes all labor, equipment, & odc costs for Cap Placement**	**Cap Placement**	**76,777**	**CY**	**$102.20**	**$6,538,516.59**	**$980,777.49**	**$326,925.83**	**$ 7,846,220**	
		Clay Import	19,194	CY	$200.00	$3,838,847.26	$575,827.09	$191,942.36		PER MEANS 31 23 23.15.6000
		Sand Import	9,597	CY	$23.00	$220,733.72	$33,110.06	$11,036.69		PER MEANS 04 05 13.95.0200
		Habitat Sand Import	9,597	CY	$23.00	$220,733.72	$33,110.06	$11,036.69		PER MEANS 04 05 13.95.0200
		Gravel Import	9,597	CY	$28.00	$268,719.31	$40,307.90	$13,435.97		
		Armor Import	28,791	CY	$31.50	$906,927.66	$136,039.15	$45,346.38		PER MEANS 31 37 13.10.0011
		Material Placement-Equipment	192	DAY	$2,580.00	$495,211.30	$74,281.69	$24,760.56		
		Material Placement-Labor	192	DAY	$3,060.00	$587,343.63	$88,101.54	$29,367.18		

TABLE F5b

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

Gowanus Canal Feasibility Study

Brooklyn, New York

BASE IMPLEMENTATION COSTS									
PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL
5	**Includes all labor, equipment, & odc costs for Dewatering & Treating Dredge Cell Water**	**Dewatering/Dredge Cell Water Treatment**	**181,200,000**	**GAL**	**$0.04**	**$6,015,977.62**	**$902,396.64**	**$300,798.88**	**$ 7,219,173**
		Power/Electric	9.38	MO	$10,000.00	$93,750.00	$14,062.50	$4,687.50	
		Treatment System Operation	6,750	HR	$74.53	$503,068.62	$75,460.29	$25,153.43	
		Treatment System Rental	9.38	MO	$75,000.00	$703,125.00	$105,468.75	$35,156.25	
		Treatment Chemicals	9.38	MO	$10,000.00	$93,750.00	$14,062.50	$4,687.50	
		Replacement Carbon	2,311,142	LBS	$2.00	$4,622,284.00	$693,342.60	$231,114.20	
6	**Includes all labor, equipment, & odc costs for Sediment Removal via Mechanical Dredge**	**Dredging: Debris and Sediment Removal**	**225,000**	**CY**	**$29.31**	**$5,496,534.98**	**$824,480.25**	**$274,826.75**	**$ 6,595,842**
		Transfer Pump	281	DAY	$1,000.00	$281,250.00	$42,187.50	$14,062.50	
		Barge With Clamshell	281	DAY	$1,380.00	$388,125.00	$58,218.75	$19,406.25	
		Barge With Excavator	281	DAY	$800.00	$225,000.00	$33,750.00	$11,250.00	
		Scow	281	DAY	$180.00	$50,625.00	$7,593.75	$2,531.25	
		Scow	281	DAY	$180.00	$50,625.00	$7,593.75	$2,531.25	
		Scow	281	DAY	$180.00	$50,625.00	$7,593.75	$2,531.25	
		Superintendent	281	DAY	$1,566.45	$440,564.71	$66,084.71	$22,028.24	
		Tug Operator	281	DAY	$1,213.83	$341,389.81	$51,208.47	$17,069.49	
		Tug Operator	281	DAY	$1,213.83	$341,389.81	$51,208.47	$17,069.49	
		Tug Operator	281	DAY	$1,213.83	$341,389.81	$51,208.47	$17,069.49	
		Crane Operator	281	DAY	$1,362.13	$383,099.75	$57,464.96	$19,154.99	
		Equipment Operator	281	DAY	$1,362.13	$383,099.75	$57,464.96	$19,154.99	
		Dredge Laborer	281	DAY	$945.51	$265,925.66	$39,888.85	$13,296.28	
		Dredge Laborer	281	DAY	$945.51	$265,925.66	$39,888.85	$13,296.28	
		FOGM	281	DAY	$6,000.00	$1,687,500.00	$253,125.00	$84,375.00	
7	**Includes all labor, equipment, & odc costs for Dewatering Dredged Material**	**Dredging: Dewatering**	**1**	**LS**	**$320,625.00**	**$267,187.50**	**$40,078.13**	**$13,359.38**	**$ 320,625**
		Dewatering Pump	281	DAY	$750.00	$210,937.50	$31,640.63	$10,546.88	
		Pump Fuel	281	DAY	$200.00	$56,250.00	$8,437.50	$2,812.50	
		Pump Laborer	3,375	HR	$0.00	$0.00	$0.00	$0.00	
		ESTIMATED COST							**$ 25,165,702**
						Contingency	**30%**		**$ 7,549,711**
						Construction Management/Oversigh	**6%**		**$ 1,509,942**
						Project Management	**5%**		**$ 1,258,285**
		TOTAL RTA#2 REMEDIATION							**$ 35,483,639**

TABLE F5b

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

Gowanus Canal Feasibility Study

Brooklyn, New York

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

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

TABLE F5b

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

Gowanus Canal Feasibility Study

Brooklyn, New York

BASE IMPLEMENTATION COSTS									
PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL
5	**Includes all labor, equipment, & odc costs for Dewatering & Treating Dredge Cell Water**	**Dewatering/Dredge Cell Water Treatment**	**22,480,000**	**GAL**	**$0.12**	**$2,314,016.48**	**$347,102.47**	**$115,700.82**	**$ 2,776,820**
		Power/Electric	11.71	MO	$10,000.00	$117,083.33	$17,562.50	$5,854.17	
		Treatment System Operation	8,430	HR	$74.53	$628,276.81	$94,241.52	$31,413.84	
		Treatment System Rental	11.71	MO	$75,000.00	$878,125.00	$131,718.75	$43,906.25	
		Treatment Chemicals	11.71	MO	$10,000.00	$117,083.33	$17,562.50	$5,854.17	
		Replacement Carbon	286,724	LBS	$2.00	$573,448.00	$86,017.20	$28,672.40	
6	**Includes all labor, equipment, & odc costs for Sediment Removal via Mechanical Dredge**	**Dredging: Debris and Sediment Removal**	**281,000**	**CY**	**$29.31**	**$6,864,561.46**	**$1,029,684.22**	**$343,228.07**	**$ 8,237,474**
		Transfer Pump	351	DAY	$1,000.00	$351,250.00	$52,687.50	$17,562.50	
		Barge With Clamshell	351	DAY	$1,380.00	$484,725.00	$72,708.75	$24,236.25	
		Barge With Excavator	351	DAY	$800.00	$281,000.00	$42,150.00	$14,050.00	
		Scow	351	DAY	$180.00	$63,225.00	$9,483.75	$3,161.25	
		Scow	351	DAY	$180.00	$63,225.00	$9,483.75	$3,161.25	
		Scow	351	DAY	$180.00	$63,225.00	$9,483.75	$3,161.25	
		Superintendent	351	DAY	$1,566.45	$550,216.38	$82,532.46	$27,510.82	
		Tug Operator	351	DAY	$1,213.83	$426,357.95	$63,953.69	$21,317.90	
		Tug Operator	351	DAY	$1,213.83	$426,357.95	$63,953.69	$21,317.90	
		Tug Operator	351	DAY	$1,213.83	$426,357.95	$63,953.69	$21,317.90	
		Crane Operator	351	DAY	$1,362.13	$478,449.02	$71,767.35	$23,922.45	
		Equipment Operator	351	DAY	$1,362.13	$478,449.02	$71,767.35	$23,922.45	
		Dredge Laborer	351	DAY	$945.51	$332,111.60	$49,816.74	$16,605.58	
		Dredge Laborer	351	DAY	$945.51	$332,111.60	$49,816.74	$16,605.58	
		FOGM	351	DAY	$6,000.00	$2,107,500.00	$316,125.00	$105,375.00	
7	**Includes all labor, equipment, & odc costs for Dewatering Dredged Material**	**Dredging: Dewatering**	**1**	**LS**	**$400,425.00**	**$333,687.50**	**$50,053.13**	**$16,684.38**	**$ 400,425**
		Dewatering Pump	351	DAY	$750.00	$263,437.50	$39,515.63	$13,171.88	
		Pump Fuel	351	DAY	$200.00	$70,250.00	$10,537.50	$3,512.50	
		Pump Laborer	4,215	HR	$0.00	$0.00	$0.00	$0.00	
		ESTIMATED COST							**$ 20,216,518**
						Contingency	**30%**		**$ 6,064,955**
						Construction Management/Oversigh	**6%**		**$ 1,212,991**
						Project Management	**5%**		**$ 1,010,826**
		TOTAL RTA#3 REMEDIATION							**$ 28,505,290**

TABLE F5b

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

Gowanus Canal Feasibility Study

Brooklyn, New York

BASE IMPLEMENTATION COSTS

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

ISS: RTA#1

PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL	
1	**Pre-Design Testing/Site Investigation/Design Costs**	**Remedial Design and Pre-Design Sampling & Testing**	**1**	**LS**	**$614,528.88**	**$512,107.40**	**$76,816.11**	**$25,605.37**	**$ 614,529**	
		Pre-Design Treatability Sampling	1	LS	$ 100,000.00	$100,000.00	$15,000.00	$5,000.00		
		Pilot Test	1	LS	$ 400,000.00	$400,000.00	$60,000.00	$20,000.00		
		Coordination With Agencies/Stakeholders/Permitting (1% of Remediation Costs)	1	LS	$ 12,107.40	$12,107.40	$1,816.11	$605.37		
2	**Includes all labor, equipment, & odc costs to complete pre-remedial site work**	**Pre-Remediation Site Work**	**1**	**LS**	**$39,947.46**	**$33,289.55**	**$4,993.43**	**$1,664.48**	**$ 39,947**	
		Temporary Access Road Construction	2,933	SY	$ 11.35	$33,289.55	$4,993.43	$1,664.48		PER MEANS 01 55 23.50.0100
3	**Includes all labor, equipment, & odc costs for project long facility costs**	**Facility Costs**	**1.4**	**MO**	**$20,220.00**	**$23,298.77**	**$3,494.81**	**$1,164.94**	**$ 27,959**	
		Office Facilities	1.4	MO	$ 5,200.00	$7,190.12	$1,078.52	$359.51		ALLOWANCE: (2) Trailers
		Jobsite Sanitation	1.4	MO	$ 750.00	$1,037.04	$155.56	$51.85		PER MEANS 01 56 26.50.0020
		Site Security	1.4	MO	$ 5,400.00	$7,466.67	$1,120.00	$373.33		PER MEANS 31 22 16.10.0010
		Site Utilities	1.4	MO	$ 4,500.00	$6,222.22	$933.33	$311.11		ALLOWANCE: Phone/Power/Misc
		Temporary Storage	1.4	MO	$ 1,000.00	$1,382.72	$207.41	$69.14		ALLOWANCE: (3) Conex Boxes
4	**Includes all labor, equipment, & odc costs for Sediment Solidification**	**RTA #1: In-Situ Sediment Solidification**	**15,556**	**TON**	**$73.47**	**$952,361.92**	**$142,854.29**	**$47,618.10**	**$ 1,142,834**	
		Blast Furnace Slag	1,750	TON	$ 50.00	$87,500.00	$13,125.00	$4,375.00		
		Portland Cement	583	TON	$ 125.00	$72,916.67	$10,937.50	$3,645.83		

TABLE F5b

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

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

TABLE F5b

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

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Brooklyn, New York

PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL	
BASE IMPLEMENTATION COSTS										
ISS: RTA#2 MAIN CANAL										
PAY ITEM No.	**PAY ITEM DESCRIPTION**	**LINE ITEM DESCRIPTION**	**QUANTITY**	**UNIT**	**UNIT PRICE**	**CONTRACTOR COST**	**CONTRACTOR FEE**	**CONTRACTOR PM/OH**	**TOTAL**	
1	**Pre-Design Testing/Site Investigation/Design Costs**	**Remedial Design and Pre-Design Sampling & Testing**	**1**	**LS**	**$644,969.50**	**$537,474.58**	**$80,621.19**	**$26,873.73**	**$ 644,969**	
		Pre-Design Treatability Sampling	1	LS	$ 100,000.00	$100,000.00	$15,000.00	$5,000.00		
		Pilot Test	1	LS	$ 400,000.00	$400,000.00	$60,000.00	$20,000.00		
		Coordination With Agencies/Stakeholders/Permitting (1% of Remediation Costs)	1	LS	$ 37,474.58	$37,474.58	$5,621.19	$1,873.73		
2	**Includes all labor, equipment, & odc costs to complete pre-remedial site work**	**Pre-Remediation Site Work**	**1**	**LS**	**$39,947.46**	**$33,289.55**	**$4,993.43**	**$1,664.48**	**$ 39,947**	
		Temporary Access Road Construction	2,933	SY	$ 11.35	$33,289.55	$4,993.43	$1,664.48		PER MEANS 01 55 23.50.0100
3	**Includes all labor, equipment, & odc costs for project long facility costs**	**Facility Costs**	**4.4**	**MO**	**$20,220.00**	**$73,779.42**	**$11,066.91**	**$3,688.97**	**$ 88,535**	
		Office Facilities	4.4	MO	$ 5,200.00	$22,768.72	$3,415.31	$1,138.44		ALLOWANCE: (2) Trailers
		Jobsite Sanitation	4.4	MO	$ 750.00	$3,283.95	$492.59	$164.20		PER MEANS 01 56 26.50.0020
		Site Security	4.4	MO	$ 5,400.00	$23,644.44	$3,546.67	$1,182.22		PER MEANS 31 22 16.10.0010
		Site Utilities	4.4	MO	$ 4,500.00	$19,703.70	$2,955.56	$985.19		ALLOWANCE: Phone/Power/Misc
		Temporary Storage	4.4	MO	$ 1,000.00	$4,378.60	$656.79	$218.93		ALLOWANCE: (3) Conex Boxes
4	**Includes all labor, equipment, & odc costs for Sediment Solidification**	**ISS: RTA#2 MAIN CANAL**	**49,259**	**TON**	**$73.47**	**$3,015,812.76**	**$452,371.91**	**$150,790.64**	**$ 3,618,975**	
		Blast Furnace Slag	5,542	TON	$ 50.00	$277,083.33	$41,562.50	$13,854.17		
		Portland Cement	1,847	TON	$ 125.00	$230,902.78	$34,635.42	$11,545.14		
		Barge With Deep Soil Auger	131	DAY	$ 1,380.00	$181,274.07	$27,191.11	$9,063.70		

TABLE F5b

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

Gowanus Canal Feasibility Study

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

TABLE F5b

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

Gowanus Canal Feasibility Study

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

ISS: RTA#2 4TH STREET AND 6TH STREET TURNING BASINS										
PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL	
1	**Pre-Design Testing/Site Investigation//Design Costs**	**Remedial Design and Pre-Design Sampling & Testing**	**1**	**LS**	**$612,187.30**	**$510,156.08**	**$76,523.41**	**$25,507.80**	**$ 612,187**	
		Pre-Design Treatability Sampling	1	LS	$ 100,000.00	$100,000.00	$15,000.00	$5,000.00		
		Pilot Test	1	LS	$ 400,000.00	$400,000.00	$60,000.00	$20,000.00		
		Coordination With Agencies/Stakeholders/Permitting (1% of Remediation Costs)	1	LS	$ 10,156.08	$10,156.08	$1,523.41	$507.80		
2	**Includes all labor, equipment, & odc costs to complete pre-remedial site work**	**Pre-Remediation Site Work**	**1**	**LS**	**$39,947.46**	**$33,289.55**	**$4,993.43**	**$1,664.48**	**$ 39,947**	
		Temporary Access Road Construction	2,933	SY	$ 11.35	$33,289.55	$4,993.43	$1,664.48		PER MEANS 01 55 23.50.0100
3	**Includes all labor, equipment, & odc costs for project long facility costs**	**Facility Costs**	**1.2**	**MO**	**$20,220.00**	**$19,415.64**	**$2,912.35**	**$970.78**	**$ 23,299**	
		Office Facilities	1.2	MO	$ 5,200.00	$5,991.77	$898.77	$299.59		ALLOWANCE: (2) Trailers
		Jobsite Sanitation	1.2	MO	$ 750.00	$864.20	$129.63	$43.21		PER MEANS 01 56 26.50.0020
		Site Security	1.2	MO	$ 5,400.00	$6,222.22	$933.33	$311.11		PER MEANS 31 22 16.10.0010
		Site Utilities	1.2	MO	$ 4,500.00	$5,185.19	$777.78	$259.26		ALLOWANCE: Phone/Power/Misc
		Temporary Storage	1.2	MO	$ 1,000.00	$1,152.26	$172.84	$57.61		ALLOWANCE: (3) Conex Boxes
4	**Includes all labor, equipment, & odc costs for Sediment Solidification**	**ISS: RTA#2 4TH STREET AND 6TH STREET TURNING BASINS**	**12,963**	**TON**	**$73.47**	**$793,634.94**	**$119,045.24**	**$39,681.75**	**$ 952,362**	
		Blast Furnace Slag	1,458	TON	$ 50.00	$72,916.67	$10,937.50	$3,645.83		
		Portland Cement	486	TON	$ 125.00	$60,763.89	$9,114.58	$3,038.19		
		Barge With Deep Soil Auger	35	DAY	$ 1,380.00	$47,703.70	$7,155.56	$2,385.19		

TABLE F5b

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

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

TABLE F5b

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

Gowanus Canal Feasibility Study

Brooklyn, New York

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

ISS: RTA#2 7TH STREET TURNING BASIN										
PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL	
1	**Pre-Design Testing/Site Investigation//Design Costs**	**Remedial Design and Pre-Design Sampling & Testing**	**1**	**LS**	**$607,504.13**	**$506,253.44**	**$75,938.02**	**$25,312.67**	**$ 607,504**	
		Pre-Design Treatability Sampling	1	LS	$ 100,000.00	$100,000.00	$15,000.00	$5,000.00		
		Pilot Test	1	LS	$ 400,000.00	$400,000.00	$60,000.00	$20,000.00		
		Coordination With Agencies/Stakeholders/Permitting (1% of Remediation Costs)	1	LS	$ 6,253.44	$6,253.44	$938.02	$312.67		
2	**Includes all labor, equipment, & odc costs to complete pre-remedial site work**	**Pre-Remediation Site Work**	**1**	**LS**	**$39,947.46**	**$33,289.55**	**$4,993.43**	**$1,664.48**	**$ 39,947**	
		Temporary Access Road Construction	2,933	SY	$ 11.35	$33,289.55	$4,993.43	$1,664.48		PER MEANS 01 55 23.50.0100
3	**Includes all labor, equipment, & odc costs for project long facility costs**	**Facility Costs**	**0.7**	**MO**	**$20,220.00**	**$11,649.38**	**$1,747.41**	**$582.47**	**$ 13,979**	
		Office Facilities	0.7	MO	$ 5,200.00	$3,595.06	$539.26	$179.75		ALLOWANCE: (2) Trailers
		Jobsite Sanitation	0.7	MO	$ 750.00	$518.52	$77.78	$25.93		PER MEANS 01 56 26.50.0020
		Site Security	0.7	MO	$ 5,400.00	$3,733.33	$560.00	$186.67		PER MEANS 31 22 16.10.0010
		Site Utilities	0.7	MO	$ 4,500.00	$3,111.11	$466.67	$155.56		ALLOWANCE: Phone/Power/Misc
		Temporary Storage	0.7	MO	$ 1,000.00	$691.36	$103.70	$34.57		ALLOWANCE: (3) Conex Boxes
4	**Includes all labor, equipment, & odc costs for Sediment Solidification**	**ISS: RTA#2 7TH STREET TURNING BASIN**	**7,778**	**TON**	**$73.47**	**$476,180.96**	**$71,427.14**	**$23,809.05**	**$ 571,417**	
		Blast Furnace Slag	875	TON	$ 50.00	$43,750.00	$6,562.50	$2,187.50		
		Portland Cement	292	TON	$ 125.00	$36,458.33	$5,468.75	$1,822.92		
		Barge With Deep Soil Auger	21	DAY	$ 1,380.00	$28,622.22	$4,293.33	$1,431.11		

TABLE F5b

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

Gowanus Canal Feasibility Study

Brooklyn, New York

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

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

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

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

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

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

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

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

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

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

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

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

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

DISPOSALTREATMENT OPTION C: COGEN RTA#1

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

DISPOSALTREATMENT OPTION C: COGEN RTA#2

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

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

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

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

DISPOSALTREATMENT OPTION D: RTA#1 OFFSITE STABILIZATION/BENEFICIAL USE

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

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

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

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

DISPOSALTREATMENT OPTION E: RTA#1 ONSITE STABILIZATION/BENEFICIAL USE

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

TABLE F-6a

Treatment and Disposal Costs by RTA

Gowanus Canal Feasibility Study

Brooklyn, New York

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

TABLE F-6a

Treatment and Disposal Costs by RTA

Gowanus Canal Feasibility Study

Brooklyn, New York

PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL
DISPOSALTREATMENT OPTION F: RTA#3 OFFSITE STABILIZATION/CDF DISPOSAL									
1	**Includes all labor, equipment, & odc costs for Transporting Dredged Material to Offsite Stabilization Site**	**Transport to Offsite Stabilization Site**	**393,400**	**TON**	**$30.00**	**$9,835,000.00**	**$1,475,250.00**	**$491,750.00**	**$ 11,802,000**
		Soil Transport	393,400	TON	$25.00	$9,835,000.00	$1,475,250.00	$491,750.00	
2	**Includes all labor, equipment, & odc costs for CDF Construction**	**CDF Construction**	**1**	**LS**	**$11,552,550.00**	**$9,627,125.00**	**$1,444,068.75**	**$481,356.25**	**$ 11,552,550**
		Sheet Piling Installation	148,500	SF	$ 39.53	$5,870,205.00	$880,530.75	$293,510.25	
		Bentonite Augmented Soil	2,200	CY	$ 50.00	$110,000.00	$16,500.00	$5,500.00	
		Dewatering Pump	404	DAY	$ 750.00	$303,000.00	$45,450.00	$15,150.00	
		Pump Fuel	404	DAY	$ 200.00	$80,800.00	$12,120.00	$4,040.00	
		Existing Soil Stabilization	105,000	TON	$ 30.00	$3,150,000.00	$472,500.00	$157,500.00	
		Dewatering Pump Operator	404	DAY	$ 280.00	$113,120.00	$16,968.00	$5,656.00	
3	**Includes all labor, equipment, & odc costs for Sediment Solidification**	**Sediment Solidification For CDF Placement (assumes 15% by weight reagent; reagents are 75% blast furnace slag and 25% Portland cement).**	**393,400**	**TON**	**$53.78**	**$17,629,237.50**	**$2,644,385.63**	**$881,461.88**	**$ 21,155,085**
		Blast Furnace Slag	44,258	TON	$ 50.00	$2,212,875.00	$331,931.25	$110,643.75	
		Portland Cement	14,753	TON	$ 125.00	$1,844,062.50	$276,609.38	$92,203.13	
		Soil Mixing	452,410	TON	$ 30.00	$13,572,300.00	$2,035,845.00	$678,615.00	
4	**Includes all labor, equipment, & odc costs for Transporting Dredged Material to CDF**	**Transport To CDF (assumed to be approximately 30 nautical miles via barge)**	**452,410**	**TON**	**$12.00**	**$4,524,100.00**	**$678,615.00**	**$226,205.00**	**$ 5,428,920**
		Soil Transport	452,410	TON	$ 10.00	$4,524,100.00	$678,615.00	$226,205.00	
5	**Includes all labor, equipment, & odc costs for Sediment Placement in the CDF**	**Disposal Option F: Sediment Placement in CDF**	**323,150**	**CY**	**$7.06**	**$1,900,066.66**	**$285,010.00**	**$95,003.33**	**$ 2,280,080**
		D8 Dozer	162	DAY	$ 440.00	$71,093.00	$10,663.95	$3,554.65	
		FOGM	162	DAY	$ 264.00	$42,655.80	$6,398.37	$2,132.79	
		D8 Dozer	162	DAY	$ 440.00	$71,093.00	$10,663.95	$3,554.65	
		FOGM	162	DAY	$ 264.00	$42,655.80	$6,398.37	$2,132.79	
		Cat 825C Soil Compactor	162	DAY	$ 520.00	$84,019.00	$12,602.85	$4,200.95	
		FOGM	162	DAY	$ 312.00	$50,411.40	$7,561.71	$2,520.57	
		Cat 825C Soil Compactor	162	DAY	$ 520.00	$84,019.00	$12,602.85	$4,200.95	
		FOGM	162	DAY	$ 312.00	$50,411.40	$7,561.71	$2,520.57	
		Cat 963 Track Loader	162	DAY	$ 360.00	$58,167.00	$8,725.05	$2,908.35	
		FOGM	162	DAY	$ 216.00	$34,900.20	$5,235.03	$1,745.01	
		Laborer	1,939	HR	$ 78.79	$152,771.34	$22,915.70	$7,638.57	
		Laborer	1,939	HR	$ 78.79	$152,771.34	$22,915.70	$7,638.57	
		Laborer	1,939	HR	$ 78.79	$152,771.34	$22,915.70	$7,638.57	
		Laborer	1,939	HR	$ 78.79	$152,771.34	$22,915.70	$7,638.57	
		Operator	1,939	HR	$ 113.51	$220,086.55	$33,012.98	$11,004.33	
		Operator	1,939	HR	$ 113.51	$220,086.55	$33,012.98	$11,004.33	
		Operator	1,939	HR	$ 113.51	$220,086.55	$33,012.98	$11,004.33	
		Asphalt Surfacing: 6"	5,000	SY	$ 7.86	$39,296.07	$5,894.41	$1,964.80	
		ESTIMATED COST							**$ 52,218,635**
						Contingency	**30%**		**$ 15,665,590**
						Construction Management/Oversight	**6%**		**$ 3,133,118**
						Project Management	**5%**		**$ 2,610,932**
		TOTAL DISPOSAL OPTION ESTIMATED COST							**$ 73,628,275**

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

DISPOSALTREATMENT OPTION G: RTA#3 ONSITE STABILIZATION/CDF DISPOSAL

PAY ITEM No.	PAY ITEM DESCRIPTION	LINE ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	CONTRACTOR COST	CONTRACTOR FEE	CONTRACTOR PM/OH	TOTAL
1	Includes all labor, equipment, & odc costs for Transporting Dredged Material to Onsite Stabilization Site	Transport to Onsite Stabilization Site	393,400	TON	$18.00	$5,901,000.00	$885,150.00	$295,050.00	$ 7,081,200
		Soil Transport	393,400	TON	$15.00	$5,901,000.00	$885,150.00	$295,050.00	
2	Includes all labor, equipment, & odc costs for CDF Construction	CDF Construction	1	LS	$11,552,550.00	$9,627,125.00	$1,444,068.75	$481,356.25	$ 11,552,550
		Sheet Piling Installation	148,500	SF	$ 39.53	$5,870,205.00	$880,530.75	$293,510.25	
		Bentonite Augmented Soil	2,200	CY	$ 50.00	$110,000.00	$16,500.00	$5,500.00	
		Dewatering Pump	404	DAY	$ 750.00	$303,000.00	$45,450.00	$15,150.00	
		Pump Fuel	404	DAY	$ 200.00	$80,800.00	$12,120.00	$4,040.00	
		Existing Soil Stabilization	105,000	TON	$ 30.00	$3,150,000.00	$472,500.00	$157,500.00	
		Dewatering Pump Operator	404	DAY	$ 280.00	$113,120.00	$16,968.00	$5,656.00	
3	Includes all labor, equipment, & odc costs for Sediment Solidification	Sediment Solidification For CDF Placement (assumes 15% by weight reagent; reagents are 75% blast furnace slag and 25% Portland cement).	393,400	TON	$53.78	$17,629,237.50	$2,644,385.63	$881,461.88	$ 21,155,085
		Blast Furnace Slag	44,258	TON	$ 50.00	$2,212,875.00	$331,931.25	$110,643.75	
		Portland Cement	14,753	TON	$ 125.00	$1,844,062.50	$276,609.38	$92,203.13	
		Soil Mixing	452,410	TON	$ 30.00	$13,572,300.00	$2,035,845.00	$678,615.00	
4	Includes all labor, equipment, & odc costs for Transporting Dredged Material to CDF	Transport To CDF (assumed to be approximately 2 nautical miles via barge)	452,410	TON	$12.00	$4,524,100.00	$678,615.00	$226,205.00	$ 5,428,920
		Soil Transport	452,410	TON	$ 10.00	$4,524,100.00	$678,615.00	$226,205.00	
5	Includes all labor, equipment, & odc costs for Sediment Placement in the CDF	Disposal Option G: Sediment Placement in CDF	323,150	CY	$7.06	$1,900,066.66	$285,010.00	$95,003.33	$ 2,280,080
		D8 Dozer	162	DAY	$ 440.00	$71,093.00	$10,663.95	$3,554.65	
		FOGM	162	DAY	$ 264.00	$42,655.80	$6,398.37	$2,132.79	
		D8 Dozer	162	DAY	$ 440.00	$71,093.00	$10,663.95	$3,554.65	
		FOGM	162	DAY	$ 264.00	$42,655.80	$6,398.37	$2,132.79	
		Cat 825C Soil Compactor	162	DAY	$ 520.00	$84,019.00	$12,602.85	$4,200.95	
		FOGM	162	DAY	$ 312.00	$50,411.40	$7,561.71	$2,520.57	
		Cat 825C Soil Compactor	162	DAY	$ 520.00	$84,019.00	$12,602.85	$4,200.95	
		FOGM	162	DAY	$ 312.00	$50,411.40	$7,561.71	$2,520.57	
		Cat 963 Track Loader	162	DAY	$ 360.00	$58,167.00	$8,725.05	$2,908.35	
		FOGM	162	DAY	$ 216.00	$34,900.20	$5,235.03	$1,745.01	
		Laborer	1,939	HR	$ 78.79	$152,771.34	$22,915.70	$7,638.57	
		Laborer	1,939	HR	$ 78.79	$152,771.34	$22,915.70	$7,638.57	
		Laborer	1,939	HR	$ 78.79	$152,771.34	$22,915.70	$7,638.57	
		Laborer	1,939	HR	$ 78.79	$152,771.34	$22,915.70	$7,638.57	
		Operator	1,939	HR	$ 113.51	$220,086.55	$33,012.98	$11,004.33	
		Operator	1,939	HR	$ 113.51	$220,086.55	$33,012.98	$11,004.33	
		Operator	1,939	HR	$ 113.51	$220,086.55	$33,012.98	$11,004.33	
		Asphalt Surfacing: 6"	5,000	SY	$ 7.86	$39,296.07	$5,894.41	$1,964.80	
		ESTIMATED COST							$ 47,497,835
						Contingency	30%		$ 14,249,350
						Construction Management/Oversight	6%		$ 2,849,870
						Project Management	5%		$ 2,374,892
		TOTAL DISPOSAL OPTION ESTIMATED COST							$ 66,971,947

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TABLE F-6b

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

Gowanus Canal Feasibility Study

Brooklyn, New York

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

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TABLE F-7

Long Term Operations and Maintenance Costs for Sediment Cap

Gowanus Canal Feasibility Study

Brooklyn, New York

Site:	Gowanus Canal	**Description:**	Operations and Maintenance Detailed Costing
Location:	Brooklyn, NY		

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

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

PRESENT VALUE ANALYSIS (30-year) Discount Rate = 2.3%

End Year	COST TYPE	Capital Cost	O&M Cost	TOTAL COST/YEAR	DISCOUNT FACTOR	PRESENT VALUE
0	CAPITAL COST	$583,022	$0	$583,022	1.000	$ 583,022
1	PERIODIC COST - O&M	$0	$0	$0	0.978	$ -
2	PERIODIC COST - O&M	$0	$0	$0	0.956	$ -
3	PERIODIC COST - O&M	$0	$0	$0	0.934	$ -
4	PERIODIC COST - O&M	$0	$0	$0	0.913	$ -
5	PERIODIC COST - O&M	$583,022	$89,700	$672,722	0.893	$ 600,424
6	PERIODIC COST - O&M	$0		$0	0.872	$ -
7	PERIODIC COST - O&M	$0		$0	0.853	$ -
8	PERIODIC COST - O&M	$0		$0	0.834	$ -
9	PERIODIC COST - O&M	$0		$0	0.815	$ -
10	PERIODIC COST - O&M	$583,022	$89,700	$672,722	0.797	$ 535,895
11	PERIODIC COST - O&M	$0		$0	0.779	$ -
12	PERIODIC COST - O&M	$0		$0	0.761	$ -
13	PERIODIC COST - O&M	$0		$0	0.744	$ -
14	PERIODIC COST - O&M	$0		$0	0.727	$ -
15	PERIODIC COST - O&M	$583,022	$89,700	$672,722	0.711	$ 478,301
16	PERIODIC COST - O&M	$0		$0	0.695	$ -
17	PERIODIC COST - O&M	$0		$0	0.679	$ -
18	PERIODIC COST - O&M	$0		$0	0.664	$ -
19	PERIODIC COST - O&M	$0		$0	0.649	$ -
20	PERIODIC COST - O&M	$583,022	$89,700	$672,722	0.635	$ 426,897
21	PERIODIC COST - O&M	$0		$0	0.620	$ -
22	PERIODIC COST - O&M	$0		$0	0.606	$ -
23	PERIODIC COST - O&M	$0		$0	0.593	$ -
24	PERIODIC COST - O&M	$0		$0	0.579	$ -
25	PERIODIC COST - O&M	$583,022	$89,700	$672,722	0.566	$ 381,018
26	PERIODIC COST - O&M	$0		$0	0.554	$ -
27	PERIODIC COST - O&M	$0		$0	0.541	$ -
28	PERIODIC COST - O&M	$0		$0	0.529	$ -
29	PERIODIC COST - O&M	$0		$0	0.517	$ -
30	PERIODIC COST - O&M	$583,022	$89,700	$672,722	0.506	$ 340,069
					TOTAL PRESENT VALUE OF ALTERNATIVE	**$ 3,345,600**

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TABLE F-8

Long Term Operations and Maintenance Costs for Onsite Confined Disposal Facility (CDF) - Disposal Options F and G

Gowanus Canal Feasibility Study

Brooklyn, New York

Site: Gowanus Canal
Location: Brooklyn, NY
Description: Operations and Maintenance Detailed Costing

CAPITAL COSTS	DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
CDF Maintenance						
	Integrity Surveys	5	DAY	$2,100.00	$10,500	
	Mowing	0	EA	$1,000.00	$0	
	Utilities	0	MO	$1,000.00	$0	
	SUBTOTAL CDF MAINTENANCE				$10,500	
	TOTAL CAPITAL COST				**$10,500**	

O&M	DESCRIPTION	YEAR	QTY	UNIT	COST	TOTAL	NOTES
	Sampling						
				ea	$0	$0	
	Subtotal Annual O&M					**$0**	
	Reporting (1 annual report)		1	LS	$5,000	$5,000	
	Contingency		20%			$1,000	
	Subtotal Annual O&M					$6,000	
	Project Management		15%			$900	
	TOTAL PERIODIC O&M COST					**$6,900**	

PRESENT VALUE ANALYSIS (30-year) Discount Rate = 2.3%

End Year	COST TYPE	Capital Cost	O&M Cost	TOTAL COST/YEAR	DISCOUNT FACTOR	PRESENT VALUE
0	CAPITAL COST	$10,500	$0	$10,500	1.000	$ 10,500
1	PERIODIC COST - O&M	$10,500	$0	$10,500	0.978	$ 10,264
2	PERIODIC COST - O&M	$10,500	$0	$10,500	0.956	$ 10,033
3	PERIODIC COST - O&M	$10,500	$0	$10,500	0.934	$ 9,808
4	PERIODIC COST - O&M	$10,500	$0	$10,500	0.913	$ 9,587
5	PERIODIC COST - O&M	$10,500	$6,900	$17,400	0.893	$ 15,530
6	PERIODIC COST - O&M	$10,500	$0	$10,500	0.872	$ 9,161
7	PERIODIC COST - O&M	$10,500	$0	$10,500	0.853	$ 8,955
8	PERIODIC COST - O&M	$10,500	$0	$10,500	0.834	$ 8,754
9	PERIODIC COST - O&M	$10,500	$0	$10,500	0.815	$ 8,557
10	PERIODIC COST - O&M	$10,500	$6,900	$17,400	0.797	$ 13,861
11	PERIODIC COST - O&M	$10,500	$0	$10,500	0.779	$ 8,176
12	PERIODIC COST - O&M	$10,500	$0	$10,500	0.761	$ 7,992
13	PERIODIC COST - O&M	$10,500	$0	$10,500	0.744	$ 7,813
14	PERIODIC COST - O&M	$10,500	$0	$10,500	0.727	$ 7,637
15	PERIODIC COST - O&M	$10,500	$6,900	$17,400	0.711	$ 12,371
16	PERIODIC COST - O&M	$10,500	$0	$10,500	0.695	$ 7,298
17	PERIODIC COST - O&M	$10,500	$0	$10,500	0.679	$ 7,134
18	PERIODIC COST - O&M	$10,500	$0	$10,500	0.664	$ 6,973
19	PERIODIC COST - O&M	$10,500	$0	$10,500	0.649	$ 6,816
20	PERIODIC COST - O&M	$10,500	$6,900	$17,400	0.635	$ 11,042
21	PERIODIC COST - O&M	$10,500	$0	$10,500	0.620	$ 6,513
22	PERIODIC COST - O&M	$10,500	$0	$10,500	0.606	$ 6,367
23	PERIODIC COST - O&M	$10,500	$0	$10,500	0.593	$ 6,224
24	PERIODIC COST - O&M	$10,500	$0	$10,500	0.579	$ 6,084
25	PERIODIC COST - O&M	$10,500	$6,900	$17,400	0.566	$ 9,855
26	PERIODIC COST - O&M	$10,500	$0	$10,500	0.554	$ 5,813
27	PERIODIC COST - O&M	$10,500	$0	$10,500	0.541	$ 5,683
28	PERIODIC COST - O&M	$10,500	$0	$10,500	0.529	$ 5,555
29	PERIODIC COST - O&M	$10,500	$0	$10,500	0.517	$ 5,430
30	PERIODIC COST - O&M	$10,500	$6,900	$17,400	0.506	$ 8,796
				TOTAL PRESENT VALUE OF ALTERNATIVE		**$ 264,600**

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TABLE F-9

Long Term Operations and Maintenance Costs for Onsite Stabilization and Beneficial Use Disposal Option (Option E)

Gowanus Canal Feasibility Study

Brooklyn, New York

Site: Gowanus Canal

Location: Brooklyn, NY

Description: Operations and Maintenance Detailed Costing

CAPITAL COSTS	DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Staging Facility Maintenance						
	Temporary Access Road Construction	2,500	SY	$11.35	$28,375	
	Rough Grading	2,421	SY	$1.00	$2,421	
	Stone Base	541	CY	$30.00	$16,221	
	Silt Fence	750	LF	$5.00	$3,750	
	Filter Fabric	2,421	SY	$2.00	$4,842	
	SUBTOTAL FACILITY MAINTENANCE				$55,609	
Property Rental						
	Temporary Storage Area (2 Acres)	12	MO	20000	$240,000	
	SUBTOTAL PROPERTY RENTAL				$240,000	
	TOTAL CAPITAL COST				**$295,609**	

O&M	DESCRIPTION	YEAR	QTY	UNIT	COST	TOTAL	NOTES
	Sampling						
	Geoprobe Sampling		1	LS	$7,150	$7,150	
	Subtotal Annual O&M					**$7,150**	
	Reporting (1 annual report)		1	LS	$15,000	$15,000	
	Contingency		20%			$4,430	
	Subtotal Annual O&M					$26,580	
	Project Management		15%			$3,987	
	TOTAL PERIODIC O&M COST					**$30,567**	

PRESENT VALUE ANALYSIS (30-year) Discount Rate = 2.3%

End Year	COST TYPE	Capital Cost	O&M Cost	TOTAL COST/YEAR	DISCOUNT FACTOR	PRESENT VALUE
0	CAPITAL COST	$0.00	$0.00	$0.00	1.000	$ -
1	CAPITAL COST/PERIODIC COST - O&M	$295,609	$30,567	$326,176	0.978	$ 318,843
2	CAPITAL COST/PERIODIC COST - O&M	$295,609	$30,567	$326,176	0.956	$ 311,674
3	CAPITAL COST/PERIODIC COST - O&M	$295,609	$30,567	$326,176	0.934	$ 304,667
4	CAPITAL COST/PERIODIC COST - O&M	$295,609	$30,567	$326,176	0.913	$ 297,817
5	CAPITAL COST/PERIODIC COST - O&M	$295,609	$30,567	$326,176	0.893	$ 291,121
6	CAPITAL COST/PERIODIC COST - O&M	$295,609	$30,567	$326,176	0.872	$ 284,576
10	CAPITAL COST/PERIODIC COST - O&M	$295,609	$30,567	$326,176	0.797	$ 259,834
15	CAPITAL COST/PERIODIC COST - O&M	$295,609	$30,567	$326,176	0.711	$ 231,909
20	CAPITAL COST/PERIODIC COST - O&M	$295,609	$30,567	$326,176	0.635	$ 206,985
25	CAPITAL COST/PERIODIC COST - O&M	$295,609	$30,567	$326,176	0.566	$ 184,740
30	CAPITAL COST/PERIODIC COST - O&M	$295,609	$30,567	$326,176	0.506	$ 164,886
					TOTAL PRESENT VALUE OF ALTERNATIVE	**$ 2,857,100**

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TABLE 1-1
Summary of Sediment Physical Characteristics
Gowanus Canal Feasibility Study
Brooklyn, New York

	Canal Surface Sediment			Reference Area Surface Sediment		
Surface Sediment Data	**Minimum**	**Maximum**	**Average**	**Minimum**	**Maximum**	**Average**
Total Organic Carbon (mg/kg)	25,100	137,000	64,385	2,980	43,400	28,358
Percent Sand	10	58	39	9.7	44	28
Percent Silt	35	74	52	44	72	57
Percent Clay	4.9	15	8.9	12	21	15
Total Percent Fines	42	90	61	56	90	72
Percent Solids	26	78	36	27	70	41
Sulfide (mg/kg)	51	8,790	3,448	383	2,160	1,167
	Soft Sediment			***Native Sediment***		
Sediment Core Data	**Minimum**	**Maximum**	**Average**	**Minimum**	**Maximum**	**Average**
Total Organic Carbon (mg/kg)	730	490,000	119,650	550	168,000	18,677
Percent Sand	10	80	35	0	100	51
Percent Silt	18	70	54	0	81	38
Percent Clay	1.2	24	11	0	74	10
Total Percent Fines	20	90	65	0.53	100	49
Percent Solids	25	99	54	48	91	81
Sulfide (mg/kg)	184	8,330	3,909	7.6	7,300	145
Bulk Density (g/cm^3)	0.31	2.0	0.83	0.59	2.1	1.5

Notes:

Surface sediment is 0-6 inch interval.

Statistics were generated using 1/2 the detection limit for non-detected results

Statistics for surface sediment were generated using only USEPA 2010 data.

Total percent fines is the sum of percent silt and percent clay.

Total Organic Carbon and Percent Solids summary statistics for soft sediment from sediment cores were calculated using the USEPA 2010 and National Grid 2005 data sets. The summaries for native sediment were determined using only the USEPA 2010 data set.

Sulfide and Total Percent Fines summary statistics for soft and native sediment for sediment cores were determined using only the USEPA 2010 data set.

Bulk density for soft sediment was determined using only the National Grid 2005 data set. This parameter was not measured in the 2010 investigation. Bulk density values for native sediment were obtained from GEI (2007).

mg/kg = milligram per kilogram

g/cm^3 = grams per cubic centimeter

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TABLE 1-2
Average Concentrations of Selected Constituents in Surface Sediment, Soft Sediment, and Native Sediment
Gowanus Canal Feasibility Study
Brooklyn, New York

Constituent	Average Concentration (mg/kg)			
	Canal Surface Sediment	Canal Soft Sediment	Canal Native Sediment	Reference Surface Sediment
Total BTEX	0.36	188	233	ND
Total PAHs	527	3490	2920	5.8
Total PCBs	0.43	3.5	0.026	ND
Barium	175	441	32	67
Cadmium	6.30	9.70	0.32	2.31
Copper	226	388	12	81
Lead	533	770	14	93
Mercury	1.27	2.63	0.095	1.12
Nickel	44	78	15	32
Silver	3.40	11	0.61	2.15

Notes:
mg/kg - milligrams/kilogram
ND - not detected
BTEX - benzene, toluene, ethylbenzene, and xylenes
Reference area in Gowanus Bay and Upper New York Bay

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TABLE 1-3
Summary of Equilibrium Sediment Benchmark Toxic Units for PAHs in Groundwater
Gowanus Canal Feasibility Study
Brooklyn, New York

Shallow Wells		Intermediate Wells	
Field Sample ID	**Adjusted ESB TU_{FCV}[1]**	**Field Sample ID**	**Adjusted ESB TU_{FCV}[1]**
GC-MW25S	0	GC-MW08I	0
GC-MW04S	0	GC-MW42I	0
GC-MW26S	0	GC-MW12I	0
GC-MW15S	0	GC-MW19I-S-NYC	0
GC-MW17S-S-NYC	0	GC-MW15I	0
GC-MW28S	0	GC-MW26I	0
GC-MW42S	0	GC-MW14I	1
GC-MW31S(6.75-14.6)	0	GC-MW17I	1
GC-MW31S-S-NG	1	GC-MW02I	2
GC-MW08S	1	GC-MW17I-S-NYC	2
GC-MW19S-S-NYC	1	GC-MW06I	2
GC-MW19S	1	GC-MW05I	2
GC-MW14S	1	GC-MW28I	2
GC-MW44S	1	GC-MW46D	3
GC-MW33S	2	GC-MW02I-S-NYC	3
GC-MW05S	2	GC-MW25I	3
GC-MW06S	2	GC-MW04I	4
GC-MW01S-S-NYC	3	GC-MW44I	4
GC-MW21S	3	GC-MW01I	4
GC-MW29S	4	GC-MW16I	5
GC-MW01S	5	GC-MW29I	6
GC-MW32S-S-NG	7	GC-MW40I	8
GC-MW16S	7	GC-MW24I	11
GC-MW24S	8	GC-MW38I	15
GC-MW37S	8	GC-MW-41I(53-58)	16
GC-MW09S	9	GC-MW01I-S-NYC	19
GC-MW38S	9	GC-MW37I	24
GC-MW-32S(12-19)	15	GC-MW41I-S-NG	28
GC-MW23S	15	GC-MW43I	37
GC-MW12S	18	GC-MW10I	52
GC-MW18S	26	GC-MW03I	67
GC-MW18S-S-NYC	27	GC-MW10I-S-NYC	85
GC-MW20S	27	GC-MW39I	116
GC-MW03S	31	GC-MW13I	119
GC-MW23S-S-NG	36	GC-MW35I	158
GC-MW07S	38	GC-MW36I	165
GC-MW27S	39	GC-MW34I	166
GC-MW39S	40	GC-MW-23I(33.75-38.75)	188
GC-MW43S	49	GC-MW09I	192
GC-MW36S	77	GC-MW18I-S-NYC	202
GC-MW34S	96	GC-MW18I	222
GC-MW09S-S-NYC	98	GC-MW09I-S-NYC	239
GC-MW13S	128	GC-MW20I	266
GC-MW35S	136	GC-MW30I(30-35)	291
GC-MW45S	216	GC-MW47I	294
GC-MW41S-S-NG	247	GC-MW23I-S-NG	305
GC-MW-41S(8-13)	269	GC-MW27I	328
GC-MW30S-S-NG	278	GC-MW33I	512
GC-MW30S(7-16)	313	GC-MW45I	537
GC-MW11S	318	GC-MW31I(30-35)	566
GC-MW47S	367	GC-MW31I-S-NG	575
		GC-MW32I-S-NG	900
		GC-MW-32I(40-45)	941
		GC-MW07I	1461
		GC-MW11I	3041

Notes:
Groundwater samples with no detected PAHs are excluded.
ESB - equilibrium sediment benchmark
TU - toxic unit
FCV - final chronic value
[1] Adjusted with an uncertainty factor at a 95% confidence level associated with using 13 PAHs (uncertainty factor = 11.5) (USEPA, 2003)

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TABLE 1-4

Summary of PAH and Metals Concentrations in CSO Solids and Surface Sediment Samples

Gowanus Canal Feasibility Study

Brooklyn, New York

Constituent	CSO Wet Weather Solids[1] (mg/kg)		Surface Sediment Samples (mg/kg)					
			Upper Canal		Middle Canal		Lower Canal	
	Lower Bound	Upper Bound	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Total PAHs	13	103	11	140	13	6670	13	83
Barium	160	1650	87	157	88	631	83	251
Copper	177	1580	86	698	166	395	110	186
Lead	249	1410	184	3465	355	994	146	360
Nickel	16	201	18	46	31	82	33	47

Notes:

PCBs were not detected in CSO water samples. Cadmium, mercury, and silver are not included because of low frequency of detection in CSO wet weather water samples.

[1] Estimated concentrations based on CSO wet weather water samples from the four outfalls that account for 95 percent of the annual CSO discharge (RH-034, RH-035, OH-007 and RH-031)

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TABLE 1-5
Average Concentrations of Selected Constituents in Surface Sediment in the Upper, Middle, and Lower Canal
Gowanus Canal Feasibility Study
Brooklyn, New York

Constituent	Average Concentration (mg/kg)			
	Upper Reach (Head of Canal to 3rd St.)	Middle Reach (3rd St. to Creamer St.)	Lower Reach (Creamer St. to South End of Study Area)	Reference (Gowanus Bay and Upper New York Bay)
Total PAHs	56	951	34	5.8
Total PCBs	0.055	0.83	0.046	ND
Barium	112	250	106	67
Cadmium	3.99	7.28	7.88	2.31
Copper	223	255	139	81
Lead	613	491	192	93
Mercury	1.23	1.32	1.09	1.12
Nickel	36	51	40	32
Silver	2.93	4.31	1.75	2.15

Notes:
Surface sediment is 0-to-6-inch interval
mg/kg - milligrams/kilogram
ND - not detected

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TABLE 2-1

Summary of Preliminary Remediation Goals for Sediment

Gowanus Canal Feasibility Study

Brooklyn, New York

	Concentration (mg/kg)						
Preliminary Remediation Goal	**Total PAHs**	**BAA**	**BAP**	**BBF**	**BKF**	**DA**	**ID**
Ecological Risk							
Amphipod - survival [1]	39	--	--	--	--	--	--
Amphipod - growth/reproduction [1]	7.8	--	--	--	--	--	--
Polychaete - survival/growth	290	--	--	--	--	--	--
Herbivorous birds - dietary exposure	230	--	--	--	--	--	--
Human Health Risk [2]							
Recreational use - 10^{-5} risk level	--	24	2.4	24	240	2.4	24

Notes:

BAA - benzo(a) anthracene, BAP - benzo(a)pyrene, BBF - benzo(b)fluoranthene, BKF - benzo(k)fluoranthene, DA - dibenz(a,h)anthracene, ID - indeno(1,2,3-c,d)pyrene

[1] PRGs do not include confidence intervals

[2] Cumulative risk of six carcinogenic PAHs that individually pose a risk of 10^{-5} would be above the upper bound of USEPA's acceptable risk range

-- Not applicable

TABLE 2-2

Summary of Preliminary Remediation Goals for Surface Water

Gowanus Canal Feasibility Study

Brooklyn, New York

	Concentration (µg/L)				
Preliminary Remediation Goal	**BAA**	**BAP**	**BBF**	**DA**	**ID**
Human Health Risk					
Recreational use - 10^{-5} risk level	180	11.0	110	6.7	110

Notes:

BAA - benzo(a) anthracene, BAP - benzo(a)pyrene, BBF - benzo(b)fluoranthene, DA - dibenz(a,h)anthracene, ID - indeno(1,2,3-c,d)pyrene

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TABLE 2-3
Chemical-Specific ARARs and TBCs
Gowanus Canal Superfund Site, Brooklyn, NY

Citation	Requirement/Purpose	Preliminary Determination and Comments
Federal Water Pollution Control Act as amended by the Clean Water Act of 1977, Section 208(b)	The proposed action must be consistent with regional water quality management plans as developed under Section 208 of Clean Water Act.	ARAR. Substantive requirements applicable to direct discharge of treatment system effluent if alternative includes construction and operation of a noncommercial treatment facility that discharges to surface water.
40 CFR Part 131—Water Quality Standards	States are granted enforcement jurisdiction over direct discharges and may adopt reasonable standards to protect or enhance the uses and qualities of surface water bodies in the state.	ARAR. Substantive requirements applicable to direct discharge of treatment system effluent if alternative includes construction and operation of a noncommercial treatment facility that discharges to surface water.
Federal Water Pollution Control Act (Clean Water Act 40), 33 USC §§ 1251-1387 40 CFR Part 129 Toxic Pollutant Effluent Standards	Toxic pollutant effluent standards for aldrin/dieldrin, DDT, endrin, toxaphene, benzidene, and PCBs.	ARAR. Part 129 applies to direct discharge to surface water of treatment system effluent if alternative includes construction and operation of a noncommercial treatment facility that discharges to surface water. Must comply with substantive requirements (effluent standards) of an SPDES permit.
New York State Environmental Conservation Law (ECL) Article 15, Title 3 and Article 17, Titles 3 and 8 6 NYCRR Part 608, Use and Protection of Waters [Section 608.5 (Excavation and Placement of Fill in Navigable Water), 608.6(Permit Application Procedures) and 608.9 (Water Quality Certifications)]	Section 608.5 includes the requirement to obtain an SPDES permit for certain discharges in any navigable waters of the State. Part 608.5 also requires a permit for the excavation or placement of fill directly or indirectly in navigable waters. This includes marshes, estuaries, tidal marshes and wetlands that are adjacent to and contiguous at any point to any of the navigable waters of the state, and that are inundated at mean high water level or tide. Water Quality Certifications required by Section 401 of the federal Water Pollution Control Act are incorporated into the State regulations in Part 608.9. Section 608.9(a) requires that construction or operation of facilities that may result in a discharge to navigable waters demonstrate compliance with CWA §§ 301–303, 306, and 307 and 6 NYCRR §§ 751.2 (prohibited discharges) and 754.1 (effluent prohibitions; effluent limitations and water quality-related effluent limitations; pretreatment standards; standards of performance for new sources).	ARAR. Substantive requirements would apply to all portions of the canal determined by NYSDEC to be navigable. Applicable to direct discharge of treatment system effluent if alternative includes construction and operation of a noncommercial treatment facility that discharges to navigable surface water.

TABLE 2-3
Chemical-Specific ARARs and TBCs
Gowanus Canal Superfund Site, Brooklyn, NY

Citation	Requirement/Purpose	Preliminary Determination and Comments
6 NYCRR Part 703 Surface Water and Groundwater Quality Standards and Groundwater Effluent Limitations	Part 703 establishes surface water and groundwater quality standards and groundwater effluent limitations. The turbidity standard is non-numeric: No increase that will cause a substantial visible contrast to natural conditions. The suspended, colloidal, and settleable solids standard is non-numeric: None from sewage, industrial wastes or other wastes that will cause deposition or impair the waters for their best usages.	ARARs. Substantive requirements applicable to water quality in the canal during remedy implementation and to direct discharge of treatment system effluent if alternative includes construction and operation of a non-commercial treatment facility that discharges to surface water (note standards vary based on water classification). Note that numeric standards may be established as part of a Water Quality Certification.
Federal Water Pollution Control Act as amended by the Clean Water Act of 1977, Section 304 Information and Guidelines	Establishes water quality criteria for specific pollutants for the protection of human health and aquatic life. These federal water quality criteria are not directly enforceable guidelines used by the state to set water quality standards for surface water.	TBC for direct discharge to surface water of treatment system effluent from a non-commercial treatment facility. Water quality criteria are TBCs used in setting standards for discharges to surface water.
USEPA *Federal Register*, Volume 57, No. 246, December 22, 1992	Ambient water quality criteria	TBC. Note that numeric standards may be established as part of a Water Quality Certification.
USEPA: Residential soil RSL from EPA Regional Screening Table, (May 2010)	There are currently no chemical-specific RSLs for contact with sediment. Site-specific sediment cleanup objectives were developed for the site as described in the FS report.	TBC
NYSDEC: Technical and Operational Guidance Series (TOGS) 1.1.1 Ambient Water	Provide guidance for ambient water quality standards and guidance values for pollutants.	TBC. Note that numeric standards may be established as part of a Water Quality Certification.
NYSDEC Division of Fish, Wildlife and Marine Resources: Draft Technical Memorandum, Numerical Guidance Values for Assessing Risk to Aquatic Life from Contaminants in Sediment, June 2007	Provides sediment guidance values for the protection of benthic organisms and other varieties of aquatic or marine life, and is intended to provide only one component for evaluation, assessment, and management of contaminated sediment in New York State.	TBC. Note that numeric standards may be established as part of a Water Quality Certification.

TABLE 2-3
Chemical-Specific ARARs and TBCs
Gowanus Canal Superfund Site, Brooklyn, NY

Citation	Requirement/Purpose	Preliminary Determination and Comments
NYSDEC Technical Guidance for Screening Contaminated Sediments (1999)	Includes a methodology to establish sediment criteria for the purpose of identifying contaminated sediments. Site-specific sediment cleanup objectives were developed for the site as described in the FS report.	TBC
Jones, D.S., G.W. Suter II, and R.N. Hull. 1997. Toxicological benchmarks for screening contaminants of potential concern for effects on sediment-associated biota: 1997 revision. Environmental Restoration Division, ORNL Environmental Restoration Program. ES/ER/TM-95/R4.	Report on toxicological benchmarks for screening contaminants of potential concern for effects on sediment-associated biota. Site-specific sediment cleanup objectives were developed for the site as described in the FS report.	TBC
Buchman, M.F., 2008. NOAA Screening Quick Reference Tables, NOAA OR&R Report 08-1, Seattle WA, Office of Response and Restoration Division, National Oceanic and Atmospheric Administration, 34 pages.	Site-specific sediment cleanup objectives were developed for the site as described in the FS report.	TBC

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TABLE 2-4
Action-Specific Federal, State, and Local ARARs and TBCs
Gowanus Canal Superfund Site, Brooklyn, NY

Citation	Requirement/Purpose	Preliminary Determination and Comments
Section 401 of the Clean Water Act Certification 6 NYCRR Part 608 Use and Protection of Waters 6 NYCRR Part 701 Classifications-Surface Waters and Groundwaters	A Water Quality Certification (WQC) under Section 401 of the Clean Water Act would specify the requirements to be implemented so that the proposed activity will comply with water quality standards. Activities requiring a Water Quality Certification include those where a federal permit is required, for example: • Placement of fill in waters of the United States; • Temporary discharges of decant waters from dredge material disposal sites or from barges and vessels. Part 701 establishes classifications for surface waters and groundwater.	ARAR. Substantive requirements would be applicable to portions of the canal determined by NYSDEC to be navigable. The WQC addresses in-water activities and substantive requirements may cover temporary dewatering, barge transportation, disposal of dredged sediment, and other requirements that the regulating agency considers applicable. Part 701 provides classifications of waters of the State, as well as a general prohibition on any discharge that impairs the receiving water for its assigned best usages.
Section 402 of the Clean Water Act 40 CFR Parts 121, State Certification of Activities Requiring a Federal License or Permit, 40 CFR Parts 401 and 403.5 Effluent Guidelines and Standards	Provisions related to the implementation of the National pollutant Discharge Elimination System (NPDES) program including direct discharge and pre-treatment prior to discharge to a POTW.	ARAR. 40 CFR Parts 121, 122, 125, 401 and 403.5 substantive requirements apply to direct discharge of treatment system effluent if alternative includes construction and operation of an onsite non-commercial treatment facility that discharges to surface water or to a POTW.
Section 404(b) of the Clean Water Act 40 CFR Part 230	Guidelines for Specification of Disposal Sites for Dredged or Fill Material. Except as otherwise provided under Clean Water Act Section 404(b)(2), no discharge of dredged or fill material shall be permitted if there is a practicable alternative to the proposed discharge which would have less adverse impact on the aquatic ecosystem, so long as the alternative does not have other significant adverse environmental consequences. Includes criteria for evaluating whether a particular discharge site may be specified.	Not an ARAR. The alternatives developed in this FS do not consider ocean disposal of dredged sediments or other residuals.

TABLE 2-4
Action-Specific Federal, State, and Local ARARs and TBCs
Gowanus Canal Superfund Site, Brooklyn, NY

Citation	Requirement/Purpose	Preliminary Determination and Comments
Section 404(c) of the Clean Water Act, 33 USC § 1344 - Permits for Dredged or Fill Material 33 CFR Navigation and Navigable Waters, Parts 320, 323, 325, 329 and 330	Regulations to authorize the discharge of dredged or fill material into navigable waters of the United States pursuant to Section 404 of the Clean Water Act (CWA) (33 U.S.C. 1344). The USACE and USEPA regard the use of mechanized earth-moving equipment to conduct earth-moving activity in waters of the United States as resulting in a discharge of dredged material unless project-specific evidence shows that the activity results in only incidental fallback. Any proposed discharge must avoid, to the fullest extent practicable, adverse effects, especially on aquatic ecosystems.	ARAR for the portion of the canal South of the Hamilton Avenue Bridge. Substantive portions of 33 CFR Parts 320, 323 325, 329 and 330 apply to alternatives that include dredging or capping of sediments. Though actual discharge of dredged material back into the canal is not anticipated, requirements apply to dredging and capping. Substantive requirements are likely to include measures to minimize re-suspension of sediments and erosion of sediments during excavation (i.e., measures to avoid, to the fullest extent practicable, adverse effects, especially on aquatic ecosystems). TBC for the portion of the canal North of the Hamilton Avenue Bridge.
40 CFR Part 122 EPA Administered Permit Programs: the National Pollutant Discharge Elimination System and Part 125 Criteria and Standards for the National Pollutant Discharge Elimination System	Requires the development and implementation of a stormwater pollution prevention plan or a stormwater best management plan. Also outlines monitoring and reporting requirement for a variety of facilities.	ARAR. Substantive requirements apply to management of dewatered sediment and associated runoff if alternative includes construction and operation of an onsite noncommercial treatment facility.
Clean Air Act 40 CFR 50-99	Specifies requirements for air emissions such as particulates, sulfur dioxide, VOCs, hazardous air pollutants, and asbestos.	ARAR. Particulates are not likely to be generated during excavation or in-situ treatment of sediments. Particulates may be generated during cap placement. Best available practices to control particulates will be used, as needed, during remedial activities. Substantive requirements apply if alternative includes the operation of an onsite noncommercial treatment facility.
40 CFR 241–Guidelines for Land Disposal of Solid Wastes	Offsite solid waste land disposal units must meet the federal guidelines for the land disposal of solid wastes.	Not an ARAR. The alternatives developed in this FS do not include construction of an offsite solid waste land disposal unit. Offsite commercial facilities where sediments are sent for treatment / disposal must comply with the USEPA Offsite Rule per 40 CFR 300.440.

TABLE 2-4
Action-Specific Federal, State, and Local ARARs and TBCs
Gowanus Canal Superfund Site, Brooklyn, NY

Citation	Requirement/Purpose	Preliminary Determination and Comments
40 CFR 260 through 265 Solid Waste Disposal Act, as amended, 42 USC §§ 6901-6992k Hazardous Materials Transportation Act (HMTA), as amended, 49 USC §§ 5101-5127 49 CFR Part 171: Department of Transportation Rules for Transportation of Hazardous Materials 49 CFR 100 through 199	Requirements for the generation, transport, storage, treatment, and disposal and operation of hazardous wastes including those generated in the course of a remedial action. Requirements also cover the construction, design, monitoring, operation, and closure of hazardous waste facilities.	Not an ARAR based on current testing results. Testing of sediments for RCRA characteristics (including TCLP) indicated that the tested samples are not hazardous. There is no documentation of the release of a listed waste to the sediments and therefore, they are not considered listed waste. Note that alternatives include management of sediments and these requirements would be an ARAR if testing shows that the removed materials are hazardous. Note that dredged sediment removed under Article 15 Water Resources, 24 Freshwater Wetlands, 25 Tidal Wetlands, or 34 Coastal Erosion Hazard Area of the Environmental Conservation Law or under the water quality certification requirements under section 401 of the Federal Water Pollution Control Act is considered exempt from being a solid waste. The substantive requirements that would be part of a WQC describe the appropriate management of the dredged sediments.
40 CFR 268 Land Disposal Restrictions	The land disposal restrictions require treatment before land disposal for a wide range of hazardous wastes.	Not an ARAR. The sediments are not listed hazardous waste. The sediments also are not characteristic waste. Note that alternatives include management of sediments and these requirements would be an ARAR if testing shows that the removed materials are hazardous waste. Note that dredged sediment pursuant to WQC requirements is exempt from being a solid waste, and therefore would not be a hazardous waste. The substantive requirements that would be part of a WQC describe the appropriate management of the dredged sediments.
40 CFR 300.440 Offsite Rule	CERCLA wastes may only be placed in a facility operating in compliance with RCRA or other applicable federal or state requirements. Establishes criteria and a process for determining whether those facilities are acceptable.	ARAR for alternatives where sediments are disposed of at an offsite commercial facility.

TABLE 2-4
Action-Specific Federal, State, and Local ARARs and TBCs
Gowanus Canal Superfund Site, Brooklyn, NY

Citation	Requirement/Purpose	Preliminary Determination and Comments
Toxic Substances Control Act (TSCA) PCB Remediation Wastes 40 CFR 761	Identifies storage, disposal, and decontamination requirements for various PCB waste types and specifies requirements for PCB remediation waste. PCB remediation waste is defined as waste containing PCBs as a result of a spill, release, or other unauthorized disposal at the following concentrations: • Materials disposed of prior to April 18, 1978, that are currently at concentrations > 50 ppm PCB, regardless of the concentrations of the original spill; • Materials currently at any volume or concentration where the original source was >500 ppm PCB beginning on April 18, 1978, or > 50 ppm PCB beginning on July 2, 1979; and • Materials currently at any concentration if the PCBs are from a source not authorized for use. Examples are: soil, gravel, dredged materials, sewage sludge, and buildings contaminated by leaking PCBs as described above. PCB remediation wastes are managed based on the concentrations at which the PCBs are found, as opposed to their original concentration.	Would be an ARAR and substantive requirements would apply if the sediments are considered PCB remediation waste. Requires coordination with USEPA TSCA Regional contact per guidance to determine applicability and path forward.
Occupational Safety and Health Act: 29CFR 1904, 1910, and 1926	Specifies minimum requirements to maintain worker health and safety, including training and construction safety requirements.	ARAR applicable to all remedial activities.
New York State ECL Article 1 Title 1 Article 3 Title 3 Article 15 Title 3 Article 17 Title 1 and 3	New York State requirements to conserve, improve and protect the State's natural resources and environment and to prevent, abate and control water, land and air pollution. Protection of waters requirements when filling and excavating in navigable waters and other areas that are adjacent to and contiguous at any point to any of the navigable waters of the state and that are inundated at mean high water level or tide,	ARAR. Substantive requirements apply to remedial activities within the canal and if remedial alternative includes the operation of an onsite noncommercial treatment facility.

TABLE 2-4
Action-Specific Federal, State, and Local ARARs and TBCs
Gowanus Canal Superfund Site, Brooklyn, NY

Citation	Requirement/Purpose	Preliminary Determination and Comments
New York State ECL Article 7,Title 7 6 NYCRR Part 360	Prohibits the disposal of solid waste except at an authorized facility. These regulations identify the requirements for design, construction, operation, and closure, and other solid waste management activities for solid waste management facilities. Beneficial-use requirements include testing of the materials, control of run-off and run-on, and implementation of best management practices.	ARAR. The alternatives developed in this FS include management of dredged sediments which requires compliance with regulations for offsite components of alternatives or compliance with substantive requirements for onsite components of alternatives unless the sediments are exempted from being solid waste through the WQC process or through the Environmental Conservation Law Article 15, Water Resources; 24, Freshwater Wetlands; 25, Tidal Wetlands; or 34, Coastal Erosion Hazard Area. The substantive requirements that would be part of a WQC describe the appropriate management of the dredged sediments.
New York State ECL Article 11, Title 5 - NY ECL § 11-0503	Fish & Wildlife Law against water pollution. No deleterious or poisonous substances shall be thrown or allowed to run into any public or private waters in quantities injurious to fish life, protected wildlife, or waterfowl inhabiting those waters, or injurious to the propagation of fish, protected wildlife, or waterfowl therein.	ARAR. Substantive requirements of 11-0503 apply to the onsite components of remedial activities (e.g., if remedial alternative includes construction and operation of an onsite noncommercial treatment facility).
New York State ECL Article 17, Title 5	It shall be unlawful for any person, directly or indirectly, to throw, drain, run or otherwise discharge into such waters organic or inorganic matter that shall cause or contribute to a condition in contravention of applicable standards identified at 6 NYCRR § 701.1.	ARAR. Substantive requirements of 17-0501, 17-0503, 17-0505, 17-0507, 17-0509 and 17-0511 apply to the onsite components of remedial alternatives (e.g., if remedial alternative includes construction and operation of an onsite noncommercial treatment facility).
New York State ECL Article 17, Title 8 6 NYCRR Parts 750–758	New York State Pollutant Discharge Elimination System (SPDES) Requirements and Standards for Storm Water Runoff, Surface Water, and Groundwater Discharges. In general, no person shall discharge or cause a discharge to NY State waters of any pollutant without a permit under the New York State Pollutant Discharge Elimination System (SPDES) program.	ARAR. Substantive portions of 6 NYCRR Parts 750 - 758 apply to the onsite components of remedial alternatives (e.g., if remedial alternative includes construction and operation of an onsite noncommercial treatment facility).

TABLE 2-4
Action-Specific Federal, State, and Local ARARs and TBCs
Gowanus Canal Superfund Site, Brooklyn, NY

Citation	Requirement/Purpose	Preliminary Determination and Comments
New York State ECL, Article 19, Title 3 6 NYCRR Parts 200–257	Air Pollution Control Regulations. The NYSDEC regulations that pertain to emissions are 6NYCRR Parts 200, 202, 211, 212, 219, and 257. The emission of air contaminates that jeopardize human, plant, or animal life, are ruinous to property, or cause a level of discomfort is strictly prohibited (6 NYCRR 211). Adopted pursuant to New York State's Air Pollution Control Law, and submitted to and approved by USEPA pursuant to Section 110 of federal Clean Air Act. The USEPA-approved New York State Regulations are listed at 40 CFR § 52.1679.	ARAR. Particulates are not likely to be generated during dredging. Particulates may be generated during cap placement. Best available practices as needed, will be used to control particulates during remedial activities. Substantive requirements also apply if remedial alternative includes construction and operation of an onsite noncommercial treatment facility).
New York State ECL Article 27 (Collection, Treatment And Disposal Of Refuse And Other Solid Waste), Titles 1, 3, 7, 9, 11; and ECL Article 7, Council of Environmental Advisors, Title 7 6 NYCRR Part 364 Waste Transporter Permits 6 NYCRR Part 370-372 Hazardous Waste Management	Standards for Waste Transportation Regulations governing the collection, manifesting, transport, and delivery of regulated wastes.	ARAR. Substantive requirements of 6 NYCRR Part 364 apply to the transport of sediment and other residuals from the remedial activities unless exempted as solid waste.
New York State ECL Article 27, Title 9 6 NYCRR Part 376	Land Disposal Restrictions. Certain hazardous wastes including dredge spoils containing PCBs greater than 50 mg/kg must be disposed of in accordance with federal regulations at 40 CFR Part 761.	Not an ARAR because sediments are not hazardous per 6 NYCRR Part 371 based on available data. Would be an ARAR if sediments are determined to be hazardous and if the sediment is not exempted as a solid and hazardous waste.
NYSDEC - New York Guidelines for Soil Erosion and Sediment Control	Requirements for development of a plan and measures to reduce soil erosion, control sediment, and minimize related discharges.	ARAR. Apply to management of dewatered sediment and associated runoff if alternative includes construction and operation of an onsite non-commercial treatment facility.
USEPA Remedial Design/Remedial Action Handbook (OSWER Directive No. 9355.0-04B, June 1995)	Provides assistance in planning and managing remedial design and remedial action projects	TBC

TABLE 2-4
Action-Specific Federal, State, and Local ARARs and TBCs
Gowanus Canal Superfund Site, Brooklyn, NY

Citation	Requirement/Purpose	Preliminary Determination and Comments
USEPA Superfund Remedial Design and Remedial Action Guidance (OSWER Directive No. 9355.0-4A, June 1986	Provides assistance in planning and managing remedial design and remedial action projects	TBC
USEPA - Land Use in the CERCLA Remedy Selection Process (OSWER Directive No. 9355.7-04, May 1995)	Presents information for considering land use in making remedy selection decisions at NPL sites.	TBC
USEPA - Contaminated Sediment Strategy (EPA-823-R-98- 001, April 1998)	Establishes an Agency-wide strategy for contaminated sediments, with the following four goals: 1) prevent the volume of contaminated sediments from increasing; 2) reduce the volume of existing contaminated sediment; 3) ensure that sediment dredging and dredged material disposal are managed in an environmentally sound manner; and 4) develop scientifically sound sediment management tools for use in pollution prevention, source control, remediation, and dredged material management.	TBC
USEPA Structure and Components of Five-Year Reviews; Supplemental Five-Year Review Guidance Second Supplemental Five-Year Review Guidance	These documents (OSWER Directive 9355.7-02, USEPA 1991 through 9355.7-03B-P June 2001) provide guidance on conducting Five Year Review to evaluate whether the selected response action continues to be protective of public health and the environment and is functioning as designed.	TBC
NYSDEC- Technical & Operational Guidance Series (TOGS) 5.1.9 In-Water and Riparian Management of Sediment and Dredged Material (November, 2004)	Procedures for the in-water and riparian management of sediment and dredged material. Jointly developed by the Division of Water and the Division of Fish, Wildlife and Marine Resources.	TBC for dredging, and if alternative includes construction and operation of an onsite noncommercial facility in a riparian zone. Includes: descriptions of 3 classes of dredged materials (A, B, and C); material management requirements based on the classification of the material; sediment sampling requirements; and handling and monitoring requirements for dredging and materials management. For Class C sediments, in water placement is ordinarily precluded. Class materials can be capped with available cleaner materials. The document specifies limits for turbidity, suspended solids and other parameters during dredging.

TABLE 2-4
Action-Specific Federal, State, and Local ARARs and TBCs
Gowanus Canal Superfund Site, Brooklyn, NY

Citation	Requirement/Purpose	Preliminary Determination and Comments
NYSDEC - Technical and Operational Guidance Series (TOGS) 1.2.1 Industrial SPDES Permit Drafting Strategy for Surface Waters	Provides guidance for writing permits for discharges of wastewater from industrial facilities and for writing requirements equivalent to SPDES permits for discharges from remediation sites.	TBC.
NYSDEC - Technical and Operational Guidance Series (TOGS) 1.3.1 Waste Assimilative Capacity Analysis & Allocation for Setting	Provides guidance to water quality control engineers in determining whether discharges to water bodies have a reasonable potential to violate water quality standards and guidance values	TBC
NYSDEC - Technical and Operational Guidance Series (TOGS) 1.3.2 Toxicity Testing in the SPDES Permit Program	TOGS 1.3.2 describes the criteria for deciding when toxicity testing will be required in a permit and the procedures which should be followed when including toxicity testing requirements in a permit.	TBC
NYSDEC - Technical and Operational 1.3.7 Analytical Detectability & Quantitation Guidelines for Selected Environmental Parameters	Provides guidance on use and selection of analytical detection limits in writing SPDES permits	TBC
NYSDEC Technical and Administrative Guidance Memorandum(TAGM) 4031 Fugitive Dust Suppression and Particulate Monitoring Program at Inactive Hazardous Waste Sites	Provides guidance on dust suppression and monitoring during remedial activities	TBC
NYSDEC Interim Guidance on Freshwater Navigational Dredging, October 1994	Provides guidance for navigational dredging activities in freshwater areas.	TBC

TABLE 2-4
Action-Specific Federal, State, and Local ARARs and TBCs
Gowanus Canal Superfund Site, Brooklyn, NY

Citation	Requirement/Purpose	Preliminary Determination and Comments
NYSDEC Technical and Administrative Guidance Memorandum (TAGM) 3028 - "Contained-In" Criteria for Environmental Media (November 30, 1992).	Provides "contained-in" concentrations/ action levels for environmental media and the basis for these criteria.	TBC
NYSDEC TAGM 4031 Fugitive Dust Suppression and Particulate Monitoring Program at Inactive Hazardous Waste Sites	Dust suppression and monitoring guidelines	TBC
NYSDEC Division of Air Resources: Air Guide 1 – Guidelines for the Control of Toxic Ambient Air Contaminants	This document provides guidance for the control of toxic ambient air contaminants in New York State.	TBC
NYC Law 77 Title 24 Section 24-163.3 NYCDEP Notice of Promulgation of Chapter 14 of Title 15 of the Rules of the City of New York	Requirements for the use of low sulfur diesel oil.	TBC. Specifies the use of ultra low sulfur diesel fuel (ULSD) and "best available technology" (BAT) for reducing emissions from non-road equipment used on City construction projects.

TABLE 2-4
Action-Specific Federal, State, and Local ARARs and TBCs
Gowanus Canal Superfund Site, Brooklyn, NY

Citation	Requirement/Purpose	Preliminary Determination and Comments
New York City Noise Code (Local Law 113 of 2005)	The noise code prescribes ways to lessen the noise from each type of construction equipment Construction work requires a noise mitigation plan prior to the start of work. When construction activity is planned near "sensitive receptors," such as schools, hospitals and houses of worship, the noise mitigation plan must be responsive to these receptors. Prohibited noises are those that exceed ambient sound levels by more than 10 decibels as measured from inside any property or on a public street, at 15 feet from the source. Construction may occur between 7:00 a.m. and 6:00 p.m. on weekdays. Work may take place after hours and on weekends only with express authorization from the Departments of Buildings and Transportation. Certifications are also required that equipment is maintained in according to manufacturer's specifications.	TBC.
New York City Administrative Codes: Title 13, Article 15 Prevention of Emission of Dust from Construction Related Activities, Title 24: Environmental Protection and Utilities	Regulations address air pollution control, noise control, drainage and sewer control, climate protection.	TBC.

TABLE 2-5
Location-Specific Federal, State, and Local ARARs and TBCs
Gowanus Canal Superfund Site, Brooklyn, NY

Citation	Requirement/Purpose	Preliminary Determination and Comments
National Historical Preservation Act 16 USC § 470 & 661 et seq. 36 CFR Part 65 36 CFR Part 800	Establishes procedures to provide for preservation of scientific, historical, and archaeological data that might be destroyed through alteration of terrain as a result of a federal construction project or a federally licensed activity or program. If scientific, historical, or archaeological artifacts are discovered at the site, work in the area of the site affected by such discovery will be halted pending the completion of any data recovery and preservation activities required pursuant to the Act and its implementing regulations.	ARAR. Applicable if scientific, historic, or archaeological artifacts are identified during implementation of the remedy. Meetings have been held with the New York State Historic Preservation Office (SHPO) and the design will include measures to manage such artifacts if encountered.
Endangered Species Act of 1973 16 USC §1531 et seq. 50 CFR 222- 228	Requires that Federal agencies ensure that any action authorized, funded, or carried out by the agency is not likely to jeopardize the continued existence of any threatened or endangered species or destroy or adversely modify critical habitat.	ARAR. No threatened or endangered species or habitat for threatened or endangered species were identified in the Gowanus Canal. Substantive provisions would apply if threatened or endangered species are identified onsite where support facilities and activities for the selected remedy are established (for example, if an alternative includes the onsite construction of a treatment facility and for staging areas).
Rivers and Harbors Act of 1899 Section 10 (33 USC §401et. seq.) 33 CFR 322	U.S. Army Corps of Engineers approval is generally required to excavate or fill or in any manner to alter or modify the course, location, condition, or capacity of the channel of any navigable water of the United States.	ARAR. Substantive requirements apply to the canal below the Hamilton Avenue Bridge. Typical requirements for dredging include measures to minimize re-suspension of sediments and erosion of sediments and stream banks during excavation. TBC for the canal above the Hamilton Avenue Bridge.

TABLE 2-5
Location-Specific Federal, State, and Local ARARs and TBCs
Gowanus Canal Superfund Site, Brooklyn, NY

Citation	Requirement/Purpose	Preliminary Determination and Comments
Federal Coastal Zone Management Act §307 156 CFR 930.30 Federal Consistency Determination Title 15--Commerce and Foreign Trade Chapter Ix--National Oceanic and Atmospheric Administration, Department Of Commerce Part 923--Coastal Zone Management Program Regulations and Title 16 U.S.C §§ 1451-1465	The Act is administered by National Oceanic and Atmospheric Administration (NOAA) and provides for management of the nation's coastal resources, to "preserve, protect, develop, and where possible, to restore or enhance the resources of the nation's coastal zone."	ARAR. Applies to placement of bulkhead, sheet piling within the canal, barge/boat docks, barge offloading facilities, boat launches, bridge abutment bulkhead protection, utility protection, dredging.
Fish and Wildlife Coordination Act, 16 U.S.C. § 662	Whenever the waters of any stream or other body of water are proposed or authorized to be impounded, diverted, the channel deepened, or the stream or other body of water otherwise controlled or modified for any purpose, by any department or agency of the United States, such department or agency first shall consult with the United States Fish and Wildlife Service, Department of the Interior, and with the head of the agency exercising administration over the wildlife resources of the particular State in which the impoundment, diversion, or other control facility is to be constructed, with a view to the conservation of wildlife resources by preventing loss of and damage to such resources.	ARAR.

TABLE 2-5
Location-Specific Federal, State, and Local ARARs and TBCs
Gowanus Canal Superfund Site, Brooklyn, NY

Citation	Requirement/Purpose	Preliminary Determination and Comments
USACE Nationwide Permit 38 Cleanup of Hazardous and Toxic Waste	The NWP authorizes a discharge into waters of the United States, contingent upon obtaining individual water quality certification or a case-specific WQC waiver. Likewise, the use of an NWP to authorize an activity within, or outside, a state's coastal zone that will affect land or water uses or natural resources of that state's coastal zone, is contingent upon obtaining an individual CZMA consistency determination, or a case-specific presumption of CZMA concurrence. Authorizes specific activities required to effect the containment, stabilization or removal of hazardous or toxic waste materials that are performed, ordered, or sponsored by a government agency with established legal or regulatory authority provided the permittee notifies the district engineer in accordance with the "Notification" general condition. For discharges in special aquatic sites, the notification must also include a delineation of affected special aquatic sites. Court ordered remedial action plans or related settlements are also authorized by this nationwide permit.	ARAR. NWP 38 imposes general conditions and requirements in the areas of: Navigation, Aquatic Life Movements, Spawning Areas, Migratory Bird Breeding Areas, Shellfish Beds, Water Supply Intakes, Adverse Effects From Impoundments, Fills Within 100-Year Floodplains, Soil Erosion and Sediment Controls, Management of Water Flows, Removal of Temporary Fills, Wild and Scenic Rivers, Tribal rights, Endangered species, Historic Properties, Coastal Zone Management.
Executive Order 11990 50 CFR Part 6, Appendix A	Requires actions to minimize the destruction, loss, or degradation of wetlands and to preserve and enhance the natural and beneficial values of wetlands.	EO 11990 is a TBC. 50 CFR Part 6 Appendix A is an ARAR. Wetlands are not present within the Gowanus Canal. 50 CFR Part 6 is an ARAR if wetlands are found onsite where support facilities and activities for the selected remedy are established (for example, if alternative includes the construction of a treatment facility and for staging areas).
Executive Order 11988 50 CFR Part 6, Appendix A	Requires actions to reduce the risk of flood loss; to minimize the impact of floods on human safety, health, and welfare; and to restore and preserve the natural and beneficial values served by floodplains.	TBC. Preventing flood loss as a result of the canal is not the objective of the project, however, actions that consider how to minimize flood loss during remedy implementation should be considered.

TABLE 2-5
Location-Specific Federal, State, and Local ARARs and TBCs
Gowanus Canal Superfund Site, Brooklyn, NY

Citation	Requirement/Purpose	Preliminary Determination and Comments
USACE Nationwide Permit 3 Maintenance	Authorizes the removal of accumulated sediments and debris in the vicinity of and within existing structures (e.g., bridges, culverted road crossings, water intake structures, etc.) and the placement of new or additional riprap to protect the structure. Any bank stabilization measures not directly associated with the structure will require a separate authorization from the district engineer. Also authorizes temporary structures, fills, and work necessary to conduct the maintenance activity. Appropriate measures must be taken to maintain normal downstream flows and minimize flooding to the maximum extent practicable, when temporary structures, work, and discharges, including cofferdams, are necessary for construction activities, access fills, or dewatering of construction sites.	TBC. Maintenance is not the objective of the project; however, removal of accumulated sediments in the vicinity of existing structures such as the footings to the Hamilton Avenue Bridge may be necessary.

TABLE 2-5
Location-Specific Federal, State, and Local ARARs and TBCs
Gowanus Canal Superfund Site, Brooklyn, NY

Citation	Requirement/Purpose	Preliminary Determination and Comments
USACE Nationwide Permit 13 Bank Stabilization	Bank stabilization activities necessary for erosion prevention provided the activity meets all of the following criteria: a. No material is placed in excess of the minimum needed for erosion protection; b. The bank stabilization activity is less than 500 feet in length; c. The activity will not exceed an average of one cubic yard per running foot placed along the bank below the plane of the ordinary high water mark or the high tide line; d. No material is placed in any special aquatic site, including wetlands; e. No material is of the type or is placed in any location or in any manner so as to impair surface water flow into or out of any wetland area; f. No material is placed in a manner that will be eroded by normal or expected high flows (properly anchored trees and treetops may be used in low energy areas); and, g. The activity is part of a single and complete project. Bank stabilization activities in excess of 500 feet in length or greater than an average of one cubic yard per running foot may be authorized if notification is provided and the district engineer provides approval.	TBC. Bank stabilization is not the objective of the remedial action but may be necessary or appropriate at portions of the canal.
New York State ECL Article 11, Title 5 , Endangered and Threatened Species of Fish and Wildlife – Species of Special Concern 6 NYCRR Part 182	The New York State endangered species legislation authorizes NYSDEC to create a state list of species endangered, threatened, or of special concern in New York. Restricts activities in areas inhabited by endangered species. The taking of any endangered or threatened species is prohibited, except under a permit or license issued by NYSDEC. The destroying or degrading the habitat of a protected animal likely constitutes a "taking" of that animal under NY ECL § 11-0535. The list of state-regulated species in the Gowanus Canal is presented in the Revised ERA (USEPA, 2000q).	ARAR. No threatened or endangered species or habitat for threatened or endangered species were identified in the Gowanus Canal. Substantive provisions would apply if threatened or endangered species are identified onsite where support facilities and activities for the selected remedy are established (for example, if alternative includes the construction of an onsite treatment facility and for staging areas).

TABLE 2-5
Location-Specific Federal, State, and Local ARARs and TBCs
Gowanus Canal Superfund Site, Brooklyn, NY

Citation	Requirement/Purpose	Preliminary Determination and Comments
New York State ECL Article 17, Title 8; Water Resources Law 6 NYCRR Part 750-758 6 NYCRR 608	These regulations cover excavation and fill of the navigable waters of the state and in marshes, estuaries, tidal marshes and wetlands that are adjacent to and contiguous at any point to any of the navigable waters of the state, and that are inundated at mean high water level or tide.	ARAR. Applies to the entire canal if determined by NYSDEC to be navigable under state laws and regulations.
New York State ECL Article 24, Title 7 Freshwater Wetlands Law 6 NYCRR Parts 662-665	Defines procedural requirements for undertaking different activities in and adjacent to freshwater wetlands, and establishes standards governing the issuance of permits to alter or fill freshwater wetlands.	ARAR. Wetlands are not known to be present within Gowanus Canal. Substantive provisions would apply if wetlands are identified onsite where support facilities and activities for the selected remedy are established (for example, if alternative includes the construction of a treatment facility and for staging areas).
EPA Office of Solid Waste and Emergency Response. Policy on Floodplains and Waste and Wetland Assessments for CERCLA Actions, August 1985	The Floodplain Management Emergency Executive Order (E.O. 11988) and the Protection of Response 1985 Wetlands Executive Order (E.O. 11990) discuss situations that require preparation of a floodplain or wetlands assessment and the factors that should be considered in preparing an assessment for response actions taken pursuant to Section 104 or 106 of CERCLA. For remedial actions, a floodplain/wetlands assessment must be incorporated into the analysis conducted during the planning of the remedial action.	TBC. Wetlands are not known to be present within Gowanus Canal. The Gowanus Canal is in the 100-year floodplain. Substantive provisions would be TBCs if wetlands / floodplains are identified onsite where support facilities and activities for the selected remedy are established (for example, if alternative includes the construction of an onsite treatment facility and for staging areas).
USACE. Notice on Issuance of Nationwide Permits, new general conditions and 13 new definitions, 72FR11092, Mar 12, 2007	Reissuance of Nationwide Permits, new general conditions and 13 new definitions. Final notice describes the permits and the changes, and refers to applicable regulations.	TBC
New York State Waterfront Revitalization and Coastal Resources Act	These policies are used to guide the State's and local government efforts to create and maintain clean, accessible, and prosperous coastal areas and inland waterways. The New York State Coastal Management Program includes policies in the following categories: Development, Fish and Wildlife, Flooding and Erosion, General Safeguards, Public Access, Recreation Historic and Scenic Resources, Agricultural Lands Energy and Ice Management, Air and Water Resources, Wetlands.	TBC

TABLE 2-5
Location-Specific Federal, State, and Local ARARs and TBCs
Gowanus Canal Superfund Site, Brooklyn, NY

Citation	Requirement/Purpose	Preliminary Determination and Comments
New York City Department of City Planning Waterfront Revitalization Program (WRP) in 1982.	The WRP promotes sound waterfront planning and requires considerations of the program goals in making land use decisions. The WRP addresses concerns about inappropriate uses of the waterfront as well as deterioration to waterfront structures. Compliance with the WRP is required for projects within the Coastal Zone.	TBC

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TABLE 2-6
Comparison of PAH Concentrations in Surface Sediment to Human-Health-Based Preliminary Remediation Goals
Gowanus Canal Feasibility Study
Brooklyn, New York

Human Health Exposure Point Sample Location	Concentration in mg/kg						Ratio of Concentration to Recreational Use PRG						
	BAA	**BAP**	**BBF**	**BKF**	**DA**	**ID**	**BAA**	**BAP**	**BBF**	**BKF**	**DA**	**ID**	**SUM [2]**
PRG - recreational use	24	2.4	24	240	2.4	24							
301	1.1	1.2	1.0	0.87	0.2	1.0	0.0	0.5	0.0	0.0	0.1	0.0	0.6
302	4.2	5.2	3.5	2.8	0.92	3.0	0.2	2.2	0.1	0.0	0.4	0.1	3.0
303	3.4	3.6	3.4	2.8	0.52	2.4	0.1	1.5	0.1	0.0	0.2	0.1	2.0
305	6.5	5.4	6	4.6	0.7	3.9	0.3	2.3	0.3	0.0	0.3	0.2	3.4
307A	1.9	2.8	3.1	1.9	0.46	2.1	0.1	1.2	0.1	0.0	0.2	0.1	1.7
307B	2.2	2.4	2.9	2.6	0.99	1.5	0.1	1.0	0.1	0.0	0.4	0.1	1.7
308A [1]	7.3	5.5	6.6	5.4	1.7	4.5	0.3	2.3	0.3	0.0	0.7	0.2	3.8
308B	1.6	1.7	1.2	0.82	0.42	1.2	0.1	0.7	0.1	0.0	0.2	0.1	1.2
309	1.7	*0.125*	*0.125*	*0.125*	0.34	2.5	0.1	0.1	0.0	0.0	0.1	0.1	0.4
310	4.8	8.7	11	5.4	*0.85*	5.3	0.2	3.6	0.5	0.0	0.4	0.2	4.9
314 [1]	275	170	160	107	14	94	11.5	71	6.7	0.4	5.8	3.9	**99**
316	4.8	7.1	11	4.9	*1.55*	5.6	0.2	3.0	0.5	0.0	0.6	0.2	4.5
319	21	14	13	8.8	2.5	11	0.9	5.8	0.5	0.0	1.0	0.5	8.7
318	25	15	17	11	3.1	11	1.0	6.3	0.7	0.0	1.3	0.5	9.8

Notes:
BAA - benzo(a)anthracene; BAP - benzo(a)pyrene; BBF - benzo(b)fluoranthene; BKF - benzo(k)fluoranthene; DA - dibenz(a,h)anthracene;
ID - indeno(1,2,3-cd)pyrene
Individual preliminary remediation goals (PRGs) are based on 10^{-5} risk so that cumulative risk is less than 10^{-4}
Italics: constituent not detected; value is one-half the detection limit
Boldface: sum exceeds 10
[1] Average of field duplicates
[2] Potential risk is greater than 10^{-4} if the sum of the exceedances exceeds 10

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TABLE 2-7
Summary of Remediation Target Areas
Gowanus Canal Feasibility Study, Brooklyn, NY

Remediation Target Area	Approximate Limits	Average Total PAH Concentration Surface Sediment (mg/kg)	Average Total PAH Concentration Subsurface Soft Sediment (mg/kg)	Average Total PAH Concentration Native Sediment (mg/kg)	Occurrence of NAPL Saturation in Soft Sediment	Occurrence of NAPL Saturation in Native Sediment	Commercial Navigational Depth [1] (feet NAVD88)
1	Head of canal to 3rd St.	56	1,640	2,020	Minimal; some localized occurrences	NAPL-saturated intervals at many locations	--
2	3rd Street to 150 ft south of Gowanus Expressway 4th St. basin6th St. basin 3 7th St. basin 11th St. basin	951	6,680	4,250	Common	NAPL-saturated intervals at many locations	-19
3	150 ft south of Gowanus Expressway to south end of study area	34	1,210	241	Minimal; one localized occurrence	Minimal	-21 / -33

PAH – polycyclic aromatic hydrocarbon
NAPL – non-aqueous phase liquid
[1] from USACE (2009); elevations reported relative to North American Vertical Datum 1988 (NAVD88) rather than mean lower low water (MLLW)

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TABLE 2-8
Average Concentrations of Selected Constituents in Surface and Subsurface Soft Sediment by Remediation Target Area
Gowanus Canal Feasibility Study
Brooklyn, New York

Area	Sediment Type	Total PCBs	Barium	Cadmium	Copper	Lead	Mercury	Nickel	Silver
RTA 1	Surface	0.06	112	3.99	223	613	1.23	36.2	2.93
	Subsurface	2.66	502	7.13	412	918	3.13	73.9	14.4
RTA 2	Surface	0.83	250	7.28	255	491	1.32	50.9	4.31
	Subsurface	4.90	432	11.92	397	748	2.23	92.0	8.13
RTA 3	Surface	0.05	106	7.88	139	192	1.09	39.8	1.75
	Subsurface	1.97	272	11.78	284	395	2.03	55.2	6.87

Notes:
In milligrams/kilogram.

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TABLE 3-1
General Response Actions
Gowanus Canal Feasibility Study
Brooklyn, New York.

Action	Description/Examples
No Action	Provides a baseline against which other remedial technologies are evaluated. The site is considered unchanged and represents the existing site conditions (i.e., no remedial activities would be implemented).
Institutional Controls	Administrative or legal controls such as fish consumption advisories, waterway use restrictions, site access restrictions, and environmental easements are implemented. The measures are intended to prevent or reduce human exposure to on-site contaminants by eliminating the amount of direct or indirect contact with contaminated sediments.
Monitored Natural Recovery	MNR involves leaving the contaminated sediment in place and allowing natural processes (physical, chemical and/or biological) to contain, destroy, alter, or reduce contaminant concentrations in sediment. Long-term monitoring is often a component of MNR. Monitoring may include sampling and analysis of sediment, soil, groundwater, surface water, groundwater/surface water interface, fish tissue, toxicity tests, and/or bioaccumulation tests.
Enhanced Natural Recovery	ENR is the application of thin layers of clean material over areas where natural recovery processes are already occurring or to address residual contamination in areas where contaminated sediments have been removed. Long-term monitoring is often a component of ENR.
Containment	Containment involves the installation of a cap (e.g., low permeability, sand, armor, reactive) to isolate exposure to impacted sediment and to reduce the amount of contaminant flux to the environment. Long-term monitoring and maintenance activities are needed as part of this response action. Additionally, institutional controls may also be employed.
In situ Treatment	In situ treatment (e.g., bioremediation, stabilization) involves treating contaminated sediment in place by applying various physical or chemical methods to contain chemical concentrations, mobility, or bioavailability.
Ex situ Treatment	Ex-situ treatments (e.g., thermal treatment, physical/chemical treatment) can be performed onsite or at an offsite treatment facility. The treatments are usually applied to meet final disposal requirements, reduce costs by generating material with less stringent disposal requirements, and/or create a beneficial use product.
Removal	This response action involves removal of impacted sediment (e.g., excavation, dredging) for treatment and/or onsite or offsite disposal. Factors that influence removal of sediment include site conditions, water depth, sediment characteristics (including water content), volumes to be removed, and accessibility. Removed sediment requires transport (e.g., barge, truck, and/or rail) for treatment and disposal.
Disposal	Removed sediment from the site is disposed of in a landfill, in-water confined aquatic disposal (CAD) facility, and/or at a confined disposal facility (CDF).

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TABLE 3-2
Guidelines for Technology Screening Ranking
Gowanus Canal Feasibility Study
Brooklyn, New York.

Ranking Guidelines for the Technology Screening Scores in Table 3-3

Technical Effectiveness

1: Would not be effective.

2: Would be only partially effective, or the effectiveness is unknown.

3: An innovative technology that may work and there have been some successful applications.

4: Effectiveness is more certain and there have been many successful applications.

Implementability

1: Would cause a high amount of disruption in the project area and would require significant specialized equipment, technical knowledge, and/or administrative permits.

2: Would cause a modest amount of disruption in the project area and would require some specialized equipment, technical knowledge, and/or administrative permits.

3: Would cause a modest amount of disruption in the project area but would not require significant specialized equipment, technical knowledge, or administrative permits.

4: Could be readily implemented at the site with minimal equipment and would not disrupt the project area.

Cost

1: High
2: Moderate
3: Low
4: No Cost

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TABLE 3-3
Technology Screening Evaluation Using Established Criteria
Gowanus Canal Superfund Site, Brooklyn, New York

General Response Action	Remedial Technology Type	Process Option	Description	Ranking[a] Effectiveness	Ranking[a] Implementability	Ranking[a] Cost	Retained for Further Evaluation?	Screening Comments
No action	None	Not applicable	Remedial actions would not be implemented. No action assumes the site would be unchanged.	1	4	4	Yes	Because remedial actions would not be implemented, No Action would not be effective at reducing contaminant concentrations in sediments. No Action is retained for further evaluation as a baseline for comparison with other alternatives in accordance with the NCP.
Source control actions for upland sites (including former MGP sites), CSO discharges, and unauthorized discharges from open pipes to the canal	To be determined on a site-by-site basis	Not applicable	Remedial actions need to be implemented to control/ limit future contributions to the canal from upland sources, CSO discharges, and discharges from other open pipes to the canal.	NA	NA	NA	Yes	Source control actions for upland sources, CSO discharges, and discharges from other open pipes to the canal must be implemented as part of the remedy to ensure its long term effectiveness.
Institutional controls	None	Deed and use restrictions	Administrative or legal controls such as fish consumption advisories, waterway use restrictions, site access restrictions, and environmental easements would be implemented. Institutional controls are typically used in conjunction with other remedy components and not as a stand-alone remedy.	2	4	3	Yes	Institutional controls alone would not be an effective technology. However, they can be a useful approach to mitigate human exposures to contaminants and can be readily combined with various technologies to enhance the overall effectiveness of a remedy. Therefore, they are retained for further evaluation.
Monitored natural recovery (MNR)	MNR	MNR	MNR involves leaving the contaminated sediments in place and allowing natural processes (physical, chemical and/or biological) to contain, destroy, alter or reduce contaminant concentrations in sediments. Long-term monitoring is a component of MNR. Monitoring may include sampling and analysis of sediments, soil, groundwater, surface water, groundwater/surface water interface, fish tissue, toxicity tests, and/or bioaccumulation tests. A sampling and analysis plan would be required.	2	4	3	No	MNR would not be applicable to the upper reaches (e.g., RTAs 1 and 2) of the canal based on the relatively high contaminant concentrations and presence of NAPL in the soft and native sediments. MNR might be applicable to the lower reaches (RTAs 3a and 3b) of the canal where contaminant concentrations in surface sediments are lower. However, because the lower reaches of the canal support significant commercial and recreational navigation, future dredging may be required and the higher contaminant concentrations in the subsurface sediments may become exposed. Therefore, MNR is not retained for further evaluation.
Enhanced natural recovery (ENR)	ENR	ENR	ENR is the application of thin layers of clean material over areas where natural recovery processes are already occurring or to facilitate recovery in areas where contaminated sediments have been removed. Long-term monitoring is often a component of ENR.	2	4	3	No	ENR would not be applicable to the upper reaches of the canal based on the relatively high contaminant concentrations and presence of NAPL in the soft and native sediments. ENR might be applicable to the lower reaches of the canal where contaminant concentrations in surface sediments are lower. However, because the lower reaches of the canal support significant commercial and recreational navigation, future dredging may be required and higher contaminant concentrations in the subsurface sediments may become exposed. Therefore, ENR is not retained for further evaluation.
Containment	Capping	Sand cap	Sand is applied, potentially in multiple layers, to prevent exposure to chemicals in sediments. Long-term monitoring and maintenance activities are required to ensure the long-term effectiveness of this remedial technology. Additionally, institutional controls may be employed.	3	3	3	Yes	A sand cap may be effective alone or in combination with other capping materials (e.g., reactive/adsorptive cap, armor cap) selected to address impacted sediments. Therefore, it is retained for further evaluation.
	Capping	Armored cap	Armored caps are used to stabilize cap materials. They generally consist of the placement of stone, gravel or riprap over the primary capping material. Long-term monitoring and maintenance activities are required to ensure the long-term effectiveness of this remedial technology. Additionally, institutional controls may be employed.	3	3	3	Yes	Cap armoring may be used to protect other cap materials (e.g., sand cap, oleophilic clay cap) from hydrodynamic forces within the canal, including propeller wash due to commercial and recreational navigation. Therefore, it is retained for further evaluation.

TABLE 3-3
Technology Screening Evaluation Using Established Criteria
Gowanus Canal Superfund Site, Brooklyn, New York

General Response Action	Remedial Technology Type	Process Option	Description	Ranking[a] Effectiveness	Implementability	Cost	Retained for Further Evaluation?	Screening Comments
	Capping	Active cap	Active caps use various products and installation techniques to encourage fate and transport processes such as sequestration or degradation of contaminants beneath the cap and discourage recontamination of the cap. Performance goals for active caps can include permeability control to discourage upwelling through contaminated sediment by diverting groundwater flow, contaminant migration control through sorption-related retardation and as contaminant degradation aids. Long-term monitoring and maintenance activities are required to ensure the long-term effectiveness of this remedial technology. Additionally, institutional controls may be employed.	3	3	3	Yes	Low-permeability capping would not be suitable for treating NAPL-impacted sediments. Methane gases may be generated beneath the cap, causing its potential uplift and deformation without special design considerations. Could be implemented to reduce permeability and reduce groundwater discharge to the canal. Oleophilic clay caps may be used to treat or immobilize contaminants and prevent NAPL from mobilizing up through the cap and migrating to the water column. Activated carbon caps are effective for dissolved-phase hydrophobic contaminants because activated carbon's sorption coefficient is higher than that of oleophilic clay.
In situ treatment	Bioremediatio n	Enhanced biological oxidation/ reduction	Bioremediation uses natural microbiological processes to degrade or transform organic chemicals in the sediment environment. Nutrients and potential electron donors/acceptors are provided while controlling temperature and pH to stimulate existing microorganisms to grow and use chemicals as a source of food and energy. Limnofix™ is an example bioremediation technology that degrades organic contaminants (e.g., PAHs, TPH).	1	2	3	No	Bioremediation is not applicable for treatment of metals, and has not proven to be effective in the treatment of NAPL-impacted sediment. This technology has not been shown to be effective under the conditions observed in the Gowanus Canal. Therefore, it is not retained for further evaluation.
	Stabilization	Vitrification	Contaminated sediments are heated to a molten state with electrical current, destroying the NAPL constituents.	1	1	1	No	In situ vitrification is not appropriate in a saturated environment or high organic wastes containing little sand (e.g., soft sediments). In situ vitrification effectiveness is highly dependent upon site specific conditions and is very energy intensive and costly. Special precautions would need to be implemented to capture and treat off-gas. Because in situ vitrification is not applicable to a saturated environment, it is not retained for further evaluation.
	Stabilization	Chemical treatment	This technology involves immobilizing contaminants by physically binding or enclosing the sediments within a stabilized mass, or chemically treating the contaminants. Portland cement, lime, or other additive is mixed with the sediments in situ to encapsulate the sediments and/or reduce the solubility, mobility, and toxicity of the contaminants.	2	2	2	Yes	Solidification/stabilization (in situ) could potentially be used as an additional measure prior to placement of a cap to help contain and immobilize NAPL and prevent it from migrating through the cap and into the water column. Pilot testing has been performed in a nearby water body with soft sediments that were not contaminated with NAPL (Maher et al., 2005). However, the potential effectiveness of this technology for treating NAPL-contaminated sediments has not been established. Bench and field-scale pilot testing would be needed to assess whether this technology would be effective for stabilizing NAPL-contaminated native sediments within the canal. This technology is retained for further evaluation because of its potential to enhance the effectiveness of the capping technology and the promising results of the testing performed to date. However, its application will require pilot testing within the conditions of the Gowanus Canal to determine its applicability.
	Treatment	Chemical destruction / oxidation	Chemical oxidants are injected into the subsurface sediments to oxidize organic contaminants.	1	2	3	No	Chemical destruction/oxidation would require the injection of significant quantities of oxidants to reduce the high contaminants concentrations and mass of NAPL in the canal. It would be difficult to inject these large quantities to the depths where contamination is found. An increase in NAPL mobility may also occur during implementation of this process. The effectiveness of this technology in the conditions of the Gowanus Canal is uncertain. Therefore, it is not retained for further evaluation.

TABLE 3-3
Technology Screening Evaluation Using Established Criteria
Gowanus Canal Superfund Site, Brooklyn, New York

General Response Action	Remedial Technology Type	Process Option	Description	Ranking[a]			Retained for Further Evaluation?	Screening Comments
				Effectiveness	Implementability	Cost		
	Treatment	Adsorption	This technology is based on mixing activated carbon (e.g., granular, SediMite™) into the biologically active sediment zone (typically the top 6 to 12 inches) to reduce hydrophobic organic chemical concentrations in sediment. Granular activated carbon may be mixed into the sediments using large-scale equipment. SediMite™ is an agglomerate material that does not require mechanical mixing. It uses the activity of the benthic organisms in a bioturbation process to naturally mix the activated carbon into the top sediment layers over an extended time period.	2	2	3	No	Treatment using this remedial technology is limited to organic contaminants and certain metals (e.g., mercury) in surface sediments, and it is still being tested. This technology would not be effective in treating deeper sediments, most metals, or NAPL. Therefore, it is not retained for further evaluation.
Removal	Dry excavation	Mechanical excavation	Excavation includes the removal of sediment using earthmoving equipment (e.g., excavator, backhoe). The excavation area must first be dewatered. Temporary barriers may be installed to dewater and excavate the sediment.	4	2	2	Yes	Dry excavation may be utilized in portions of the canal that will not be affected by CSO discharges (e.g., turning basins). While dry excavation has possible application, for the purposes of developing remedial alternatives and cost estimating, mechanical dredging is retained as the process option representative of the dredging remedial GRA. The removal technology/process options that will be applied will be determined during the remedial design.
	Dredging	Mechanical dredging	Mechanical dredging removes sediment using buckets (e.g., clamshell) either suspended by cables from a crane or attached to a backhoe. The dredged sediments are typically placed in a barge for transport.	4	2	2	Yes	Mechanical dredging may be an effective removal technology throughout the canal. Accessibility in shallow areas of the canal will be limited by tidal conditions. The dredged material could be transported via a barge to a treatment and/or disposal facility. Dewatering would be needed to support the operation. Suspended sediments and, especially, NAPL are expected to be mobilized during the dredging process. NAPL released during dredging would need to be addressed by appropriate containment. For the purposes of developing remedial alternatives and cost estimating, mechanical dredging is retained as the process option representative of the dredging remedial technology GRA. The removal technology/process options that will be applied will be determined during the remedial design.
		Hydraulic dredging	Hydraulic dredging removes sediments with hydraulic suction. The sediments are then pumped through a pipeline to a staging area (e.g., dewatering site). Common hydraulic dredges include cutterhead, horizontal augers, plain suction, pneumatic submersible pumps, specialty dredge heads, and diver assisted hand-held hydraulic suctions.					Hydraulic dredging may be an effective removal technology if a nearby staging area could be identified to support the process. The volume of the sediment slurry produced by hydraulic dredging would be greater than the volume of sediments generated from mechanical dredging. This slurry would require significantly more dewatering and solidification than sediments produced from mechanical dredging prior to disposal. Debris in the canal could also interfere with the hydraulic dredging process.
	Dredging	Micro dredging	Micro dredging involves divers or remotely operated vehicles to remove small, precise volumes of sediment.	1	2	2	No	The removal of small precise volumes of sediments is not necessary at this site due to the extent of the contamination present. Micro dredging would be ineffective at removing the volume requiring remedial action within the Gowanus Canal. Therefore, it is not retained for further evaluation.
Ex situ treatment	Biological treatment	Landfarming	Landfarming involves mixing sediment contaminated with organic chemicals with nutrients, water, and amendments and placing the mixture in an engineered treatment unit.	1	2	2	No	Landfarming would not be effective at treating NAPL and metal concentrations in dredged sediments. This technology requires a large amount of available land space which is unavailable at the site. Therefore, it is not retained for further evaluation.

TABLE 3-3
Technology Screening Evaluation Using Established Criteria
Gowanus Canal Superfund Site, Brooklyn, New York

General Response Action	Remedial Technology Type	Process Option	Description	Ranking[a] Effectiveness	Implementability	Cost	Retained for Further Evaluation?	Screening Comments
	Physical/ chemical treatment	Stabilization and solidification (ex situ)	Cementing or stabilization agents are mixed with contaminated sediments to immobilize contaminants by fixing the chemicals by physical or chemical reactions.	4	2	2	Yes	Stabilization and solidification techniques may be used to treat dredged sediments, to reduce their moisture content, and prepare them for truck/rail transport to a treatment facility (e.g., a thermal desorption unit) or to a disposal facility (offsite or onsite). Stabilized/solidified sediments could have potential beneficial use applications as engineered fill or structural/nonstructural concrete. The process would not reduce contaminant concentrations but would reduce the leachability of some contaminants. The presence of NAPL in sediments may interfere with the solidification process. Bench scale testing would need to be performed to evaluate the effectiveness of this technology and determine the amount of agent to be added to meet disposal requirements (e.g., the desired reduction in contaminant leachability). This technology is retained for further evaluation. Note that new technologies/process options may be available at the time of remedy design/implementation. If these technologies/process options support the long-term performance and effectiveness of the selected remedy, they may be incorporated into the selected remedy.
	Thermal treatment	Thermal destruction	Thermal destruction technologies (e.g., Cement-Lock, co-generation electrical plant) destroy organic contaminants by heating the waste at very high temperatures (greater than 1400 C). Inorganic chemicals are concentrated in the ash generated during the incineration process. Beneficial use products may result from the thermal process (e.g., cement replacement or as a partial replacement for sand in concrete, electricity production).	2	2	1	Yes	This technology may be applied after reduction in the moisture content of the sediments. The acceptability of the sediments by the facility would need to be evaluated in greater detail during remedial design. Sediment samples may need to be sent to potential treatment facilities to determine whether they meet facility-specific acceptance criteria and to assess their potential beneficial use value. This technology could be utilized for potential treatment of the sediments prior to disposal or reuse (e.g., BTU value of NAPL in sediment may be sufficient for electricity production during incineration). The application of this technology is limited to existing facilities as there is not sufficient sediment volume from this project to economically justify the investment in new facilities based solely or mainly for this project. This technology is retained for further evaluation.
	Thermal treatment	Thermal destruction / immobilization—ex situ vitrification	Ex situ vitrification (e.g., Minergy Glass Furnace Technology) involves melting dewatered sediment contaminated with organics and/or heavy metals at very high temperatures (greater than 1,400°C) and turning it into a glass aggregate. The vitrified sediment may be used beneficially in road construction projects and in the making of concrete, shingles and ceramic floor tiles.	1	1	1	No	Vitrification would not be effective for treatment of the organic, NAPL, and metal concentrations in soft sediments due to insufficient amount of sand. Additionally, this technology is not retained for further evaluation because vitrification facilities are not currently processing sediment and based on the amount of volume to be removed from the canal, construction of a new vitrification facility solely or mainly for this project is not economically feasible.
	Thermal treatment	Thermal desorption	Thermal desorption technologies heat the sediment to temperatures ranging between 90 and 540 C and the contaminants are condensed and collected as a liquid, captured on activated carbon, and/or destroyed in an afterburner.	3	2	1	Yes	This technology may be applied after reduction in the moisture content of the sediments. The acceptability of the sediments by the thermal desorption facility would need to be evaluated in greater detail during remedial design. Sediment samples may need to be sent to potential treatment facilities to determine whether they meet facility-specific acceptance criteria and to assess their potential beneficial use value. The treated materials may be used as landfill cover or for other beneficial uses. This technology is retained for further evaluation.
	Dewatering	Passive or mechanical dewatering and/or dewatering additives	Dewatering can be accomplished by passive or mechanical means. Passive dewatering uses passive drainage and evaporation to dry sediments. Common passive dewatering methods include dewatering beds and geotextile tubes. Mechanical systems such as belt presses and filter presses can be used to accelerate the dewatering process. Dewatering additives (e.g., polymers, hydrated lime, and ferric sulfate) can be added to the dredged sediments after removal to aid in the dewatering process.	4	2	2	Yes	Dewatering would be used to remove water from dredged sediments prior to treatment and/or transport. Mechanical dewatering is the fastest method of dewatering and requires the least amount of space, but is typically more expensive than passive dewatering. However, passive dewatering requires considerably more land area than mechanical dewatering. This technology is needed to support the dredging operation and is therefore, retained as a supporting component to dredging.

TABLE 3-3
Technology Screening Evaluation Using Established Criteria
Gowanus Canal Superfund Site, Brooklyn, New York

General Response Action	Remedial Technology Type	Process Option	Description	Ranking[a] Effectiveness	Implementability	Cost	Retained for Further Evaluation?	Screening Comments
	Particle size segregation	Particle size segregation	Particle size segregation uses vibrating or fixed screens, hydrocyclones, or gravity separation to segregate particle sizes in dredged sediment. The segregated particles may be used for fill materials.	1	3	3	No	Particle size segregation would not be applicable to the fine-grained soft sediments dredged from the canal. It is uncertain whether a sufficient quantity of sand/gravel exists within the native sediments to be a source of material for beneficial use, and any NAPL in coarse-grained native sediments would need to be removed prior to beneficial use (pilot or bench scale testing would be required). Therefore, this technology is not retained for further evaluation.
	Sediment washing	Sediment washing	Sediment washing (e.g., Biogenesis) is achieved by ex situ physical separation of fine and bulk sediment particles followed by chemical washing using a solvent to remove chemicals from sediment. It is assumed that chemicals sorb to the finer particles which generally contain high levels of total organic carbon. The washed sediment may be used beneficially for fill materials.	1	2	2	No	The effectiveness of this technology for reducing contaminant concentrations in soft sediments is uncertain. This technology may be more applicable for the native sediments; however, the quantity of native sediments planned for removal would be significantly less than the volume of soft sediments. Additionally, this technology would result in a large volume of wastewater to be treated, substantial equipment and energy use, and cost. Therefore, it is not retained for further evaluation.
Disposal	Onsite disposal	Confined aquatic disposal (CAD)	CAD cells are in-water disposal units that isolate contaminated sediments by placing them into a geochemically stable environment that limits the mobility of the contaminants. The CAD cell is capped after it is filled. Long-term monitoring and maintenance activities are required as part of this remedial technology.	1	2	1	No	A CAD would not be an appropriate disposal unit for NAPL impacted sediments. Contaminants placed in CADs are usually not treated and releases to the water column may occur during and following placement. Therefore, it is not retained for further evaluation.
	Offsite disposal	Landfill	Disposal of contaminated sediments at an offsite landfill removes the chemicals of concern from the site. The removed sediments would be evaluated prior to disposal to indentify the type of landfill that will accept the material.	4	3	2	Yes	Disposal of dredged sediments at an offsite, permitted disposal facility may be implemented in combination with treatment. Disposal may be in a non-hazardous or hazardous waste landfill based on the waste characteristics determined during the RI (i.e., TCLP testing of sediment samples has indicated that the sediments in the canal are not hazardous). The acceptability of the sediments by the disposal facility would need to be evaluated in greater detail during the remedial design. Samples of the sediments planned for removal may need to be sent to the potential disposal facilities to determine whether they would accept the sediments. Therefore, this remedial technology is retained for further evaluation.
	Offsite disposal	Confined disposal facility (CDF)	A CDF is an extension of land or an island area designed for containment of contaminated dredged sediments that provides control of potential releases of contaminants to the environment. Dikes or other structures may be used to isolate the dredged materials placed in a CDF. Long-term monitoring and maintenance activities are required as part of this remedial technology.	3	2	1	Yes	Existing CDFs are typically owned and operated by the USACE. There are no CDFs in the New York/New Jersey area in permitted operational condition that could accept the contaminated sediments from the Gowanus Canal. However, construction of a CDF is potentially feasible, if the sediments are stabilized prior to placement in the CDF. Therefore, this remedial technology is retained for further evaluation.
	Transportation	Barge, truck, and/or rail	Dredged sediment may be transported to a staging area or directly to a treatment and disposal facility by barge. From there, the sediment may need further transport by truck and/or rail for further treatment. Dredged sediment may be placed directly on barges, after which the sediment would be transported to a staging area for dewatering/treatment prior to disposal. Dredged sediment would require dewatering/stabilization prior to transport by truck or rail.	4	2	2	Yes	Following removal, sediments would need to be transported by barge to a facility where they would be prepared for further treatment and / or disposal. After dewatering and treatment, sediments would need to be transported by truck or rail to the final treatment or disposal location. The use of rail to transport sediments would depend on the existence of rail lines to the chosen treatment / disposal site. Truck transport would have wider application. Both truck and rail transport would not apply for direct transport of sediments from the canal, but would apply to their transport from the dewatering facility to the treatment / disposal facilities. These options are needed to support the overall remedy and are, therefore, retained as supporting components. Transport by truck is assumed to be the representative process option for alternative development.

Shaded rows indicate technology was not retained for further evaluation. The qualitative ranking guidelines for the technology screening scores are shown in Table 3-2. BTU, British thermal unit; CAD, confined aquatic disposal; CDF, confined disposal facility; CSO, combined sewer overflow; ENR, enhanced natural recovery; HDPE, high-density polyethylene ; NAPL, non-aqueous-phase liquid ; MNR, monitored natural recovery; NCP, National Oil and Hazardous Substances Pollution Contingency Plan [Title 40 Code of Federal Regulations Section 300.430(e)].
[a] On scale of 1 (poorest) to 4 (best).

TABLE 3-4
Technology Screening Summary
Gowanus Canal Superfund Site, Brooklyn, New York

General Response Action	Remedial Technology Type	Process Options	Process Option Retained for Alternative Development	Comments
Upland Source Control Actions	To be determined on a site-by-site basis	To be determined on a site-by-site basis	To be determined on a site-by-site basis	Source control actions will be developed on a site-by-site basis and are included by reference in all developed remedial alternatives.
Institutional Controls	Not applicable	Deed and Use Restrictions	Deed and Use Restrictions	Institutional controls would be incorporated as needed into the developed remedial alternatives.
Containment	Capping	Sand Cap Armored Cap Active Cap	Sand Cap Layer Armored Cap Layer Oleophilic Clay Layer	Representative cap layouts are presented in Appendix A and used for the purposes of developing remedial alternatives and cost estimating. Cap specifications will be developed during remedial design.
Removal	Dry Excavation	Mechanical Excavation	None	Dry excavation has possible applications in the canal. However, mechanical dredging is retained as the process option representative of the dredging remedial technology under the removal GRA for the purposes of developing remedial alternatives and cost estimating.
	Dredging	Mechanical Dredging Hydraulic Dredging	Mechanical Dredging	Mechanical dredging is retained as the process option representative of the dredging remedial technology under the removal GRA for the purposes of developing remedial alternatives and cost estimating. Hydraulic dredging can be considered during remedial design if sufficient land is identified to manage dredge slurry.
In situ Treatment	Stabilization	Chemical Treatment	Chemical Treatment	In situ chemical stabilization is discussed in Appendix A and considered a viable process option retained for developing remedial alternatives and cost estimating. Bench and pilot testing would be required.

TABLE 3-4
Technology Screening Summary
Gowanus Canal Superfund Site, Brooklyn, New York

General Response Action	Remedial Technology Type	Process Options	Process Option Retained for Alternative Development	Comments
Ex situ Treatment	Stabilization and Solidification (Ex situ)	Chemical Treatment	Chemical Treatment	Chemical treatment to meet stabilization performance criteria is well established. New technologies/process options may be available at the time of remedy design / implementation. If these technologies/ process options support the long term performance and effectiveness of the selected remedy, they may be incorporated into the selected remedy.
	Thermal Treatment	Thermal Destruction Thermal Desorption	Thermal Destruction Thermal Desorption	Both thermal destruction and desorption process options are viable process options and are retained for alternative development and cost estimating.
	Dewatering	Passive or Mechanical Dewatering and/or Dewatering Additives	Mechanical Dewatering	Both mechanical and passive dewatering are viable process options; mechanical dewatering is retained as the representative process option for the purposes of developing remedial alternatives and cost estimating.
Disposal	Offsite Disposal	Landfill Confined Disposal Facility (CDF)	Landfill CDF	Both landfill and CDF disposal are viable process options and are retained for developing remedial alternatives and cost estimating.
	Transportation	Barge, Truck, and/or Rail	Truck	All three process options are viable process options; transport by truck is retained as the representative process option under the disposal GRA for the purposes of developing remedial alternatives and cost estimating.

TABLE 4-1
General Components of Remedial Alternatives
Gowanus Canal Feasibility Study
Brooklyn, New York

		Major Components of Dredging and Capping Alternatives															Treatment and Disposal Options						
		No Action	Control of Upland Sources and CSO Discharges[1]	Institutional Controls	Upgrading/Restoration of Existing Bulkheads	Containment (Capping) with Treatment Layer	Containment (Capping) without Treatment Layer	Dredging of All Soft Sediment	Dredging Soft Sediment to Specified Elevation	Dewatering (Passive or Mechanical)	Targeted In-Situ Solidification of Native Sediment[2]	Stabilization of Dredged Sediment[3]	Transportation (barge/truck/rail)	Monitoring	Confirmation Sampling/Surveying	Operation & Maintenance	A: Offsite Thermal Desorption, Beneficial Use	B: Offsite Disposal (landfill)	C: Offsite Cogeneration, Beneficial Use	D: Offsite Stabilization, Beneficial Use	E: Onsite Stabilization, Beneficial Use	F: Offsite Stabilization and Placement in Onsite CDF	G: Onsite Stabilization and Placement in Onsite CDF
1	No Action	X																					
2	Dredge soft sediment to a specified elevation determined by use Cap with isolation sand and gravel layer and armor layer		X	X	X		X		X	X		X	X	X	X	X	X	X	X	X	X	X	X
3	Dredge soft sediment to a specified elevation determined by use Cap with treatment layer, isolation sand and gravel layer, and armor layer		X	X	X	X			X	X		X	X	X	X	X	X	X	X	X	X	X	X
4	Dredge entire column of soft sediment Cap with isolation sand and gravel layer and armor layer		X	X	X		X	X		X		X	X	X	X	X	X	X	X	X	X	X	X
5	Dredge entire column of soft sediment Cap with treatment layer, isolation sand and gravel layer, and armor layer		X	X	X	X		X		X		X	X	X	X	X	X	X	X	X	X	X	X
6	Dredge entire column of soft sediment Solidify top 3-5 feet of underlying native sediment in targeted areas Cap with isolation sand and gravel layer, and armor layer		X	X	X		X	X		X	X[2]	X	X	X	X	X	X	X	X	X	X	X	X
7	Dredge entire column of soft sediment Solidify top 3-5 feet of underlying native sediment in targeted areas Cap with treatment layer, isolation sand and gravel layer, and armor layer		X	X	X	X		X		X	X[2]	X	X	X	X	X	X	X	X	X	X	X	X

Notes:

[1]This component will be implemented prior to and in conjunction with the sediment remedy.

[2] In situ stabilization of targeted areas of NAPL-saturated native sediment requires pilot testing to evaluate the effectiveness and implementability of the technology. The conceptual cap designs have been formulated to be protective assuming no in situ solidification/stabilization of the sediment remaining under the cap; however, if in situ stabilization is determined to be effective and implementable, this option would be expected to provide additional protection and support the long term effectiveness of the remedy.

3 Onsite stabilization could potentially be used in lieu of offsite stabilization. For the purposes of the FS evaluation and cost estimating, barge transport, offsite stabilization, and transport to end destination is assumed unless otherwise noted for a specific disposal and treatment option. The degree of stabilization necessary for onsite or offsite beneficial use without further treatment or placement into an onsite CDF will be more substantial than the stabilization performed t prepare the material for transport under other disposal options where follow-up treatment (e.g., thermal) would be performed.

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TABLE 4-2
Screening of Dredging and Capping Alternatives
Gowanus Canal Feasibility Study
Brooklyn, New York

Dredging and Capping Alternative	Screening Result	Screening Comments: Effectiveness	Screening Comments: Implementability	Screening Comments: Cost ($Million)
Alternative 1 No Action	Retained	Retained per NCP guidance	NA	0
Alternative 2 Dredge soft sediment to a specified elevation Cap with isolation and armor layers	Not Retained	More untreated waste (undredged soft sediment) left in canal Armored sand cap not likely to be sufficient to control long-term flux of contaminants from soft sediments under the cap	Numerous technical challenges associated with successfully capping very soft sediments[a] Potential future uses of canal would be restricted to a greater degree by depth limitations	152
Alternative 3 Dredge soft sediment to a specified elevation Cap with treatment, isolation, and armor layers	Not Retained	More untreated waste (undredged soft sediment) left in canal	Numerous technical challenges associated with successfully capping very soft sediments[1] Potential future uses of canal would be restricted to a greater degree by depth limitations	169
Alternative 4 Dredge entire soft sediment column Cap with isolation and armor layers	Not Retained	Greater opportunity for reduction of TMV through treatment if dredged sediments can be successfully treated Armored sand cap not likely to be sufficient to control long-term flux of NAPL and dissolved-phase contaminants from native sediments under the cap	Alternative is implementable.	158
Alternative 5 Dredge entire soft sediment column Cap with treatment, isolation, and armor layers	Retained	Greater opportunity for reduction of TMV through treatment if dredged sediments can be successfully treated Oleophilic clay treatment layer in cap must be able to contain upwardly mobile NAPL for remedy to be effective	Alternative is implementable.	175
Alternative 6 Dredge entire soft sediment column Targeted ISS of native sediment Cap with isolation and armor layers	Not Retained	Greater opportunity for reduction of TMV through treatment if dredged sediments can be successfully treated ISS would reduce mobility of NAPL through treatment and increase long-term effectiveness ISS would require bench-scale and pilot testing to demonstrate effectiveness Armored sand cap will not be sufficient to control long-term flux of NAPL and dissolved-phase contaminants from native sediments under the cap	ISS would require bench-scale and pilot testing to demonstrate implementability	176
Alternative 7 Dredge entire soft sediment column Targeted ISS of native sediment Cap with treatment, isolation, and armor layers	Retained	Greater opportunity for reduction of TMV through treatment if dredged sediments can be successfully treated ISS would reduce mobility of NAPL through treatment and increase long-term effectiveness ISS would require bench-scale and pilot testing to demonstrate effectiveness	ISS would require bench-scale and pilot testing to demonstrate implementability	191

[a]Additional testing would be needed to determine of the soft sediment could support a cap, if desired.

NAPL—non-aqueous-phase liquid
NCP—National Contingency Plan
ISS—in situ solidification/stabilization
TMV—toxicity, mobility or volume

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TABLE 4-3
Screening of Treatment and Disposal Options
Gowanus Canal Feasibility Study
Brooklyn, New York

	Screening Result			Screening Comments		
Treatment and Disposal Option	**RTA 1**	**RTA 2**	**RTA 3**	**Effectiveness**	**Implementability**	**Cost ($ per ton)**
Option A—Offsite thermal desorption, beneficial use	Retained	Retained	Retained	Thermal desorption would likely be effective for all three RTAs.	Implementable.	260
Option B—Offsite disposal (landfill)	Retained	Retained	Retained	Offsite disposal would be effective for all three RTAs.	Implementable.	280
Option C—Offsite cogeneration, beneficial use	Retained	Retained	Retained	Offsite cogeneration would be effective for all three RTAs.	Implementable.	320
Option D—Offsite stabilization, beneficial use	Retained	Not retained	Retained	Offsite stabilization and beneficial use is not retained for RTA 2 due to the pervasive NAPL impacts in the soft sediment. The NAPL would interfere with the stabilization agents, reducing the effectiveness of the treatment. This option is retained for RTAs 1 and 3 because the sediments in these reaches have fewer NAPL impacts than RTA 2.	Implementable; requires predesign testing to determine stabilization requirements based on beneficial use.	260
Option E—Onsite stabilization, beneficial use	Retained	Not retained	Retained	See rationale for Option D.	Implementable if onsite property is available for a temporary processing facility and if an onsite beneficial use is identified. Requires pre-design testing to determine stabilization requirements based on beneficial use. Permanent institutional controls would need to be implemented which may require significant coordination with property owners and stakeholders. These controls may be difficult to effectively implement. Stakeholder acceptance will influence implementability of this option.	200
Option F—Offsite stabilization and placement in onsite constructed CDF	Not retained	Not retained	Retained	Sediments placed in the CDF would be the least contaminated within the canal and for the purposes of this FS it is assumed that this option is only applicable to RTA 3. This does not preclude the selected remedy from using this option also for RTA 1 or RTA 2.	This disposal option is not retained for RTAs 1 and 2 because the space available to construct a CDF is likely to be insufficient to accommodate all dredged sediment. Requires predesign testing to determine stabilization requirements for placement in CDF. Permanent institutional controls would need to be implemented. Stakeholder acceptance will influence the implementability of this option.	190
Option G—Onsite stabilization and placement in onsite constructed CDF	Not retained	Not retained	Retained	See rationale for Option F.	Implementable if onsite property is available for temporary processing facility. Remaining comments are the same as under Option F.	170

RTA—remediation target area
NAPL—non-aqueous phase liquid
CDF—confined disposal facility

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TABLE 4-4
Detailed Description of Components for Alternatives 5 and 7
Gowanus Canal Feasibility Study
Brooklyn, New York

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

TABLE 4-4
Detailed Description of Components for Alternatives 5 and 7
Gowanus Canal Feasibility Study
Brooklyn, New York

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

TABLE 4-4
Detailed Description of Components for Alternatives 5 and 7
Gowanus Canal Feasibility Study
Brooklyn, New York

Base Component and Sequence	Key Differences Between Alternatives 5 and 7
Debris Removal	
Debris removal will be performed as part of the sediment removal; additional detail is presented in that section.	NA
Upgrading/Restoration of Existing Bulkheads	
Existing bulkheads identified as degraded during predesign surveys would require replacement, repair, or reinforcement prior to remedy implementation to prevent failure during sediment removal. Total canal shoreline is approximately 21,000 LF (RTA 1: 4,600 ft; RTA 2 and turning basins: 11,100 ft; and RTA 3: 5,200 ft). Assume bulkhead installation would include targeted debris removal, installation of sheet piling, installation of tieback anchors, and backfill behind the sheet piling with crushed stone. In RTAs 1 and 2, the sheet piling would be installed to a depth of 10 feet into native sediment (cap thickness of 3 feet would result in ~13 feet of sediment at the base of the sheet piling). For purposes of the FS, assume that sheet piles would be 35 feet long. In RTA 3, assume that 50-ft-long sheets are required. Assume 80% of the bulkheads require replacement in each RTA. Assume two sheet piling installation operations proceed simultaneously and can install 30 LF/day each, for a total of 60 LF/day. Estimated duration is 280 days to install 16,800 LF (80% of 21,000 LF).	NA
Installation and Removal of Sheet Pile Cells	
Sheet piling would be installed down the middle of RTA 1 and would extend to the sides of the canal to create remedial cells. Six separate cells would be used to remediate RTA 1—one cell at a time would be remediated. Each cell would be approximately 750 ft long; after the southeast side of the canal is remediated, the sheet piling dividing the middle of the canal would be left in place, and the northwest side of the canal would be remediated. Sheet piling would then be extracted and installed further down the canal. Within RTA 1, due to the shallow water depths at the head of the canal, work may be sequenced to progress from the downstream to upstream to allow work to proceed throughout the tidal cycle.	NA

TABLE 4-4
Detailed Description of Components for Alternatives 5 and 7
Gowanus Canal Feasibility Study
Brooklyn, New York

Base Component and Sequence	Key Differences Between Alternatives 5 and 7
Sheet pile cells would be installed within RTA 2 using the same means and methods as described for RTA 1, with the following differences: – The turning basins each are treated as an individual remedial cell and would be created by installing sheet piling at the confluence of the basin(s) with the canal. – A total of 12 separate cells are assumed to be used for RTA 2 for the purposes of this FS: four turning basin cells and eight cells along the canal (four on each side). – The turning basins would be remediated first, followed by the southeast side of the canal, and then the northwest side of the canal. – The remedial design would address management of the gas line crossing in RTA 2. Installation and extraction of sheet piling would be performed using a vibratory hammer/extractor; no impact driving would be necessary. Sheet piling would be used to contain turbidity and NAPL release during remedial activities, but would not be designed to withstand differential head pressures created by lowering water within the cell (except for up to 5 feet differential due to tidal fluctuation). Sheet pile wall joints would not need to be completely watertight because no significant pressure differential would exist. Overflow weirs would be cut into the top of the sheet pile wall to allow water to flow from the remedial cell during times of extreme flow to prevent upland flooding. Overflow weirs would be designed to trap oil sheens and allow them to be captured during remedial activities. Sheet piling would not be utilized or installed in RTA 3 because the potential for NAPL release is much lower and sheet piling would interfere with the federal navigation channel. Turbidity concerns would be managed with silt curtains. It is assumed that RTA 3 would be divided into three dredge units or dredge management areas. For the purposes of this FS, it is assumed that 1,500 LF of silt curtain to a depth of 30 ft would be used to control turbidity in RTA 3.	
Sediment Removal	
Large debris and obstructions would be removed from sediment using mechanical means (e.g., barge-mounted long-reach excavators). Larger debris, such as the sunken barge in the 6th Street turning basin, may require removal using a crane and clamshell bucket. Debris removal would be done within each enclosed remedial cell in order to control sheens and turbidity. All soft sediment would be removed using mechanical dredging (e.g., dredge to native sediment surface). A standard clamshell dredge bucket is assumed to be used in RTAs 1 and 2 because the work would be done inside an enclosed remedial cell. Scows for material transport would be staged outside of the remedial cell, and the dredge bucket would be swung over the sheet pile wall to place the dredged material in the material scow. RTA 3 would be dredged using an environmental bucket because enclosed sheet pile cells would not be used.	NA

Base Component and Sequence	Key Differences Between Alternatives 5 and 7
In the turning basins, a two-step sediment transfer process would be performed. Dredged sediment would be placed in a scow within the turning basin; when full, it would be pushed over to the sheet pile wall, and dredged material would be hydraulically pumped into an empty scow on the canal side of the sheet piling. The sediment removal volumes and durations are estimated to be: RTA 1—82,000 yd^3/3.5 months; RTA 2—225,000 yd^3/ 9.5 months; and RTA 3—281,000 yd^3/ 12 months. The removal durations were determined using the assumption that work would be performed 12 hours/day, 7 days/week, and that a production rate of 800 yd^3/day would be achieved.	
Sediment Dewatering Dredged sediment would be transported in the scow over to the onsite staging area. Free water on top of the sediment would be pumped out of the scow and treated at the onsite temporary water treatment system before being discharged to Gowanus Canal or Gowanus Bay. Eighty gallons of free water are assumed to be generated per cubic yard of sediment removed (or 64,000 gallons of water per day). This assumption is applied to all three RTAs. For the disposal options that include offsite stabilization, the dewatered sediment would then be transported in the same barge to a commercial dredge material transfer / treatment facility in New Jersey for stabilization prior to transport by barge back to the site for placement in the onsite CDF, or transport by truck to offsite landfill and treatment facilities, or to beneficial-use locations. If disposal options utilizing an onsite stabilization facility are selected, the dewatered sediment would be transferred to the temporary onsite facility for stabilization prior to placement in the onsite CDF or onsite beneficial use.	NA
In Situ Stabilization After the soft sediment has been removed and prior to cap placement, ISS would be performed on the remaining native sediment in targeted areas. The reagents would be delivered using barge-mounted deep-soil augers. Reagents would be delivered to a depth of 5 ft below the dredge surface. Pilot testing is needed to determine the appropriate reagents and dosage for the canal, but for purposes of this FS it is assumed 15% by weight reagent would be used for solidification, and the reagent itself would be 75% blast furnace slag (BFS120) and 25% portland cement.	ISS is only a component in Alternative 7. This component is not included in Alternative 5.

Base Component and Sequence	Key Differences Between Alternatives 5 and 7
The proposed areas to be treated with ISS are: – RTA 1—60,000 ft^2 – RTA 2—190,000 ft^2 – RTA 2—4th Street and 6th Street turning basins—50,000 ft^2 – RTA 2—7th Street turning basin—30,000 ft^2 A production rate of approximately 1,400 ft^2 per day has been assumed for this cost estimate. The cost estimate assumes two delivery platforms will be working simultaneously, 12 hours/day, 7 days/week.	
Sediment Capping Upon completion of the removal of the soft sediment (Alternative 5) or upon completion of ISS (Alternative 7), a three-layer cap would be placed in RTAs 1, 2, and 3. The conceptual cap design consists of 1 ft of granular oleophilic clay material, 6 inches of sand, 6 inches of gravel, and 1.5 ft of riprap armoring (9-inch average diameter) to prevent direct contact and NAPL migration from native sediments. In order to facilitate establishment of a benthic community, the FS assumes that approximately 6 inches of sand will be placed on top of the armor layer and allowed to fill the gaps between the stones. Based on conceptual cap design, approximately 8,000 yd^3 of clay (treatment layer), 4,000 yd^3 each of sand and gravel (isolation layer), and 12,000 yd^3 of riprap and 4,000 yd^3 of sand (armor layer) would be used for the cap in RTA 1; placement is expected to take approximately 80 days. Based on conceptual cap design, approximately 19,100 yd^3 of clay (treatment layer), 9,600 yd^3 each of sand and gravel (isolation layer), and 28,800 yd^3 of riprap and 9,600 yd^3 of sand (armor layer) would be used for the cap in RTA 2; placement is expected to take approximately 6 months. Conceptual cap design for RTA 3 consists of a 6-inch clay treatment layer, a 6-inch sand layer, a 6-inch gravel layer, and 1.5 ft armor layer. Based on conceptual design, approximately 13,600 yd^3 each of clay, sand, and gravel would make up the treatment and isolation layers. Approximately 40,700 yd^3 of riprap and 13,600 yd^3 of sand would be used for the armor layer; cap placement in RTA 3 expected to take approximately 8 months. Capping materials would be transported to the canal by barge. Capping materials would be placed using a broadcast spreader.	Cap would be placed after dredging in Alternative 5. In Alternative 7, the cap would be placed after ISS is implemented.

TABLE 4-4
Detailed Description of Components for Alternatives 5 and 7
Gowanus Canal Feasibility Study
Brooklyn, New York

Base Component and Sequence	Key Differences Between Alternatives 5 and 7
A production rate of 400 yd^3 per 12-hour workday is assumed. Final cap design will be determined during remedial design.	
Dredge Cell Water Treatment	
After sediment and cap placement is completed, the water within the dredge unit would be pumped out, treated at the onsite water treatment system, and discharged to the canal. It is assumed that two volumes of water would be pumped and treated from each dredge cell. Water would be pumped to the temporary water treatment facility through high-density polyethylene piping. Estimated treatment rate is 750 gpm. In RTA 1, approximately 63 million gallons of water would require treatment. This would be expected to take approximately 60 days. In RTA 2, approximately 160 million gallons of water would require treatment. This would be expected to take approximately 150 days. Dredge cells would not be constructed for RTA 3; therefore, this step is not applicable.	NA
Short-Term Monitoring (During Construction)	
Down-current turbidity monitoring would be performed with readings collected within the water column down-current of the work cell manually once every 3 hours (use of an automatic recording station may not be feasible due to concerns about vandalism). Sheens would be monitored visually. Assume collection of air samples for volatiles, semivolatiles, and PM_{10} (particulate matter with diameter greater than or equal to 10 µm) concentrations. Samples collected from four monitoring stations once per week.	NA
Confirmation Sampling	
Confirmation field surveys would be performed after dredging and before either cap placement or ISS implementation to verify that all soft sediment has been removed. Final bathymetric survey would be completed following verification of dredging completion via confirmation sampling to assure that all soft sediment has been removed. ISS confirmation sampling would consist of collecting sediment from within the ISS areas in Shelby tubes after stabilization and prior to cap placement. A collection frequency of one sample for approximately every 500–1000 yd^3 of treated material would be used. Samples would be analyzed for compressive strength, hydraulic conductivity, and leachability.	Since ISS will not be implemented under Alternative5, ISS confirmation sampling is not included in Alternative 5.

TABLE 4-4
Detailed Description of Components for Alternatives 5 and 7
Gowanus Canal Feasibility Study
Brooklyn, New York

Base Component and Sequence	Key Differences Between Alternatives 5 and 7
Physical surveys would be performed after placement of each of the cap layers to confirm that cap is placed to design elevation/thickness and covers entire area (assume four surveys for each dredge cell in RTAs 1 and 2 and three surveys per dredge area in RTA 3) Sampling would also be performed after placement to verify that no contaminated sediment was deposited on top of the cap surface during installation.	
Long-Term Monitoring and Operation and Maintenance[a]	
Long term monitoring would include evaluating cap integrity every five years. Sediment deposited on top of the cap would also be sampled to assess recontamination. Maintenance costs are assumed to include replacement of 5% of the cap footprint (entire cap thickness) every ten years. Maintenance dredging may be required to maintain depths required for navigation purposes; however, this is not considered as part of this FS. For purposes of this FS, costs for a bathymetric survey and sediment sampling and analysis every 5 years are assumed. Perform 5 year reviews.	NA
Dredged Material Treatment and Disposal Options for Alternatives 5 and 7	
Option A: Thermal Desorption, Offsite Beneficial Use • Dredged sediment would be treated at an offsite commercial facility by mixing with a stabilization agent and then transported by truck to a thermal desorption facility. Depending on the selected thermal facility, transport could be by rail, but for the purposes of developing estimated costs, this FS assumes approximately 60 miles of transport by truck (the higher of the two costs). • For estimating purposes, it is assumed 7.5% by weight portland cement would be used to stabilize the material in order to pass the paint filter test prior to transport for further treatment. • Following thermal desorption, the treated sediment would be used either as daily cover for a landfill, elsewhere as backfill, or otherwise beneficially. • For cost estimating purposes, it is assumed that the material would be provided to the end user free of charge and would be transported approximately 60 miles via truck. • Predesign testing would need to be performed, including bench testing of composite samples to make sure that the material would be accepted for treatment.	NA

TABLE 4-4
Detailed Description of Components for Alternatives 5 and 7
Gowanus Canal Feasibility Study
Brooklyn, New York

Base Component and Sequence	Key Differences Between Alternatives 5 and 7
Option B: Offsite Disposal (Landfill) • Dredged sediment would be treated at an offsite commercial facility by mixing with a stabilization agent and then be transported by truck to a Subtitle D disposal facility. • For estimating purposes, it is assumed 7.5% by weight portland cement would be used to stabilize the material in order to pass the paint filter test. • For estimating purposes, it is assumed that the sediment would be transported approximately 110 miles by truck for disposal. • Based on TCLP data collected during the RI, it is assumed that the sediment is not a characteristic hazardous waste under RCRA and would be accepted at a Subtitle D disposal facility; however, predesign testing needs to be performed using composite samples to confirm waste characteristics and obtain preapproval/preacceptance from disposal facilities. The costs presented herein assume that sediment from the canal would not be classified as PCB-remediation waste.	NA
Option C: Cogeneration, Offsite Beneficial Use • Dredged sediment would be treated at an offsite commercial facility by mixing with a stabilization agent and then transported by truck to a cogeneration facility (350 mile trip assumed; Jersey City, NJ, to Clarion, PA). Depending on the selected cogeneration facility, transport could be by rail, but for the purposes of developing estimated costs, this FS assumes transport by truck (the higher of the two costs). • For estimating purposes, it is assumed 7.5% by weight portland cement would be used to stabilize the material to pass the paint filter test prior to transport for further treatment. • Following treatment, the treated sediment would be used either as daily cover for a landfill, elsewhere as clean backfill, or otherwise beneficially. • For cost estimating purposes, the material would be provided to the end user free of charge and would be transported 60 miles via truck. • Predesign testing would need to be performed including testing of composite samples to make sure that the material would be accepted for treatment.	NA
Option D: Offsite Stabilization and Offsite Beneficial Use • This FS assumes the stabilized material would be used as daily cover at a landfill; however, an end use has not yet been identified and other beneficial uses may be considered.	—

TABLE 4-4
Detailed Description of Components for Alternatives 5 and 7
Gowanus Canal Feasibility Study
Brooklyn, New York

Base Component and Sequence	Key Differences Between Alternatives 5 and 7
• Dredged sediment would be dewatered onsite and then transported via barge to an offsite commercial stabilization facility. After treatment, the sediment would be transported by truck to the end use location. Transport could potentially occur via rail, but for the purposes of developing estimated costs, this FS assumes transport by truck (the higher of the two costs). • Dredged sediment would be treated at the offsite dredge-material-processing facility by mixing with a stabilization agent. The sediment would then be transported to the final use location. • For estimating purposes, it is assumed 15% by weight reagent would be used for stabilization, and the reagent itself would be 75% blast furnace slag (BFS120) and 25% portland cement. • For cost estimating purposes, the material would be provided to the end user free of charge and would be transported 110 miles via truck. • No additional O&M costs are assumed for this disposal option. • Predesign testing would need to be performed to determine stabilization requirements based on beneficial use.	
Option E: Onsite Stabilization and Onsite Beneficial Use • Dewatered sediment would be stabilized at a temporary dredge material processing facility constructed onsite. • For estimating purposes, it is assumed 30% by weight reagent would be used for solidification, and the reagent itself would be 75% blast furnace slag (BFS120) and 25% portland cement. • Institutional controls would be required to limit exposures to stabilized material beneficially used onsite. • Long-term O&M activities would include periodic sampling of the stabilized material to assess leachability and periodic surveys to assure that exposure through direct contact is prevented. • Final disposition of the stabilized sediment is assumed to be adjacent to the canal and will be a net zero cost under this disposal option. • Predesign testing would need to be performed to determine stabilization requirements based on beneficial use.	
Option F: Offsite stabilization, Transport of Treated Material Back to Site, Placement in Onsite Constructed CDF • During preconstruction site work, a confined disposal facility (CDF) would be constructed. This FS assumes that space will be available to construct a CDF that will contain all the material from RTA 3, estimated to be 281,000 yd^3.	NA

TABLE 4-4
Detailed Description of Components for Alternatives 5 and 7
Gowanus Canal Feasibility Study
Brooklyn, New York

Base Component and Sequence	Key Differences Between Alternatives 5 and 7
• An expansion factor of 1.15 is assumed to determine the CDF capacity, which will need to be approximately 323,000 yd^3. It has been assumed that the CDF will be constructed so that the dewatered, stabilized sediment will be placed in a layer 20 ft thick. The area required for a CDF of this size is 436,000 ft^2, or 10 acres. – The FS assumes that the CDF will be surrounded on three sides by land and that those sides of the CDF will consist of a single sheet pile wall. The fourth side of the CDF will consist of a double sheet pile wall, 3 ft apart, filled with bentonite-augmented soil. – A total of 5,400 LF of 45-ft-long sheet piles are estimated. • Dredged sediment would be treated at an offsite dredge-material-processing-facility by mixing with a stabilization agent. The sediment would then be transported back to the site by barge and placed in the CDF. • For estimating purposes, it is assumed 15% by weight reagent would be used for stabilization, and the reagent itself would be 75% blast furnace slag (BFS120) and 25% portland cement. • The CDF would be capped with asphalt pavement to allow use of the surface. • CDF O&M would include cap integrity surveys and periodic repairs. Predesign testing would need to be performed to determine stabilization requirements and contaminant leachability. The results would be used to determine the appropriate design for the CDF.	
Option G: Onsite Stabilization and Placement in Onsite Constructed CDF • The description of Option F is applicable to this disposal option. The only difference between Options F and G is that under Option G the dewatered sediment would be stabilized at the temporary onsite facility. This FS assumes that the onsite stabilization facility would be located adjacent to the CDF and that an additional transport step between stabilization and placement in the CDF would not be required.	NA

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

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

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TABLE 4-5

Summary of Sediment Volumes Removed by RTA

Gowanus Canal Feasibility Study

Brooklyn, New York

Remediation Target Area (RTA)	Sediment Type	Sediment Removed in Alternatives 5 and 7 (Cubic Yards)
RTA 1	Soft	82,000
RTA 2	Soft	174,000
	Native[1]	51,000
RTA 3	Soft	281,000
Total Sediment Removed (cubic yards)		**588,000**

Notes:

[1] Some native sediment will require removal in order to meet navigation depth requirements after cap is placed.

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TABLE 4-6a
Detailed Evaluation of Alternatives – RTA 1
Gowanus Canal Feasibility Study
Brooklyn, New York

Criteria	Alternative 1: No Action	Alternative 5: Dredge Entire Column of Soft Sediment Cap with Treatment Layer, Sand-and-Gravel Layer, Armor Layer	Alternative 7: Dredge Entire Column of Soft Sediment Solidify Top 3–5 Feet of Native Sediment in Targeted Areas Cap with Treatment Layer, Sand-and-Gravel Layer, Armor Layer
Threshold Criteria			
Overall protection of human health and the environment	Alternative will not provide protection of human health and the environment. • RAOs would not be achieved • Human health and ecological risks associated with contaminated sediment would not be reduced or eliminated. • NAPL migration to the water column would continue. • Contaminant concentrations in other media (e.g. surface water) would not be reduced.	Alternative will provide protection of human health and the environment. • RAOs would be achieved upon completion of the remedy, which is estimated to be approximately 5 years after the start of construction. • Removal of soft sediment and capping of native sediment would reduce and control long-term risks associated with contaminated sediment. Placement of a cap would: ○ Control risks associated with remaining sediment by preventing exposure. ○ Reduce and control toxicity to benthic organisms and eliminate risks to herbivorous birds. ○ Control risks to human health via direct contact and incidental ingestion. ○ Prevent NAPL migration from sediment to the water column. • Surface water quality would be improved by preventing contact between surface water and sediment; sheens would be controlled or eliminated.	Alternative would provide protection of human health and the environment. Application of ISS in targeted areas is expected to provide additional protectiveness against NAPL migration from sediment.
Compliance with ARARs	• ARARs are not applicable because no remedial action is taken.	Alternative can be designed to comply with substantive requirements of the ARARs.	Same as Alternative 5.
Balancing Criteria			
Long-term effectiveness and permanence	**Low** - Alternative would not result in any significant change in the risks associated with contaminated sediment.	Alternative would provide a **high** level of long-term effectiveness and permanence: • Alternative would meet RAOs. • Alternative would result in significant, permanent risk reduction due to soft sediment removal. • The sediment cap would provide long-term control of the risks associated with the native sediment remaining in the canal, provided that appropriate long-term monitoring and maintenance plans are implemented. • Long-term effectiveness of disposal options are: ○ High for Options A, B, and C because material is transferred offsite and treated or contained in a managed landfill. ○ Low to moderate for Options D and E. ▪ The long-term effectiveness will depend on the actual beneficial use and the conditions to which the stabilized sediment will be exposed. A greater degree of effectiveness would be expected from a use where the material is relatively contained and not subjected to significant water fluctuations or freeze/thaw cycles. ▪ Stabilization would be performed to a degree such that the sediment associated contaminants would be bound within the matrix and the stabilized sediment would remain onsite under Option E. ▪ The stabilized sediment would need to meet the end-use performance criteria. ▪ Permanent institutional controls and long-term monitoring would be needed under Option E.	Alternative would provide a **high** level of long-term effectiveness and permanence. • Same as Alternative 5, except that targeted ISS would provide additional long-term control of the NAPL migration in the canal.
Magnitude and type of residual risk		This evaluation is focused on the magnitude and management of residual risks associated with sediment remaining onsite (i.e., sediment that is stabilized and beneficially used onsite and contaminated sediment remaining in the canal following remedy implementation). Sediment treated and disposed at offsite facilities are not included in this discussion because it would be removed from the site. • Sediment removal and capping would: ○ Alleviate the risks associated with the sediments removed from the canal. ○ Reduce the risks associated with contaminated native sediments that remain in the canal by capping. ○ Provide long-term control of risks associated with sediment remaining in the canal. Adsorptive caps to control NAPL migration can be designed for a set life expectancy where NAPL migration rates are known (see Appendix A for additional discussion). Additional data collection and evaluation to determine site-specific NAPL seepage rates will be required during remedial design to determine the appropriate cap design (i.e., granular oleophilic clay layer thickness). • Residual risks associated with disposal Option E (onsite stabilization and onsite beneficial use) would be as follows: ○ Treatment residuals would consist of stabilized sediment, which would significantly reduce the mobility of sediment contaminants and reduce the associated risks. ○ Onsite beneficial use of the stabilized material will require identifying a beneficial use and will also require the stabilized material to meet leachability specifications and strength specifications appropriate to the identified use.	Same as Alternative 5, with the addition that the implementation of ISS would be expected to further reduce risk of NAPL migration, if proven to be effective and implementable during pilot and treatability testing.

TABLE 4-6a
Detailed Evaluation of Alternatives – RTA 1
Gowanus Canal Feasibility Study
Brooklyn, New York

Criteria	Alternative 1: No Action	Alternative 5: Dredge Entire Column of Soft Sediment Cap with Treatment Layer, Sand-and-Gravel Layer, Armor Layer	Alternative 7: Dredge Entire Column of Soft Sediment Solidify Top 3–5 Feet of Native Sediment in Targeted Areas Cap with Treatment Layer, Sand-and-Gravel Layer, Armor Layer
		○ The ability of the stabilized sediment to meet performance criteria will depend upon the designated end use of the material, and further testing is required for these disposal options. ○ The FS assumes that the end use would be such that direct human and ecological contact with the stabilized sediment would be limited. ○ The level of residual risk would be considered low to moderate for this alternative because treatment does not destroy the contaminants and the treated material would remain onsite. ○ Remedy can be designed so that the sediments stabilized and beneficially used are those with fewer NAPL impacts.	
Adequacy and reliability of controls		• Dredging ○ Mechanical dredging is an established technology and would meet the performance specifications for the removal component of the alternative. ○ Bathymetric surveys would be conducted to confirm target removal depths and samples would be collected on a defined grid to confirm sediment cap layer thicknesses. • Capping ○ Capping is an established technology and can be designed to meet the performance specifications of the alternative, provided that effective source controls have been implemented and the cap is constructed and maintained in accordance with the design specifications established for long-term isolation of the contaminated sediments. As noted above, additional data collection and evaluation are required to finalize the cap design. ○ Long-term monitoring and periodic maintenance would be required to assure cap integrity. ○ The O&M plan developed during the remedial design would determine the monitoring and maintenance frequencies required to assure and maintain cap integrity based on site-specific factors. ○ Physical (e.g., bathymetric) surveys and the collection of samples on a defined grid would be needed to assess cap layer thickness, cap performance and integrity, contaminant movement, and/or recontamination concerns. Samples for chemical analysis should also be collected at regular predetermined intervals. ○ The long-term monitoring plan should also specify monitoring requirements after severe storm events to assess cap integrity. ○ Cap repairs would be performed as needed. ○ Component failures (i.e., sediment cap failure) could potentially result in sheens on the water surface and limited exposure to ecological or human receptors; however, catastrophic failure of the cap is unlikely if appropriate long-term O&M plans are implemented. • Disposal ○ Disposal Options A (thermal treatment), and C (co-generation) would be expected to meet required performance specifications following treatability and pilot testing. ○ Option B (offsite landfill) is an established means of disposal. ○ Disposal Options D (offsite stabilization and offsite beneficial use) and E (onsite stabilization and beneficial use) require identifying a beneficial use and also require the stabilized material to meet leachability specifications, as well as strength specifications appropriate to the identified use. The ability of the stabilized sediment to meet performance criteria will depend upon the designated end use of the material and further testing is required for these disposal options. The FS assumes that the end use would be such that direct contact human and ecological contact with the stabilized sediment would be limited. ○ Additional O&M beyond that associated with the sediment cap would be required for Options A, B, C, or D. Long-term monitoring would be required for Option E (onsite stabilization and beneficial use). ○ Permanent institutional controls would also be required for Option E. The institutional controls would specify appropriate measures for digging within the fill material, and long-term monitoring would be applied to review their sustained application. The institutional controls may need to be applied to one or more properties, depending on where the material is used. Depending on the number of properties and the location where the fill is placed, significant effort and coordination may be needed to ensure successful implementation and enforcement of these controls.	Same as Alternative 5, with the addition that if additional evaluations and pilot studies indicate that in situ solidification (ISS) is implementable and effective within the canal, targeted areas of NAPL-saturated native sediment would be treated with ISS to further reduce the potential for NAPL migration. The conceptual cap specifications have been designed to be protective without the use of ISS; however, if ISS is determined to be viable for the Gowanus Canal, then its application would be expected to provide additional protection and support the long-term effectiveness of the selected remedy.
Reduction of toxicity, mobility, or volume through treatment	**Low** Alternative does not include a treatment component and does not meet the statutory preference for treatment as a principal element of a remedy.	The overall reduction of NAPL mobility by the oleophilic cap is expected to be **high.** The reduction of toxicity, mobility, or volume (TMV) of the dredged sediment by treatment ranges from **moderate to high** depending on the disposal option. Alternative 5 is considered to have **high** overall reduction of TMV based on the volume of sediment removed from the canal.	Same as Alternative 5, with the addition that the implementation of ISS would be expected to further reduce NAPL mobility, if ISS is proven to be effective and implementable during pilot and treatability testing.

TABLE 4-6a
Detailed Evaluation of Alternatives – RTA 1
Gowanus Canal Feasibility Study
Brooklyn, New York

Criteria	Alternative 1: No Action	Alternative 5: Dredge Entire Column of Soft Sediment Cap with Treatment Layer, Sand-and-Gravel Layer, Armor Layer	Alternative 7: Dredge Entire Column of Soft Sediment Solidify Top 3–5 Feet of Native Sediment in Targeted Areas Cap with Treatment Layer, Sand-and-Gravel Layer, Armor Layer
Reduction in toxicity, mobility, or volume (TMV)		• Dredging does not reduce toxicity, mobility or volume through treatment. • The granular oleophilic clay cap component of the alternative will reduce the mobility of NAPL and is considered a treatment technology. • The reduction of TMV of the dredged sediment is summarized below. Thermal treatment (Option A) and cogeneration (thermal destruction, Option C) meet the statutory preference for treatment as a principal element. The relative reductions of TMV of the disposal/beneficial use options are: ○ Option A (thermal treatment): **High** reduction of TMV. Dredged sediments would be treated using thermal desorption. The TMV associated with the organic contaminants would be significantly reduced. ○ Option B (offsite landfill): **Moderate** reduction of TMV. Dredged sediments would be stabilized prior to transfer to a landfill. Volume and toxicity would not be affected, but contaminant mobility would be reduced by placing the material in a controlled environment. Overall TMV would be transferred to the offsite disposal facility. ○ Option C (co-generation): **High** reduction of TMV. Organic contaminants would be destroyed through treatment. The overall ranking of this disposal option is **high**. ○ Option D (offsite stabilization and offsite beneficial use): **Moderate** reduction of TMV. Dredged sediments would be stabilized prior to transfer to offsite beneficial use location. Volume and toxicity would not be affected, but contaminant mobility would be reduced. Overall TMV would be transferred to the offsite location. ○ Option E (onsite stabilization and onsite beneficial use): **Moderate** reduction of TMV. Dredged sediments would be stabilized prior to placement in onsite beneficial use location. Volume and toxicity would not be affected, but contaminant mobility would be reduced. Overall TMV would remain onsite.	Same as Alternative 5, except that the overall reduction in NAPL mobility is anticipated to be greater with the addition of ISS in targeted areas of the canal.
Irreversibility		• Sorption in the oleophilic clay cap is irreversible, but once the cap is saturated, it will not be able to absorb more NAPL. • Solidification and stabilization are considered irreversible if the stabilized material is placed into a controlled environment. • Thermal treatment (Option A), thermal destruction (Option C), and the stabilization component of Option B is irreversible. The degree of irreversibility of stabilization associated with Options D and E will depend upon the selected beneficial use and the conditions to which the stabilized material is exposed.	Same as Alternative 5, with the addition that ISS is also an irreversible process.
Type and quantity of treatment residuals and associated risks		The type and quantity of residuals and the associated magnitude and management of risks is dependent upon the disposal option, as follows: • Option A (thermal treatment): ○ Residuals would consist of treated sediment. ○ Treated sediment would be beneficially used (e.g., daily cover at landfills). ○ Level of residual risk associated with this option is **low** since contaminants would be desorbed and destroyed in an afterburner. • Option B (offsite landfill): ○ Would not result in treatment residuals. ○ Stabilized sediment would be disposed in a landfill. ○ Residual risk associated with this option is **low** because material is disposed in a controlled offsite facility. • Option C (co-generation): ○ Residuals would consist of treated sediment. ○ Treated sediment would be beneficially used (e.g., daily cover at landfills). ○ The level of residual risk associated with this option is **low** since organic contaminants would be destroyed. • Options D (offsite stabilization and offsite beneficial use) and E (onsite stabilization and onsite beneficial use): ○ Stabilized sediment would be beneficially used either offsite (Option D) or onsite (Option E). ○ The level of residual risk would be considered **low to moderate** because treatment stabilizes but does not destroy the contaminants. The contaminant mobility would be significantly reduced, and the treated material would be beneficially used. The residual risk for Option D is lower because the material would be transferred offsite. • Sediment treated by thermal treatment (Option A) and co-generation (Option C) may contain concentrated levels of inorganic constituents, which may limit the beneficial use of the material.	Same as Alternative 5.
Short-term effectiveness	High; no actions are taken under this alternative.	The short-term effectiveness of this alternative is **moderate** due to construction duration and the potential risks and environmental impacts described below. • Short-term effectiveness of all disposal options is considered moderate to high.	Same as Alternative 5.

TABLE 4-6a
Detailed Evaluation of Alternatives – RTA 1
Gowanus Canal Feasibility Study
Brooklyn, New York

Criteria	Alternative 1: No Action	Alternative 5: Dredge Entire Column of Soft Sediment Cap with Treatment Layer, Sand-and-Gravel Layer, Armor Layer	Alternative 7: Dredge Entire Column of Soft Sediment Solidify Top 3–5 Feet of Native Sediment in Targeted Areas Cap with Treatment Layer, Sand-and-Gravel Layer, Armor Layer
Risks to community, workers, and the associated controls		• Potential risks to the community would include noise and vibrations during bulkhead replacement and increased levels of traffic, dust, noise, and odors during the dredging and handling of contaminated sediment. Engineering controls and best management practices can mitigate most potential risks: ○ Access to the active work and support zones would be prohibited. ○ Notification of schedule for bulkhead repair and remedy implementation would be provided to the property owners and tenants. ○ Dust and noise levels would be monitored. ○ Work periods may be restricted to specific timeframes for especially noisy operations (e.g., sheet pile installation). ○ Traffic effects can be managed by performing work in canal from barges and using water transport to move materials to and from the canal. ○ Staging areas would need to be established in areas zoned for industrial use. ○ Odors are expected during dredging and may not be able to be fully controlled. • Potential risks to workers would include physical hazards associated with general construction, potential exposure to and direct contact with dredged sediment and NAPL, noise, odors, dust, and vapors. These would be mitigated through: ○ Engineering controls and best management practices. ○ Compliance with appropriate health and safety plans and site management plans. ○ Use of appropriate personal protective equipment.	Same as Alternative 5. Implementation of ISS would likely be restricted to specific timeframes. Potential exposure risks from ISS would be mitigated as described under Alternative 5.
Environmental Impacts of Remedy and Controls		• Short-term environmental effects during implementation may include potential NAPL releases to surface water, turbidity increases within the canal, and releases of some sediment-associated contamination. Example control measures to mitigate these impacts include the following: ○ Dredge cells would contain suspended sediments (turbidity and sediment associated contaminants) and NAPL releases that result from the dredging process. Water within the dredge cells would be removed and treated before the sheet piles are removed. ○ The duration of these releases would be very short and would only occur during construction.	Same as Alternative 5, with the addition that ISS would be performed within the dredge cells to contain potential NAPL and turbidity releases.
Duration of short-term risks		• The duration of the short-term risks would be the time required for construction, which is estimated to be approximately 5 years.	Same as Alternative 5.
Implementability	Not applicable; no actions are taken under this alternative.	The overall implementability this alternative is **moderate.** The implementability of the disposal options is variable.	Same as Alternative 5 for dredging, capping, and disposal options. Implementability of ISS is likely to be more limited since this technology is not yet commercially proven for application to marine environments for the control of NAPL migration.
Technical feasibility		• Alternative is technically implementable and dredging and capping are established, field-proven technologies; however, pilot testing may be required to determine the most suitable cap placement methods based on the site-specific sediment characteristics. • Dredging and capping would be performed from barges using standard construction equipment. • The potential interference from debris within the canal will need to be considered during design. • Bulkhead repair and replacement will require property-specific designs, and construction must be planned and proceed and be coordinated carefully to minimize / prevent effects on the adjacent, upland properties. • The short- and long-term monitoring requirements can be performed using standard practices and technologies. • Implementability and feasibility of additional actions would be limited if penetration of the cap is required.	Same as Alternative 5 for dredging and capping aspects. Treatability studies and pilot testing will be required during remedial design to determine the stabilization reagents and dosages, delivery mechanism, and overall technical feasibility of ISS.
Administrative feasibility		• Alternative will require coordination between regulatory agencies (USEPA, USACE, NYSDEC, and NYCDEP), PRPs, property owners along the canal, and other stakeholders. • Bulkhead repair and replacement will require coordination with property owners and tenants. Due to the number of different properties and type of bulkheads affected, this effort will be considerable. • Implementation of disposal Option E (onsite stabilization and onsite beneficial use) is dependent upon stakeholder acceptability and effective implementation of institutional controls. This disposal option may be challenging to implement due to stakeholder acceptance. • Permanent institutional controls would also be required for disposal Option E. Depending on the number of properties and the location where the fill is placed, significant effort and coordination may be needed to ensure	Same as Alternative 5.

TABLE 4-6a
Detailed Evaluation of Alternatives – RTA 1
Gowanus Canal Feasibility Study
Brooklyn, New York

Criteria	Alternative 1: No Action	Alternative 5: Dredge Entire Column of Soft Sediment Cap with Treatment Layer, Sand-and-Gravel Layer, Armor Layer	Alternative 7: Dredge Entire Column of Soft Sediment Solidify Top 3–5 Feet of Native Sediment in Targeted Areas Cap with Treatment Layer, Sand-and-Gravel Layer, Armor Layer
		successful implementation and enforcement of these controls. The difficulties associated with implementation of institutional controls are also further discussed in Section 4.6.3.	
Availability of services and materials		• Equipment and specialists required for the sheet piling installation, dredging, and capping would be commercially available. • The volume of capping materials required is large and procuring large quantities of specialty materials, such as the oleophilic clay, will require significant advance coordination and possibly use of multiple vendors. • Available thermal treatment and co-generation facilities (Options A and C, respectively) are also limited within the geography, which may restrict the ability to competitively bid these services. • Landfill capacity for contaminated river sediments within the geography may be limited. Landfill availability will influence the implementability of disposal Option B (offsite landfill) within the region. Available landfill facilities and associated capacities will need to be identified during the remedy selection process. Facilities outside the region could be used; however, transportation costs would increase. • Onsite and offsite beneficial uses of stabilized sediment would need to be identified. In order for Options D and E to be implemented, an end use would need to be determined and treatability testing would need to be performed to evaluate the stabilization agents and dosing required and to assess whether the treated material would meet all the end-use requirements (e.g., leachability and strength characteristics). • Treatability testing will be needed to determine if available thermal treatment and co-generation facilities can accept solidified/stabilized sediment and to determine the final waste characterization.	Same as Alternative 5 for dredging, capping, and disposal components. ISS is an emerging technology, and there are few contractors with a proven performance of ISS implementation in marine environments.
Cost ($Million)[1]	0	Option A: 45 Option B: 47 Option C: 52 Option D: 45 Option E: 38	Option A: 48 Option B: 50 Option C: 55 Option D: 48 Option E: 41

Notes:
[1] Total present worth cost; cost does not include O&M or base implementation cost. Values presented include cost of dredging, capping, ISS (Alternative 7 only), and disposal. See Table 4-7 for additional cost detail for each alternative and associated disposal options. Further, source control measures will be needed to ensure that the sediment remedy achieves the RAOs and is sustainable. Source control is the first component of all alternatives except No Action. Source control measures are in the process of being developed; therefore, the costs are not included in this FS. The source control measures are included by reference in this FS.

ARAR – applicable or relevant and appropriate requirement
CDF – confined disposal facility
ISS – in-situ solidification
NAPL – non aqueous phase liquid
NYCDEP – New York City Department of Environmental Protection
NYSDEC – New York State Department of Environmental Conservation
O&M – operations and maintenance
PRP – potentially responsible party
RAO – remedial action objective
RTA – remediation target area
TMV – toxicity, mobility, or volume
USACE – United States Army Corps of Engineers
USEPA – United States Environmental Protection Agency

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TABLE 4-6b
Detailed Evaluation of Alternatives – RTA 2
Gowanus Canal Feasibility Study
Brooklyn, New York

Criteria	Alternative 1: No Action	Alternative 5: Dredge Entire Column of Soft Sediment Cap with Treatment Layer, Sand-and-Gravel Layer, Armor Layer	Alternative 7: Dredge Entire Column of Soft Sediment Solidify Top 3–5 Feet of Native Sediment in Targeted Areas Cap with Treatment Layer, Sand-and-Gravel Layer, Armor Layer
Threshold Criteria			
Overall protection of human health and the environment	Alternative will not provide protection of human health and the environment. • RAOs would not be achieved • Human health and ecological risks associated with contaminated sediment would not be reduced or eliminated. • NAPL migration to the water column would continue. • Contaminant concentrations in other media (e.g. surface water) would not be reduced.	Alternative will provide protection of human health and the environment. • RAOs would be achieved upon completion of the remedy, which is estimated to be approximately 5 years after the start of construction. • Removal of soft sediment and capping of native sediment would reduce and control long-term risks associated with contaminated sediment. Placement of a cap would: ○ Control risks associated with remaining sediment by preventing exposure. ○ Reduce and control toxicity to benthic organisms and eliminate risks to herbivorous birds. ○ Control risks to human health via direct contact and incidental ingestion. ○ Prevent NAPL migration from sediment to the water column. • Surface water quality would be improved by preventing contact between surface water and sediment; sheens would be controlled or eliminated.	Alternative would provide protection of human health and the environment. Application of ISS in targeted areas is expected to provide additional protectiveness against NAPL migration from sediment.
Compliance with ARARs	• ARARs are not applicable because no remedial action is taken.	Alternative can be designed to comply with substantive requirements of the ARARs.	Same as Alternative 5.
Balancing Criteria			
Long-term effectiveness and permanence	**Low** - Alternative would not result in any significant change in the risks associated with contaminated sediment.	Alternative would provide a **high** level of long-term effectiveness and permanence: • Alternative would meet RAOs. • Alternative would result in significant, permanent risk reduction due to soft sediment removal. • The sediment cap would provide long-term control of the risks associated with the native sediment remaining in the canal, provided that appropriate long-term monitoring and maintenance plans are implemented. • Long-term effectiveness of disposal options are: ○ High for Options A, B, and C because material is transferred offsite and treated or contained in a managed landfill.	Alternative would provide a **high** level of long-term effectiveness and permanence. • Same as Alternative 5, with the exception that targeted ISS would provide additional long-term control of the NAPL migration in the canal.
Magnitude and type of residual risk		This evaluation is focused on the magnitude and management of residual risks associated with sediment remaining onsite (i.e., sediment that is stabilized and beneficially used onsite and contaminated sediment remaining in the canal following remedy implementation). Sediment treated and disposed at offsite facilities are not included in this discussion because it would be removed from the site. • Sediment removal and capping would: ○ Alleviate the risks associated with the sediments removed from the canal. ○ Reduce the risks associated with contaminated native sediments that remain in the canal by capping. • Provide long-term control of risks associated with sediment remaining in the canal. Adsorptive caps to control NAPL migration can be designed for a set life expectancy where NAPL migration rates are known (see Appendix A for additional discussion). Additional data collection and evaluation to determine site-specific NAPL seepage rates will be required during remedial design to determine the appropriate cap design (i.e., granular oleophilic clay layer thickness).There are no residual risks associated with the three disposal options considered for RTA 2, because all sediment would be transferred offsite.	Same as Alternative 5, with the addition that the implementation of ISS would be expected to further reduce the risk of NAPL migration, if proven to be effective and implementable during pilot and treatability testing.
Adequacy and reliability of controls		• Dredging ○ Mechanical dredging is an established technology and would meet the performance specifications for the removal component of the alternative. ○ Bathymetric surveys would be conducted to confirm target removal depths and samples would be collected on a defined grid to confirm sediment cap layer thicknesses. • Capping ○ Capping is an established technology and can be designed to meet the performance specifications of the alternative, provided that effective source controls have been implemented and the cap is constructed and maintained in accordance with the design specifications established for long-term isolation of the contaminated sediments. As noted above, additional data collection and evaluation are required to finalize the cap design. ○ Long-term monitoring and periodic maintenance would be required to assure cap integrity.	Same as Alternative 5, with the addition that if additional evaluations and pilot studies indicate that in situ solidification (ISS) is implementable and effective within the canal, targeted areas of NAPL-saturated native sediment would be treated with ISS to further reduce the potential for NAPL migration. The conceptual cap specifications have been designed to be protective without the use of ISS; however, if ISS is determined to be viable for the Gowanus Canal, then its application would be expected to provide additional protection and support the long-term effectiveness of the selected remedy.

TABLE 4-6b
Detailed Evaluation of Alternatives – RTA 2
Gowanus Canal Feasibility Study
Brooklyn, New York

Criteria	Alternative 1: No Action	Alternative 5: Dredge Entire Column of Soft Sediment Cap with Treatment Layer, Sand-and-Gravel Layer, Armor Layer	Alternative 7: Dredge Entire Column of Soft Sediment Solidify Top 3–5 Feet of Native Sediment in Targeted Areas Cap with Treatment Layer, Sand-and-Gravel Layer, Armor Layer
		○ The O&M plan developed during the remedial design would determine the monitoring and maintenance frequencies required to assure and maintain cap integrity based on site-specific factors. ○ Physical (e.g., bathymetric) surveys and the collection of samples on a defined grid would be needed to assess cap layer thickness, cap performance and integrity, contaminant movement, and/or recontamination concerns. Samples for chemical analysis should also be collected at regular predetermined intervals. ○ The long-term monitoring plan should also specify monitoring requirements after severe storm events to assess cap integrity. ○ Cap repairs would be performed as needed. ○ Component failures (i.e., sediment cap failure) could potentially result in sheens on the water surface and limited exposure to ecological or human receptors; however, catastrophic failure of the cap is unlikely if appropriate long-term O&M plans are implemented. • Disposal ○ Disposal Options A (thermal treatment) and C (co-generation) would be expected to meet required performance specifications following treatability and pilot testing. ○ Option B (offsite landfill) is an established means of disposal. ○ Additional O&M beyond that associated with the sediment cap would not be required for the disposal and treatment options evaluated for RTA 2.	
Reduction of toxicity, mobility, or volume through treatment	**Low** Alternative does not include a treatment component and does not meet the statutory preference for treatment as a principal element of a remedy.	The overall reduction of NAPL mobility by the oleophilic cap is expected to be **high.** The reduction of toxicity, mobility, or volume (TMV) of the dredged sediment by treatment ranges from **moderate to high** depending on the disposal option. Alternative 5 is considered to have **high** overall reduction of TMV based on the volume of sediment removed from the canal.	Same as Alternative 5, with the addition that the implementation of ISS would be expected to further reduce NAPL mobility, if proven to be effective and implementable during pilot and treatability testing.
Reduction in toxicity, mobility, or volume (TMV)		• Dredging does not reduce toxicity, mobility or volume through treatment. • The granular oleophilic clay cap component of the alternative will reduce the mobility of NAPL and is considered a treatment technology. • The reduction of TMV of the dredged sediment is summarized below. Thermal treatment (Option A) and cogeneration (thermal destruction, Option C) meet the statutory preference for treatment as a principal element. The relative reductions of TMV of the disposal/beneficial use options are: ○ Option A (thermal treatment): **High** reduction of TMV. Dredged sediments would be treated using thermal desorption. The TMV associated with the organic contaminants would be significantly reduced or alleviated. ○ Option B (offsite landfill): **Moderate** reduction of TMV. Dredged sediments would be stabilized prior to transfer to a landfill. Volume and toxicity would not be affected, but contaminant mobility would be reduced by placing the material in a controlled environment. Overall TMV would be transferred to the offsite disposal facility. ○ Option C (co-generation): **High** reduction of TMV. Organic contaminants would be destroyed through treatment. The overall ranking of this disposal option is **high**.	Same as Alternative 5, except that the overall reduction in NAPL mobility is anticipated to be greater with the addition of ISS in targeted areas of the canal.
Irreversibility		• Sorption in the oleophilic clay cap is irreversible, but once the cap is saturated, it will not be able to absorb more NAPL. • Solidification and stabilization are considered irreversible if the stabilized material is placed into a controlled environment. • Thermal treatment (Option A), thermal destruction (Option C), and the stabilization component of Option B are irreversible.	Same as Alternative 5, with the addition that ISS is also an irreversible process.
Type and quantity of treatment residuals and associated risks		The type and quantity of residuals and the associated magnitude and management of risks is dependent upon the disposal option, as follows: • Option A (thermal treatment): ○ Residuals would consist of treated sediment. ○ Treated sediment would be beneficially used (e.g., daily cover at landfills). ○ Level of residual risk associated with this option is **low** since contaminants would be desorbed and destroyed in an afterburner. • Option B (offsite landfill): ○ Would not result in treatment residuals. ○ Stabilized sediment would be disposed in a landfill. ○ Residual risk associated with this option is **low** because material is disposed in a controlled offsite facility.	Same as Alternative 5.

TABLE 4-6b
Detailed Evaluation of Alternatives – RTA 2
Gowanus Canal Feasibility Study
Brooklyn, New York

Criteria	Alternative 1: No Action	Alternative 5: Dredge Entire Column of Soft Sediment Cap with Treatment Layer, Sand-and-Gravel Layer, Armor Layer	Alternative 7: Dredge Entire Column of Soft Sediment Solidify Top 3–5 Feet of Native Sediment in Targeted Areas Cap with Treatment Layer, Sand-and-Gravel Layer, Armor Layer
		• Option C (co-generation): ○ Residuals would consist of treated sediment. ○ Treated sediment would be beneficially used (e.g., daily cover at landfills). ○ The level of residual risk associated with this option is **low** since organic contaminants would be destroyed. • Sediment treated by thermal treatment (Option A) and co-generation (Option C) may contain concentrated levels of inorganic constituents, which may limit the beneficial use of the material.	
Short-term effectiveness	High; no actions are taken under this alternative.	The short-term effectiveness of this alternative is **moderate** due to construction duration and the potential risks and environmental impacts described below. • Short-term effectiveness of all disposal options is considered moderate to high.	Same as Alternative 5.
Risks to community, workers, and the associated controls		• Potential risks to the community would include noise and vibrations during bulkhead replacement and increased levels of traffic, dust, noise, and odors during the dredging and handling of contaminated sediment. Engineering controls and best management practices can mitigate most potential risks: ○ Access to the active work and support zones would be prohibited. ○ Notification of schedule for bulkhead repair and remedy implementation would be provided to the property owners and tenants. ○ Dust and noise levels would be monitored. ○ Work periods may be restricted to specific timeframes for especially noisy operations (e.g., sheet pile installation). ○ Traffic effects can be managed by performing work in canal from barges and using water transport to move materials to and from the canal. ○ Staging areas would need to be established in areas zoned for industrial use. ○ Odors are expected during dredging and may not be able to be fully controlled. • Potential risks to workers would include physical hazards associated with general construction, potential exposure to and direct contact with dredged sediment and NAPL, noise, odors, dust, and vapors. These would be mitigated through: ○ Engineering controls and best management practices. ○ Compliance with appropriate health and safety plans and site management plans. ○ Use of appropriate personal protective equipment.	Same as Alternative 5. Implementation of ISS would likely be restricted to specific timeframes. Potential exposure risks from ISS would be mitigated as described under Alternative 5.
Environmental Impacts of Remedy and Controls		• Short-term environmental effects during implementation may include potential NAPL releases to surface water, turbidity increases within the canal, and releases of some sediment-associated contamination. Example control measures to mitigate these impacts include the following: ○ Dredge cells would contain suspended sediments (turbidity and sediment associated contaminants) and NAPL releases that result from the dredging process. Water within the dredge cells would be removed and treated before the sheet piles are removed. ○ The duration of these releases would be very short and would only occur during construction.	Same as Alternative 5, with the addition that ISS would be performed within the dredge cells to contain potential NAPL and turbidity releases.
Duration of short-term risks		• The duration of the short-term risks would be the time required for construction, which is estimated to be approximately 5 years.	Same as Alternative 5.
Implementability	Not applicable; no actions are taken under this alternative.	The overall implementability this alternative is **moderate.** The implementability of the disposal options is variable.	Same as Alternative 5 for dredging, capping, and disposal options. Implementability of ISS is likely to be more limited since this technology is not yet commercially proven for application to marine environments for the control of NAPL migration.
Technical feasibility		• Alternative is technically implementable and dredging and capping are established, field-proven technologies; however, pilot testing may be required to determine the most suitable cap placement methods based on the site-specific sediment characteristics. • Dredging and capping would be performed from barges using standard construction equipment. • The potential interference from debris within the canal will need to be considered during design. • Bulkhead repair and replacement will require property-specific designs, and construction must be planned and proceed and be coordinated carefully to minimize / prevent effects on the adjacent, upland properties. • The short- and long-term monitoring requirements can be performed using standard practices and technologies.	Same as Alternative 5 for dredging and capping aspects. Treatability studies and pilot testing will be required during remedial design to determine the stabilization reagents and dosages, delivery mechanism, and overall technical feasibility of ISS.

TABLE 4-6b
Detailed Evaluation of Alternatives – RTA 2
Gowanus Canal Feasibility Study
Brooklyn, New York

Criteria	Alternative 1: No Action	Alternative 5: Dredge Entire Column of Soft Sediment Cap with Treatment Layer, Sand-and-Gravel Layer, Armor Layer	Alternative 7: Dredge Entire Column of Soft Sediment Solidify Top 3–5 Feet of Native Sediment in Targeted Areas Cap with Treatment Layer, Sand-and-Gravel Layer, Armor Layer
		• Implementability and feasibility of additional actions would be limited if penetration of the cap is required.	
Administrative feasibility		• Alternative will require coordination between regulatory agencies (USEPA, USACE, NYSDEC, and NYCDEP), PRPs, property owners along the canal, and other stakeholders. • Bulkhead repair and replacement will require coordination with property owners and tenants. Due to the number of different properties and type of bulkheads affected, this effort will be considerable.	Same as Alternative 5.
Availability of services and materials		• Equipment and specialists required for the sheet piling installation, dredging, and capping would be commercially available. • The volume of capping materials required is large and procuring large quantities of specialty materials, such as the oleophilic clay, will require significant advance coordination and possibly use of multiple vendors. • Available thermal treatment and co-generation facilities (Options A and C, respectively) are also limited within the geography, which may restrict the ability to competitively bid these services. • Landfill capacity for contaminated river sediments within the geography may be limited. Landfill availability will influence the implementability of Option B (offsite landfill) within the region. Available landfill facilities and associated capacities will need to be identified during the remedy selection process. Facilities outside of the region could be used; however, transportation costs would increase. • Treatability testing will be needed to determine if available thermal treatment and co-generation facilities can accept solidified/stabilized sediment and to determine the final waste characterization.	Same as Alternative 5 for dredging, capping, and disposal components. ISS is an emerging technology, and there are few contractors with a proven performance of ISS implementation in marine environments.
Cost ($Million)[1]	0	Option A: 117 Option B: 122 Option C: 136	Option A: 130 Option B: 135 Option C: 149

Notes:
[1] Total present worth cost; cost does not include O&M or base implementation cost. Values presented include cost of dredging, capping, ISS (Alternative 7 only), and disposal. See Table 4-7 for additional cost detail for each alternative and associated disposal options. Further, source control measures will be needed to ensure that the sediment remedy achieves the RAOs and is sustainable. Source control is the first component of all alternatives except No Action. Source control measures are in the process of being developed; therefore, the costs are not included in this FS. The source control measures are included by reference in this FS.

ARAR – applicable or relevant and appropriate requirement
CDF – confined disposal facility
ISS – in-situ solidification
NAPL – non aqueous phase liquid
NYCDEP – New York City Department of Environmental Protection
NYSDEC – New York State Department of Environmental Conservation
O&M – operations and maintenance
PRP – potentially responsible party
RAO – remedial action objective
RTA – remediation target area
TMV – toxicity, mobility, or volume
USACE – United States Army Corps of Engineers
USEPA – United States Environmental Protection Agency

TABLE 4-6c
Detailed Evaluation of Alternatives – RTA 3
Gowanus Canal Feasibility Study
Brooklyn, New York

Criteria	Alternative 1: No Action	Alternative 5: Dredge Entire Column of Soft Sediment Cap with Treatment Layer, Sand-and-Gravel Layer, Armor Layer	Alternative 7: Dredge Entire Column of Soft Sediment Solidify Top 3-5 Feet of Native Sediment in Targeted Areas Cap with Treatment Layer, Sand-and-Gravel Layer, Armor Layer
Threshold Criteria			
Overall protection of human health and the environment	Alternative will not provide protection of human health and the environment. • RAOs would not be achieved • Human health and ecological risks associated with contaminated sediment would not be reduced or eliminated. • NAPL migration to the water column would continue. • Contaminant concentrations in other media (e.g. surface water) would not be reduced.	Alternative will provide protection of human health and the environment. • RAOs would be achieved upon completion of the remedy, which is estimated to be approximately 5 years after the start of construction. • Removal of soft sediment and capping of native sediment would reduce and control long-term risks associated with contaminated sediment. Placement of a cap would: ○ Control risks associated with remaining sediment by preventing exposure. ○ Reduce and control toxicity to benthic organisms and eliminate risks to herbivorous birds. ○ Control risks to human health via direct contact and incidental ingestion. ○ Prevent NAPL migration from sediment to the water column. • Surface water quality would be improved by preventing contact between surface water and sediment; sheens would be controlled or eliminated.	Alternative would provide protection of human health and the environment. Application of ISS in targeted areas is expected to provide additional protectiveness against NAPL migration from sediment.
Compliance with ARARs	• ARARs are not applicable because no remedial action is taken.	Alternative can be designed to comply with substantive requirements of the ARARs.	Same as Alternative 5.
Balancing Criteria			
Long-term effectiveness and permanence	**Low** - Alternative would not result in any significant change in the risks associated with contaminated sediment.	Alternative would provide a **high** level of long-term effectiveness and permanence: • Alternative would meet RAOs. • Alternative would result in significant, permanent risk reduction due to soft sediment removal. • The sediment cap would provide long-term control of the risks associated with the native sediment remaining in the canal, provided that appropriate long-term monitoring and maintenance plans are implemented. • Long-term effectiveness of disposal options are: ○ High for Options A, B, and C because material is transferred offsite and treated or contained in a managed landfill. ○ Low to moderate for Options D and E. ▪ The long-term effectiveness will depend on the actual beneficial use and the conditions to which the stabilized sediment will be exposed. A greater degree of effectiveness would be expected from a use where the material is relatively contained and not subjected to significant water fluctuations or to freeze/thaw cycles. ▪ Stabilization would be performed to a degree such that the sediment-associated contaminants would be bound within the matrix and the stabilized sediment would remain onsite under Option E. ▪ The stabilized sediment would need to meet the end-use performance criteria. ▪ Permanent institutional controls and long-term monitoring would be needed under this option. ○ High for Options F and G as the material would be solidified/stabilized to such a degree that the sediment-associated contaminants would be permanently bound within the matrix prior to its placement in an onsite engineered facility.	Alternative would provide a **high** level of long-term effectiveness and permanence. • Same as Alternative 5, with the exception that targeted ISS would provide additional long-term control of the NAPL migration in the canal.
Magnitude and type of residual risk		This evaluation is focused on the magnitude and management of residual risks associated with sediment remaining onsite (i.e., sediment that is stabilized and beneficially used onsite, and contaminated sediment remaining in the canal following remedy implementation). Sediment treated and disposed at offsite facilities are not included in this discussion because it would be removed from the site. • Sediment removal and capping would: ○ Alleviate the risks associated with the sediments removed from the canal. ○ Reduce the risks associated with contaminated native sediments that remain in the canal by capping. ○ Provide long-term control of risks associated with sediment remaining in the canal. Adsorptive caps to control NAPL migration can be designed for a set life expectancy where NAPL migration rates are known (see Appendix A for additional discussion). Additional data collection and evaluation to determine site-specific NAPL seepage rates will be required during remedial design to determine the appropriate cap design (i.e., granular oleophilic clay layer thickness). • Residual risks associated with disposal Option E (onsite stabilization and onsite beneficial use), F (offsite stabilization and onsite CDF), and G (onsite stabilization and onsite CDF) would be as follows: ○ Treatment residuals would consist of stabilized sediment, which would significantly reduce the mobility of sediment contaminants and reduce the associated risks.	Same as Alternative 5, with the addition that the implementation of ISS would be expected to further reduce risk of NAPL migration, if proven to be effective and implementable during pilot and treatability testing.

TABLE 4-6c
Detailed Evaluation of Alternatives – RTA 3
Gowanus Canal Feasibility Study
Brooklyn, New York

Criteria	Alternative 1: No Action	Alternative 5: Dredge Entire Column of Soft Sediment Cap with Treatment Layer, Sand-and-Gravel Layer, Armor Layer	Alternative 7: Dredge Entire Column of Soft Sediment Solidify Top 3-5 Feet of Native Sediment in Targeted Areas Cap with Treatment Layer, Sand-and-Gravel Layer, Armor Layer
		○ Onsite beneficial use of the stabilized material will require identifying a beneficial use and will also require the stabilized material to meet leachability specifications and strength specifications appropriate to the identified use. ○ The ability of the stabilized sediment to meet performance criteria will depend upon the designated end use of the material, and further testing is required for these disposal options. ○ The FS assumes that the end use would be such that direct contact human and ecological contact with the stabilized sediment would be limited. ○ Placement in constructed CDF (Options F and G) would require routine monitoring and maintenance to assure materials remain isolated. ○ The level of residual risk would be considered low to moderate for these alternatives because treatment does not destroy the contaminants and the treated material would remain onsite. ○ Remedy can be designed so that the sediments stabilized and beneficially used or placed in the onsite CDF are those with fewer NAPL impacts.	
Adequacy and reliability of controls		• Dredging ○ Mechanical dredging is an established technology and would meet the performance specifications for the removal component of the alternative. ○ Bathymetric surveys would be conducted to confirm target removal depths and samples would be collected on a defined grid to confirm sediment cap layer thicknesses. • Capping ○ Capping is an established technology and can be designed to meet the performance specifications of the alternative, provided that effective source controls have been implemented and the cap is constructed and maintained in accordance with the design specifications established for long-term isolation of the contaminated sediments. As noted above, additional data collection and evaluation are required to finalize the cap design. ○ Long-term monitoring and periodic maintenance would be required to assure cap integrity. ○ The O&M plan developed during the remedial design would determine the monitoring and maintenance frequencies required to assure and maintain cap integrity based on site-specific factors. ○ Physical (e.g., bathymetric) surveys and the collection of samples on a defined grid would be needed to assess cap layer thickness, cap performance and integrity, contaminant movement, and/or recontamination concerns. Samples for chemical analysis should also be collected at regular predetermined intervals. ○ The long-term monitoring plan should also specify monitoring requirements after severe storm events to assess cap integrity. ○ Cap repairs would be performed as needed. ○ Component failures (i.e., sediment cap failure) could potentially result in sheens on the water surface and limited exposure to ecological or human receptors; however, catastrophic failure of the cap is unlikely if appropriate long-term O&M plans are implemented. • Disposal ○ Disposal Options A (thermal treatment), and C (co-generation) would be expected to meet required performance specifications following treatability and pilot testing. ○ Option B (offsite landfill) is an established means of disposal. ○ Options D (offsite stabilization and offsite beneficial use) and E (onsite stabilization and beneficial use) require identifying a beneficial use and also require that the stabilized material meet leachability specifications as well as strength specifications appropriate to the identified use. The ability of the stabilized sediment to meet performance criteria will depend upon the designated end use of the material, and further testing is required for these disposal options. The FS assumes that the end use would be such that direct contact human and ecological contact with the stabilized sediment would be limited. ○ Additional O&M beyond that associated with the sediment cap would be required for Options A, B, C, or D. Long-term monitoring would be required for Options E (onsite stabilization and beneficial use), F, or G (stabilization and onsite CDF). The O&M for the CDF would consist of inspections and a low level of maintenance. ○ Institutional controls would be required if disposal Options E, F, or G are selected. ○ The permanent institutional controls required for disposal Option E would specify appropriate measures for digging within the fill material, and long-term monitoring would be applied to review their sustained application. The institutional controls may need to be applied to one or more properties, depending on where the material is used. Depending on the number of properties and the location where the fill is placed, significant effort and coordination may be needed to ensure successful implementation and enforcement of these controls.	Same as Alternative 5, with the stipulation that if additional evaluations and pilot studies indicate that in situ solidification (ISS) is implementable and effective within the canal, targeted areas of NAPL-saturated native sediment would be treated with ISS to further reduce the potential for NAPL migration. The conceptual cap specifications have been designed to be protective without the use of ISS; however, if ISS is determined to be viable for the Gowanus Canal, then its application would be expected to provide additional protection and support the long-term effectiveness of the selected remedy.

TABLE 4-6c
Detailed Evaluation of Alternatives – RTA 3
Gowanus Canal Feasibility Study
Brooklyn, New York

Criteria	Alternative 1: No Action	Alternative 5: Dredge Entire Column of Soft Sediment Cap with Treatment Layer, Sand-and-Gravel Layer, Armor Layer	Alternative 7: Dredge Entire Column of Soft Sediment Solidify Top 3-5 Feet of Native Sediment in Targeted Areas Cap with Treatment Layer, Sand-and-Gravel Layer, Armor Layer
Reduction of toxicity, mobility, or volume through treatment	**Low** Alternative does not include a treatment component and does not meet the statutory preference for treatment as a principal element of a remedy.	The overall reduction of NAPL mobility by the oleophilic cap is expected to be **high.** The reduction of toxicity, mobility, or volume (TMV) of the dredged sediment by treatment ranges from **moderate to high** depending on the disposal option. Alternative 5 is considered to have **high** overall reduction of TMV based on the volume of sediment removed from the canal.	Same as Alternative 5, with the addition that the implementation of ISS would be expected to further reduce NAPL mobility, if proven to be effective and implementable during pilot and treatability testing.
Reduction in toxicity, mobility, or volume (TMV)		• Dredging does not reduce toxicity, mobility or volume through treatment. • The granular oleophilic clay cap component of the alternative will reduce the mobility of NAPL and is considered a treatment technology. • The reduction of TMV of the dredged sediment is summarized below. Thermal treatment (Option A) and cogeneration (thermal destruction, Option C) meet the statutory preference for treatment as a principal element. The relative reductions of TMV of the disposal/beneficial use options are: ○ Option A (thermal treatment): **High** reduction of TMV. Dredged sediments would be treated using thermal desorption. The TMV associated with the organic contaminants would be significantly reduced. ○ Option B (offsite landfill): **Moderate** reduction of TMV. Dredged sediments would be stabilized prior to transfer to a landfill. Volume and toxicity would not be affected, but contaminant mobility would be reduced by placing the material in a controlled environment. Overall TMV would be transferred to the offsite disposal facility. ○ Option C (co-generation): **High** reduction of TMV. Organic contaminants would be destroyed through treatment. The overall ranking of this disposal option is **high**. ○ Option D (offsite stabilization and offsite beneficial use): **Moderate** reduction of TMV. Dredged sediments would be stabilized prior to their transfer to an offsite beneficial-use location. Volume and toxicity would not be affected, but contaminant mobility would be reduced. Overall TMV would be transferred to the offsite location. ○ Option E (onsite stabilization and onsite beneficial use): **Moderate** reduction of TMV. Dredged sediments would be stabilized prior to placement in onsite beneficial-use location. Volume and toxicity would not be affected, but contaminant mobility would be reduced. Overall TMV would remain onsite. ○ Options F and G (stabilization and onsite CDF): **Moderate** reduction of TMV. Solidification and stabilization agents added to the dredged sediment would result in material forming a solid monolith. The toxicity and volume would not be reduced, but the mobility of the contaminants would be significantly reduced. The sediments placed in the CDF would be those with fewer NAPL impacts.	Same as Alternative 5, except that the overall reduction in NAPL mobility is anticipated to be greater with the addition of ISS in targeted areas of the canal.
Irreversibility		• Sorption in the oleophilic clay cap is irreversible, but once the cap is saturated, it will not be able to absorb more NAPL. • Solidification and stabilization are considered irreversible if the stabilized material is placed into a controlled environment. • Thermal treatment (Option A), thermal destruction (Option C), and the stabilization component of Options B, F, and G are irreversible. The degree of irreversibility of stabilization associated with Options D and E will depend upon the selected beneficial use and the conditions to which the stabilized material are exposed.	Same as Alternative 5, with the addition that ISS is also an irreversible process.
Type and quantity of treatment residuals and associated risks		The type and quantity of residuals and the associated magnitude and management of risks is dependent upon the disposal option, as follows: • Option A (thermal treatment): ○ Residuals would consist of treated sediment. ○ Treated sediment would be beneficially used (e.g., daily cover at landfills). ○ Level of residual risk associated with this option is **low** since contaminants would be desorbed and destroyed in an afterburner. • Option B (offsite landfill): ○ Would not result in treatment residuals. ○ Stabilized sediment would be disposed in a landfill. ○ Residual risk associated with this option is **low** because material is disposed in a controlled offsite facility. • Option C (co-generation): ○ Residuals would consist of treated sediment. ○ Treated sediment would be beneficially used (e.g., daily cover at landfills). ○ The level of residual risk associated with this option is **low** since organic contaminants would be destroyed. • Options D (offsite stabilization and offsite beneficial use) and E (onsite stabilization and onsite beneficial use): ○ Stabilized sediment would be beneficially used either offsite (Option D) or onsite (Option E). ○ The level of residual risk would be considered **low to moderate** because treatment stabilizes but does not	Same as Alternative 5.

TABLE 4-6c
Detailed Evaluation of Alternatives – RTA 3
Gowanus Canal Feasibility Study
Brooklyn, New York

Criteria	Alternative 1: No Action	Alternative 5: Dredge Entire Column of Soft Sediment Cap with Treatment Layer, Sand-and-Gravel Layer, Armor Layer	Alternative 7: Dredge Entire Column of Soft Sediment Solidify Top 3-5 Feet of Native Sediment in Targeted Areas Cap with Treatment Layer, Sand-and-Gravel Layer, Armor Layer
		destroy the contaminants. The contaminant mobility would be significantly reduced, and the treated material would be beneficially used. The residual risk for Option D is lower because the material would be transferred offsite. • Sediment treated by thermal treatment (Option A) and co-generation (Option C) may contain concentrated levels of inorganic constituents, which may limit the beneficial use of the material. • Options F and G (stabilization and onsite CDF): ○ Stabilized sediment would be placed in a CDF. ○ CDF would require routine monitoring and maintenance to assure materials remain isolated. ○ The level of residual risk would be considered **low to moderate** because treatment stabilizes but does not destroy the contaminants, and the treated material would remain onsite. • Materials with fewer NAPL impacts can be placed in the CDF.	
Short-term effectiveness	High; no actions are taken under this alternative.	The short-term effectiveness of this alternative is **moderate** due to construction duration and the potential risks and environmental impacts described below. • Short-term effectiveness of all disposal options is considered moderate to high.	Same as Alternative 5
Risks to community, workers, and the associated controls		• Potential risks to the community would include noise and vibrations during bulkhead replacement and increased levels of traffic, dust, noise, and odors during the dredging and handling of contaminated sediment. Engineering controls and best management practices can mitigate most potential risks: ○ Access to the active work and support zones would be prohibited. ○ Notification of schedule for bulkhead repair and remedy implementation would be provided to the property owners and tenants. ○ Dust and noise levels would be monitored. ○ Work periods may be restricted to specific timeframes for especially noisy operations (e.g., sheet pile installation). ○ Traffic effects can be managed by performing work in canal from barges and using water transport to move materials to and from the canal. ○ Staging areas would need to be established in areas zoned for industrial use. ○ Odors are expected during dredging and may not be able to be fully controlled. • Potential risks to workers would include physical hazards associated with general construction, potential exposure to and direct contact with dredged sediment and NAPL, noise, odors, dust, and vapors. These would be mitigated through: ○ Engineering controls and best management practices. ○ Compliance with appropriate health and safety plans and site management plans. ○ Use of appropriate personal protective equipment.	Same as Alternative 5. Implementation of ISS would likely be restricted to specific timeframes. Potential exposure risks from ISS would be mitigated as described under Alternative 5.
Environmental Impacts of Remedy and Controls		• Short-term environmental effects during implementation in RTA 3 may include turbidity increases within the canal and releases of some sediment-associated contamination. Significant releases of NAPL from RTA 3 are not anticipated. Example control measures to mitigate these impacts include the following: ○ Silt curtains would control turbidity in RTA 3. ○ The duration of these releases would be very short and would only occur during construction.	Same as Alternative 5, with the addition that ISS would be performed within the dredge cells to contain potential NAPL and turbidity releases.
Duration of short-term risks		• The duration of the short-term risks would be the time required for construction, which is estimated to be approximately 5 years.	Same as Alternative 5.
Implementability	Not applicable; no actions are taken under this alternative.	The overall implementability this alternative is **moderate.** The implementability of the disposal options is variable.	Same as Alternative 5 for dredging, capping, and disposal options. Implementability of ISS is likely to be more limited since this technology is not yet commercially proven for application to marine environments for the control of NAPL migration.
Technical feasibility		• Alternative is technically implementable and dredging and capping are established, field-proven technologies; however, pilot testing may be required to determine the most suitable cap placement methods based on the site-specific sediment characteristics. • Dredging and capping would be performed from barges using standard construction equipment. • The potential interference from debris within the canal will need to be considered during design. • Bulkhead repair and replacement will require property-specific designs, and construction must be planned and	Same as Alternative 5 for dredging and capping aspects. Treatability studies and pilot testing will be required during remedial design to determine the stabilization reagents and dosages, delivery mechanism, and overall technical feasibility of ISS.

TABLE 4-6c
Detailed Evaluation of Alternatives – RTA 3
Gowanus Canal Feasibility Study
Brooklyn, New York

Criteria	Alternative 1: No Action	Alternative 5: Dredge Entire Column of Soft Sediment Cap with Treatment Layer, Sand-and-Gravel Layer, Armor Layer	Alternative 7: Dredge Entire Column of Soft Sediment Solidify Top 3-5 Feet of Native Sediment in Targeted Areas Cap with Treatment Layer, Sand-and-Gravel Layer, Armor Layer
		proceed and be coordinated carefully to minimize / prevent effects on the adjacent, upland properties. • The short- and long-term monitoring requirements can be performed using standard practices and technologies. • Implementability and feasibility of additional actions would be limited if penetration of the cap is required.	
Administrative feasibility		• Alternative will require coordination between regulatory agencies (USEPA, USACE, NYSDEC, and NYCDEP), PRPs, property owners along the canal, and other stakeholders. • Bulkhead repair and replacement will require coordination with property owners and tenants. Due to the number of different properties and type of bulkheads affected, this effort will be considerable. • Implementation of disposal Option E (onsite stabilization and onsite beneficial use) is dependent upon stakeholder acceptability, and effective implementation of institutional controls. This disposal option may be challenging to implement due to stakeholder acceptance. • Permanent institutional controls would also be required for disposal Option E. Depending on the number of properties and the location where the fill is placed, significant effort and coordination may be needed to ensure successful implementation and enforcement of these controls. The difficulties associated with implementation of institutional controls are also further discussed in Section 4.6.3. • Implementation of disposal Options F and G (onsite constructed CDF) is dependent on the identification of a suitable location(s), concurrence from other stakeholders, and effective implementation of institutional controls. This option may be difficult to implement due to stakeholder acceptability challenges.	Same as Alternative 5.
Availability of services and materials		• Equipment and specialists required for the sheet piling installation, dredging, and capping would be commercially available. • The volume of capping materials required is large and procuring large quantities of specialty materials, such as the oleophilic clay, will require significant advance coordination and possibly use of multiple vendors. • Available thermal treatment and co-generation facilities (Options A and C, respectively) are also limited within the geography, which may restrict the ability to competitively bid these services. • Landfill capacity for contaminated river sediments within the geography may be limited. Landfill availability will influence the implementability of disposal Option B (offsite landfill) within the region. Available landfill facilities and associated capacities will need to be identified during the remedy selection process. Facilities outside of the region could be used; however, transportation costs would increase. • Onsite and offsite beneficial uses of stabilized sediment would need to be identified. In order for disposal options D and E to be implemented, an end use would need to be determined and treatability testing would need to be performed to evaluate the stabilization agents and dosing required and to assess whether the treated material would meet all the end-use requirements (e.g., leachability and strength characteristics). • Treatability testing will be needed to determine if available thermal treatment and co-generation facilities can accept solidified/stabilized sediment and to determine the final waste characterization.	Same as Alternative 5 for dredging, capping, and disposal components. ISS is an emerging technology and contractors with a proven performance of ISS implementation in marine environments are few.
Cost[1]	0	Option A: 131 Option B: 137 Option C: 155 Option D: 133 Option E: 107 Option F: 103 Option G: 96	Option A: 131 Option B: 137 Option C: 155 Option D: 133 Option E: 107 Option F: 103 Option G: 96

Notes:
[1] Total present worth cost; cost does not include O&M or base implementation cost. Values presented include cost of dredging, capping, ISS (Alternative 7 only), and disposal. See Table 4-7 for additional cost detail for each alternative and associated disposal options. Further, source control measures will be needed to ensure that the sediment remedy achieves the RAOs and is sustainable. Source control is the first component of all alternatives except No Action. Source control measures are in the process of being developed; therefore, the costs are not included in this FS. The source control measures are included by reference in this FS. Areas for ISS have not been identified in RTA 3; therefore costs have not been included in this FS. ISS may be applied to RTA 3 if predesign investigations indicate areas of NAPL saturated sediment where ISS may be beneficial.

ARAR – applicable or relevant and appropriate requirement
CDF – confined disposal facility
ISS – in-situ solidification
NAPL – non aqueous phase liquid
NYCDEP – New York City Department of Environmental Protection
NYSDEC – New York State Department of Environmental Conservation
O&M – operations and maintenance
PRP – potentially responsible party
RAO – remedial action objective
RTA – remediation target area
TMV – toxicity, mobility, or volume
USACE – United States Army Corps of Engineers
USEPA – United States Environmental Protection Agency

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TABLE 4-7

Summary of Alternative, Disposal, and O&M Cost by RTA

Gowanus Canal Feasibility Study

Brooklyn, New York

Alternative Description	Base Implementation Capital Cost[1]	Dredging, Capping, Treatment, and Disposal Capital Cost by RTA[2,3]			Present Worth O&M Cost[4]	Total Cost
		RTA 1	RTA 2	RTA 3		
Dredging and Capping Alternatives						
No Action	$0	$0	$0	$0	$0	$0
Dredge entire column of soft sediment Cap with treatment layer, isolation sand layer, and armor layer	$93,000,000	$15,000,000	$35,000,000	$29,000,000	$3,300,000	$173,000,000
Dredge entire column of soft sediment Solidify top 3-5 feet of underlying native sediment in targeted areas Cap with treatment layer, isolation sand layer, and armor layer	$93,000,000	$18,000,000	$48,000,000	$29,000,000	$3,300,000	$191,000,000
Treatment and Disposal Options						
A - Offsite thermal desorption, beneficial use	NA	$30,000,000	$82,000,000	$102,000,000	NA	$214,000,000
B - Offsite disposal (landfill)	NA	$32,000,000	$87,000,000	$108,000,000	NA	$227,000,000
C - Offsite co-gen	NA	$37,000,000	$101,000,000	$126,000,000	NA	$264,000,000
D - Offsite stabilization, beneficial use	NA	$30,000,000	NA	$104,000,000	NA	$104,000,000
E - Onsite stabilization, beneficial use	$5,400,000	$23,000,000	NA	$78,000,000	$2,900,000	$109,000,000
F - Offsite stabilization and disposal in on-site constructed CDF	NA	NA	NA	$74,000,000	$260,000	$74,000,000
G - Onsite stabilization and disposal in on-site constructed CDF	$5,400,000	NA	NA	$67,000,000	$260,000	$73,000,000

Notes:

1. Base implementation costs for the dredging and capping alternatives consist of the following cost items: remedial design and pre-design sampling and testing; pre-remediation site work, facility costs, bulkhead upgrade/stabilization, short term morning costs, and confirmation sampling costs. The base implementation cost for disposal options E and G includes setting up the onsite sediment stabilization facility.

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

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

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

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TABLE 4-8
Sustainability Evaluation of Disposal Options
Gowanus Canal Feasibility Study
Brooklyn, New York

	Option A: Offsite Thermal Desorption, Offsite Beneficial Use	**Option B: Offsite Landfill Disposal**	**Option C: Offsite Cogeneration, Offsite Beneficial Use**	**Option D: Offsite Stabilization, Offsite Beneficial Use**
Sustainability Impacts (Relative Importance)	Under Option A, the dredged, dewatered sediment would be stabilized to the degree required to pass the paint filter test at the offsite dredge material processing facility. The material would then be transported by truck to an offsite thermal desorption facility for thermal treatment. The treatment residuals will be destroyed in an afterburner. Thermally treated sediment would be transported by truck to be used as daily cover at a landfill or for other beneficial use.	Under Option B, the dredged, dewatered sediment would be stabilized to the degree required to pass the paint filter test at the offsite dredge material processing facility. The material would then be transported by truck to an offsite disposal facility. Disposal at a RCRA Subtitle D landfill is assumed for the stabilized sediment.	Under Option C, the dredged, dewatered sediment would be stabilized to the degree required to pass the paint filter test at the offsite dredge material processing facility. The material would then be transported by truck to an offsite cogeneration electrical plant. The treatment would include thermal destruction of the organic contaminants through burning of the sediments at high temperatures (greater than 1,400°C). Treated sediment would be transported by truck to be used as daily cover at a landfill or for other beneficial use.	Option D consists of transporting the stabilized sediment to the offsite treatment facility and then transferring the stabilized sediment to the end beneficial-use location. The specific type or location of beneficial use has not been identified, but for purposes of the FS it is assumed that the stabilized sediment would be used as fill. It is assumed that the material would be transported by truck to the end-use location.
Energy Consumed/Fossil Fuel Depletion (1)	• Moderate transport distance (approximately 60 miles). • Transport assumed to be by truck. • Additional energy requirements to handle and treat the dredged material would be the highest of the four options. • Thermal desorption requires significant energy inputs to reach and maintain the temperatures needed. • Disposal and possible burning of the treatment condensate or residual would require further energy inputs.	• Moderate transportation distance (approximately 110 miles). • Transport assumed to be by truck. • Additional energy requirements limited to the sediment handling to transfer the material on and off the barge and to mix in the reagents.	• Furthest transportation distance (approximately 325 to 350 miles). • Transport assumed to be by truck. • Stabilized sediment would be burned to generate energy at a cogeneration facility. • Energy gained from NAPL-contaminated sediment may offset transport energy used. • Sediment containing greater than approximately 1,000 BTUs/lb would produce more energy than required for transport if the BTU efficiency of the burned sediment is greater than 30%[a]. • Canal sediments from RTAs 1 and 2 are expected to range from 500 to 4,000 BTUs/lb.	• Moderate transportation distance (approximately 110 miles). • Transport assumed to be by truck. • Additional energy requirements limited to the sediment handling to transfer the material on and off the barge and to mix in the reagents.
Green House Gas and Other Air Emissions (3)	• GHG emissions are likely to be the highest of the four options. • Significant emissions from energy used to achieve the temperatures required for treatment. • Portland cement (7.5% by weight) is assumed as a stabilization reagent and will contribute to GHG emissions.	• GHG emissions are expected to be moderate due to the transportation distance and transport method (truck). • Portland cement (7.5% by weight) is assumed as a stabilization reagent and will contribute to GHG emissions.	• GHG emissions are expected to be relatively high. • Furthest transport distance. • Combustion is part of treatment; however the use of contaminated sediment as a fuel source would prevent the use of virgin fuel sources. • Portland cement (7.5% by weight) is assumed as a stabilization reagent and will contribute to GHG emissions.	• GHG emissions are expected to be moderate due to the transportation distance and transport method (truck). • Addition of stabilization reagents may also contribute to GHG emissions. This option assumes the stabilization reagents would be 15% by weight and the reagents would be 75% blast furnace slag (BFS120) and 25% portland cement. This would result in a dosage of approximately 4% portland cement by weight which would contribute less GHGs than Options A, B, C, and E.
Transportation Impacts (4—also considered in energy consumption) • Proximity • Efficiency • Hauling	• Moderate transport distance (approximately 60 miles). • Transport assumed to be by truck.	• Moderate to high transport distance (approximately 110 miles). • Transport assumed to be by truck.	• Furthest transport distance (approximately 325 to 350 miles). • Transport would be by truck.	• Moderate to high transport distance (approximately 110 miles). • Transport assumed to be by truck.
Waste Reduction, Reuse, and Recycling (2) • *Waste or Residuals Generated from Treatment* • *Solid/ Hazardous Waste Reduction*	• Overall volume of waste would be significantly reduced. • Treated dredged material would be beneficially used as long as concentrations of metals are below the end-user requirements. • *The reduction of solid/hazardous waste is discussed within the alternative evaluation against the NCP criteria in Tables 4-6a through 4-6c.*	• Volume of waste (dredge material) would not be reduced. • No reuse of the dredged material is planned. • Disposal option would not result in any treatment residuals. • *Solidified/stabilized sediment would be placed in offsite landfill.* • *The reduction of solid/hazardous waste is discussed within the alternative evaluation against the NCP criteria in Tables 4-6a through 4-6c.*	• Volume of waste would be eliminated for material treated. • Contaminated sediment will be used as a fuel source. • Treated dredged material would be beneficially used as long as concentrations of metals are below the end-user requirements. • *The reduction of solid/hazardous waste is discussed within the alternative evaluation against the NCP criteria in Tables 4-6a through 4-6c.*	• Volume of waste would be eliminated for material treated. • Treated dredged material would be beneficially used as long as leachability and strength requirements were met. • *The reduction of solid/hazardous waste is discussed within the alternative evaluation against the NCP criteria in Tables 4-6a and4-6c.*
Water Requirements and Impacts on Water Resources	• *This is not considered a significant criterion for evaluation of the disposal options.* • *Water required will be limited to decontamination and possibly backwashing of the water treatment system.*			
Overall sustainability impacts	**High**	**Moderate to high**	**Moderate**	**Moderate**

[a]Estimate based on a 30% assumed energy recovery efficiency from the burned sediment, 325 mile trip, 5 mile/gallon truck economy, 30,000 lb/truck load, and 129,500 BTU/gallon diesel.

BTU—British thermal unit
CDF—confined disposal facility
GHG—green house gas
lb—pound
NAPL—non aqueous phase liquid
RCRA—Resource Conservation and Recovery Act

No shading /italicized Insignificant relative to other impacts
(green) Lower negative impacts
(yellow) Moderate negative impacts
(pink) Higher negative impacts

TABLE 4-8
Sustainability Evaluation of Disposal Options
Gowanus Canal Feasibility Study
Brooklyn, New York

	Option E: Onsite Stabilization, Onsite Beneficial Use	**Option F: Offsite Stabilization and Onsite Disposal in Constructed CDF**	**Option G: Onsite Stabilization and Onsite Disposal in Constructed CDF**
Sustainability Impacts (Relative Importance)	Option E includes solidifying/stabilizing dredged sediment onsite and then beneficially using the stabilized sediment. The specific type of beneficial use has not been identified; however, for the purposes of this FS it is assumed the stabilized sediment would be used onsite as fill material.	Option F consists of transporting the solidified/stabilized sediment to and from the offsite treatment facility back to the site by barge, and then transferring the sediment into a constructed CDF within or adjacent to the canal. The containment facility would be constructed by installing a double-sheet pile wall around the perimeter of the CDF and filling the void between the sheet piling with bentonite-augmented soil or a similar low-permeability material.	Option G consists of solidifying or stabilizing dredged sediment onsite and then transferring the stabilized sediment into a constructed CDF within or adjacent to the canal. The containment facility would be constructed by installing a double-sheet pile wall around the perimeter of the CDF and filling the void between the sheet piling with bentonite-augmented soil or a similar low-permeability material.
Energy Consumed/Fossil Fuel Depletion (1)	• Requires no offsite transport. • Additional energy requirements limited to the sediment handling to mix in the reagents and transfer to the CDF.	• Requires low transport distance. • Transport to and from solidification/ stabilization facility would be by barge. • Additional energy requirements limited to the sediment handling to transfer the material on and off the barge and to mix in the reagents.	• Requires no offsite transport. • Additional energy requirements limited to the sediment handling to mix in the reagents and transfer solidified/stabilized sediment to the CDF.
Green House Gas and Other Air Emissions (3)	• GHG and other air emissions are expected to be low for Option E. • Requires the no offsite transport. • Does not have a combustion component to the treatment. • Some off-gassing may occur during solidification/ stabilization. This disposal option assumes the same types of reagents as option D; however the application would be 30% by weight. This would result in a dosage of approximately 8% portland cement, by weight, which would be similar Options A, B, or C, but greater than Options D, F, and G.	• GHG and other air emissions are expected to be low for Option F. • Requires the least amount of transportation. • Does not have a combustion component to the treatment. • Some off-gassing may occur during solidification/ stabilization. The stabilization reagents and dosages assumed for this option are the same as Option D, This would result in a dosage of approximately 4% portland cement, by weight, which would contribute less GHGs than Options A, B, C, and E.	• GHG and other air emissions are expected to be very low for Option G. • Requires no offsite transportation. • Does not have a combustion component to the treatment. • Some off-gassing may occur during solidification/ stabilization. The stabilization reagents and dosages assumed for this option are the same as Option D, This would result in a dosage of approximately 4% portland cement, by weight, which would contribute less GHGs than Options A, B, C, and E.
Transportation Impacts (4—also considered in energy consumption) • Proximity • Efficiency • Hauling	• Requires no offsite transport of sediment.	• Requires the very low transport distance (approximately 30 nautical miles) • Transport would be performed by barge, which has comparatively lower energy consumption than truck transport.	• Requires no offsite transport of sediment.
Waste Reduction, Reuse, and Recycling (2) • *Waste or Residuals Generated from Treatment* • *Solid/ Hazardous Waste Reduction*	• Volume of waste would be eliminated for material treated. • Treated dredged material would be beneficially used as long as leachability and strength requirements were met. • *The reduction of solid/hazardous waste is discussed within the alternative evaluation against the NCP criteria in Tables 4-6a and 4-6c.*	• Volume of waste (dredged material) not reduced. • Use of constructed CDF would not use existing landfill capacity. • *Disposal option would not result in any treatment residuals.* • *Solidified/stabilized sediment would be placed in constructed CDF.* • *The reduction of solid/hazardous waste is discussed within the alternative evaluation against the NCP criteria in Table 4-6c.*	• Volume of waste (dredged material) not reduced. • Use of constructed CDF would not use existing landfill capacity. • *Disposal option would not result in any treatment residuals.* • *Solidified/stabilized sediment would be placed in constructed CDF. The reduction of solid/hazardous waste is discussed within the alternative evaluation against the NCP criteria in Tables 4-6c.*
Water Requirements and Impacts on Water Resources	• *This is not considered a significant criterion for evaluation of the disposal options.* • *Water required will be limited to decontamination and possibly backwashing of the water treatment system.*		
Overall sustainability impacts	**Low**	**Low**	**Low**

TABLE 4-9a
Comparative Analysis of Alternatives RTA 1
Gowanus Canal Feasibility Study
Brooklyn, New York

Dredging and Capping Alternatives	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness	Reduction of Toxicity, Mobility, or Volume	Short-Term Effectiveness	Implementability	Cost ($Million)[1]
Alternative 1 No Action	Does not satisfy criterion	Does not satisfy criterion	Low	Low	High	High	0
Alternative 5 Dredge entire column of soft sediment Cap with treatment layer, isolation sand layer, and armor layer	Satisfies criterion	Satisfies criterion	High	High	Moderate	Moderate	15
Alternative 7 Dredge entire column of soft sediment Solidify top 3-5 feet of underlying native sediment in select areas Cap with treatment layer, isolation sand layer, and armor layer	Satisfies criterion	Satisfies criterion	High 2	High	Moderate	Low to Moderate	18
Disposal Options Associated with Dredging and Capping alternatives							
Option A: Thermal desorption, offsite beneficial use	Satisfies criterion	Satisfies criterion	High	High	Moderate to High	Moderate	30
Option B: Offsite disposal (landfill)	Satisfies criterion	Satisfies criterion	High	Moderate	Moderate to High	Moderate to High	32
Option C: Co-gen, offsite beneficial use	Satisfies criterion	Satisfies criterion	High	High	Moderate to High	Moderate	37
Option D: Offsite stabilization, offsite beneficial use[3]	Satisfies criterion	Satisfies criterion	Low to Moderate	Moderate	Moderate to High	Moderate	30
Option E: Onsite stabilization, onsite beneficial use[3]	Satisfies criterion	Satisfies criterion	Low to Moderate	Moderate	Moderate to High	Moderate	23

[1]Present worth: 30-year period of performance (*I* = 2.3 percent). Cost does not include O&M or base implementation cost. See Table 4-7 and Appendix F for additional cost detail.
[2] If pilot testing and treatability studies indicate ISS will be effective and implementable within the canal, Alternative 7 would be expected to have greater long-term effectiveness than Alternative 5.
[3]The relative rankings of the stabilization and beneficial use disposal options could be modified following the identification of a specific beneficial use.

Source control measures will be needed to ensure that the sediment remedy achieves the RAOs and is sustainable. Source control is the first component of all alternatives except No Action. Source control measures are in the process of being developed; therefore, the costs are not included in this FS. The source control measures are included by reference in this FS

Legend:

Threshold Criteria:

- Does not satisfy criterion
- Satisfies criterion

Balancing Criteria:

- Low
- Low to Moderate
- Moderate
- Moderate to High
- High

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TABLE 4-9b
Comparative Analysis of Alternatives RTA 2
Gowanus Canal Feasibility Study
Brooklyn, New York

Dredging and Capping Alternatives	Threshold Criteria: Overall Protection of Human Health and the Environment	Threshold Criteria: Compliance with ARARs	Balancing Criteria: Long-Term Effectiveness	Balancing Criteria: Reduction of Toxicity, Mobility, or Volume	Balancing Criteria: Short-Term Effectiveness	Balancing Criteria: Implementability	Balancing Criteria: Cost ($Million)[1]
Alternative 1 No Action	Does not satisfy criterion	Does not satisfy criterion	Low	Low	High	High	0
Alternative 5 Dredge entire column of soft sediment Cap with treatment layer, isolation sand layer, and armor layer	Satisfies criterion	Satisfies criterion	High	High	Moderate	Moderate	35
Alternative 7 Dredge entire column of soft sediment Solidify top 3-5 feet of underlying native sediment in select areas Cap with treatment layer, isolation sand layer, and armor layer	Satisfies criterion	Satisfies criterion	High [2]	High	Moderate	Low to Moderate	48
Disposal Options Associated with Dredging and Capping alternatives							
Option A: Thermal desorption, offsite beneficial use	Satisfies criterion	Satisfies criterion	High	High	Moderate to High	Moderate	82
Option B: Offsite disposal (landfill)	Satisfies criterion	Satisfies criterion	High	Moderate	Moderate to High	Moderate to High	87
Option C: Co-gen, offsite beneficial use	Satisfies criterion	Satisfies criterion	High	High	Moderate to High	Moderate	101

[1]Present worth: 30-year period of performance (*I* = 2.3 percent). Cost does not include O&M or base implementation cost. See Table 4-7 and Appendix F for additional cost detail.
[2] If pilot testing and treatability studies indicate ISS will be effective and implementable within the canal, Alternative 7 would be expected to have greater long-term effectiveness than Alternative 5.
Source control measures will be needed to ensure that the sediment remedy achieves the RAOs and is sustainable. Source control is the first component of all alternatives except No Action. Source control measures are in the process of being developed; therefore, the costs are not included in this FS. The source control measures are included by reference in this FS.

Legend:

Threshold Criteria:

- ○ Does not satisfy criterion
- ● Satisfies criterion

Balancing Criteria:

- ○ Low
- ◔ Low to Moderate
- ◑ Moderate
- ◕ Moderate to High
- ● High

TABLE 4-9c
Comparative Analysis of Alternatives RTA 3
Gowanus Canal Feasibility Study
Brooklyn, New York

Dredging and Capping Alternatives	Threshold Criteria: Overall Protection of Human Health and the Environment	Threshold Criteria: Compliance with ARARs	Balancing Criteria: Long-Term Effectiveness	Balancing Criteria: Reduction of Toxicity, Mobility, or Volume	Balancing Criteria: Short-Term Effectiveness	Balancing Criteria: Implementability	Balancing Criteria: Cost ($Million)[1]
Alternative 1 No Action	Does not satisfy criterion	Does not satisfy criterion	Low	Low	High	High	0
Alternative 5 Dredge entire column of soft sediment Cap with treatment layer, isolation sand layer, and armor layer	Satisfies criterion	Satisfies criterion	High	High	Moderate	Moderate	29
Alternative 7 Dredge entire column of soft sediment Solidify top 3-5 feet of underlying native sediment in select areas Cap with treatment layer, isolation sand layer, and armor layer	Satisfies criterion	Satisfies criterion	High [2]	High	Moderate	Low to Moderate	29
Disposal Options Associated with Dredging and Capping alternatives							
Option A: Thermal desorption, offsite beneficial use	Satisfies criterion	Satisfies criterion	High	High	Moderate to High	Moderate	102
Option B: Offsite disposal (landfill)	Satisfies criterion	Satisfies criterion	High	Moderate	Moderate to High	Moderate to High	108
Option C: Co-gen, offsite beneficial use	Satisfies criterion	Satisfies criterion	High	High	Moderate to High	Moderate	126
Option D: Offsite stabilization, offsite beneficial use[3]	Satisfies criterion	Satisfies criterion	Low to Moderate	Moderate	Moderate to High	Moderate	104
Option E: Onsite stabilization, onsite beneficial use[3]	Satisfies criterion	Satisfies criterion	Low to Moderate	Moderate	Moderate to High	Moderate	78
Option F: Offsite stabilization, disposal in onsite CDF	Satisfies criterion	Satisfies criterion	Moderate to High	Moderate	Moderate to High	Moderate	74
Option G: Onsite stabilization, disposal in onsite CDF	Satisfies criterion	Satisfies criterion	Moderate to High	Moderate	Moderate to High	Moderate	67

[1]Present worth: 30-year period of performance (*I* = 2.3 percent). Cost does not include O&M or base implementation cost. See Table 4-7 and Appendix F for additional cost detail.
[2] If pilot testing and treatability studies indicate ISS will be effective and implementable within the canal, Alternative 7 would be expected to have greater long-term effectiveness than Alternative 5.
[3]The relative rankings of the stabilization and beneficial use disposal options could be modified following the identification of a specific beneficial use.
Source control measures will be needed to ensure that the sediment remedy achieves the RAOs and is sustainable. Source control is the first component of all alternatives except No Action. Source control measures are in the process of being developed; therefore, the costs are not included in this FS. The source control measures are included by reference in this FS.

Legend:

Threshold Criteria:

- Does not satisfy criterion
- Satisfies criterion

Balancing Criteria:

- Low
- Low to Moderate
- Moderate
- Moderate to High
- High

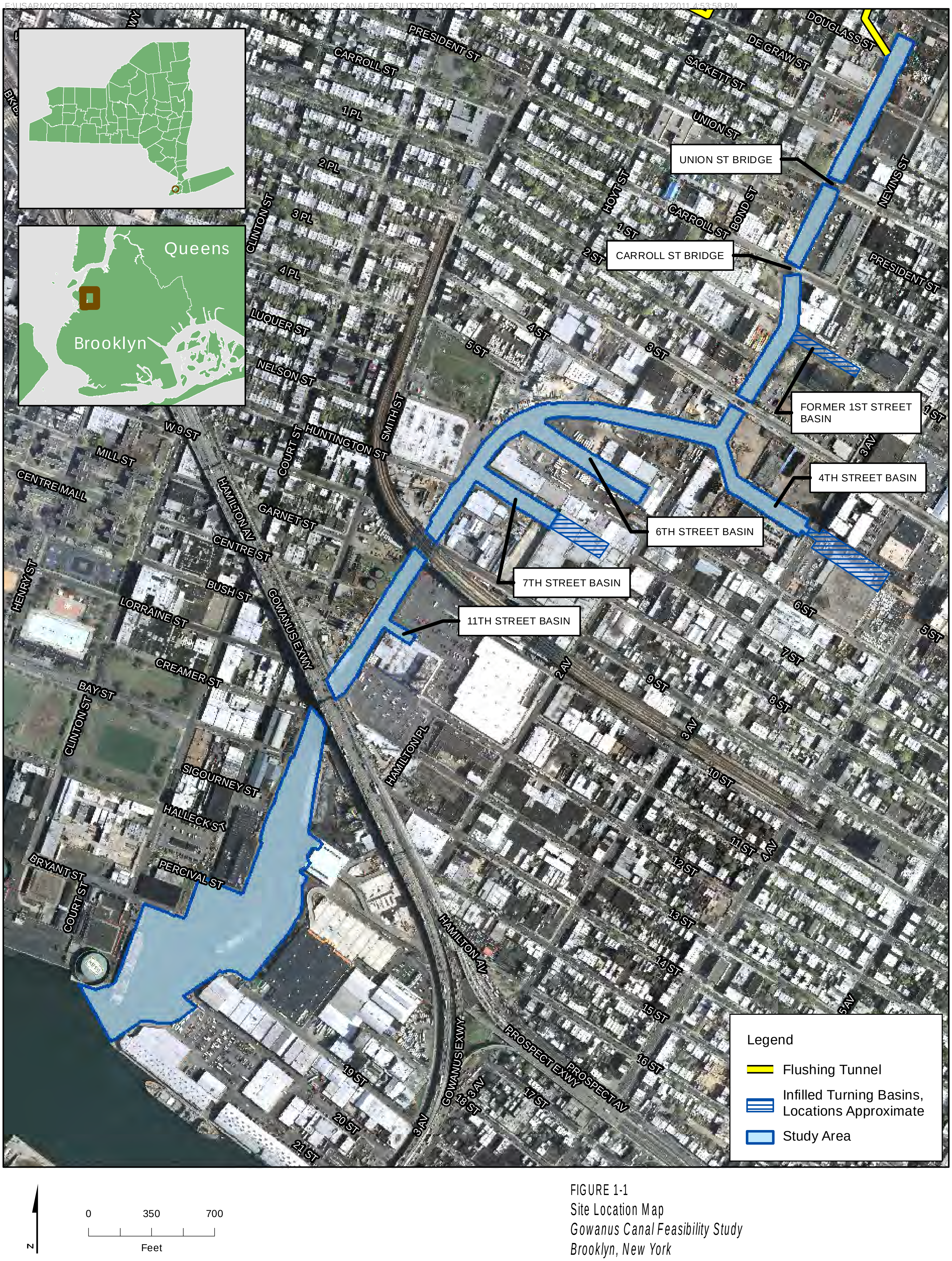

FIGURE 1-1
Site Location Map
Gowanus Canal Feasibility Study
Brooklyn, New York

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0 750 1,500
Feet

FIGURE 1-**2**
Gowanus Canal and Adjacent Water Bodies
Gowanus Canal Feasibility Study
Brooklyn, New York

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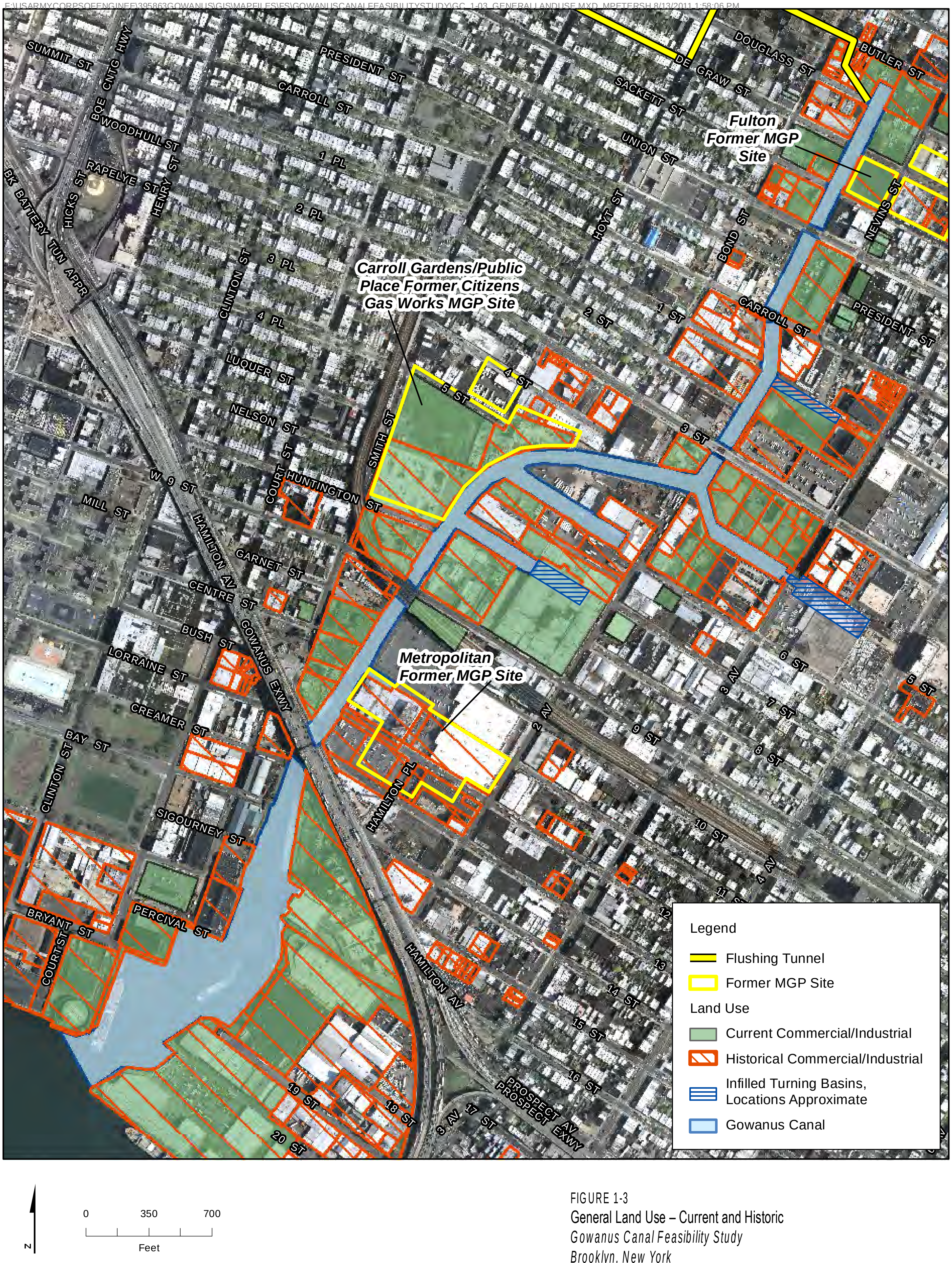

FIGURE 1-3
General Land Use – Current and Historic
Gowanus Canal Feasibility Study
Brooklyn, New York

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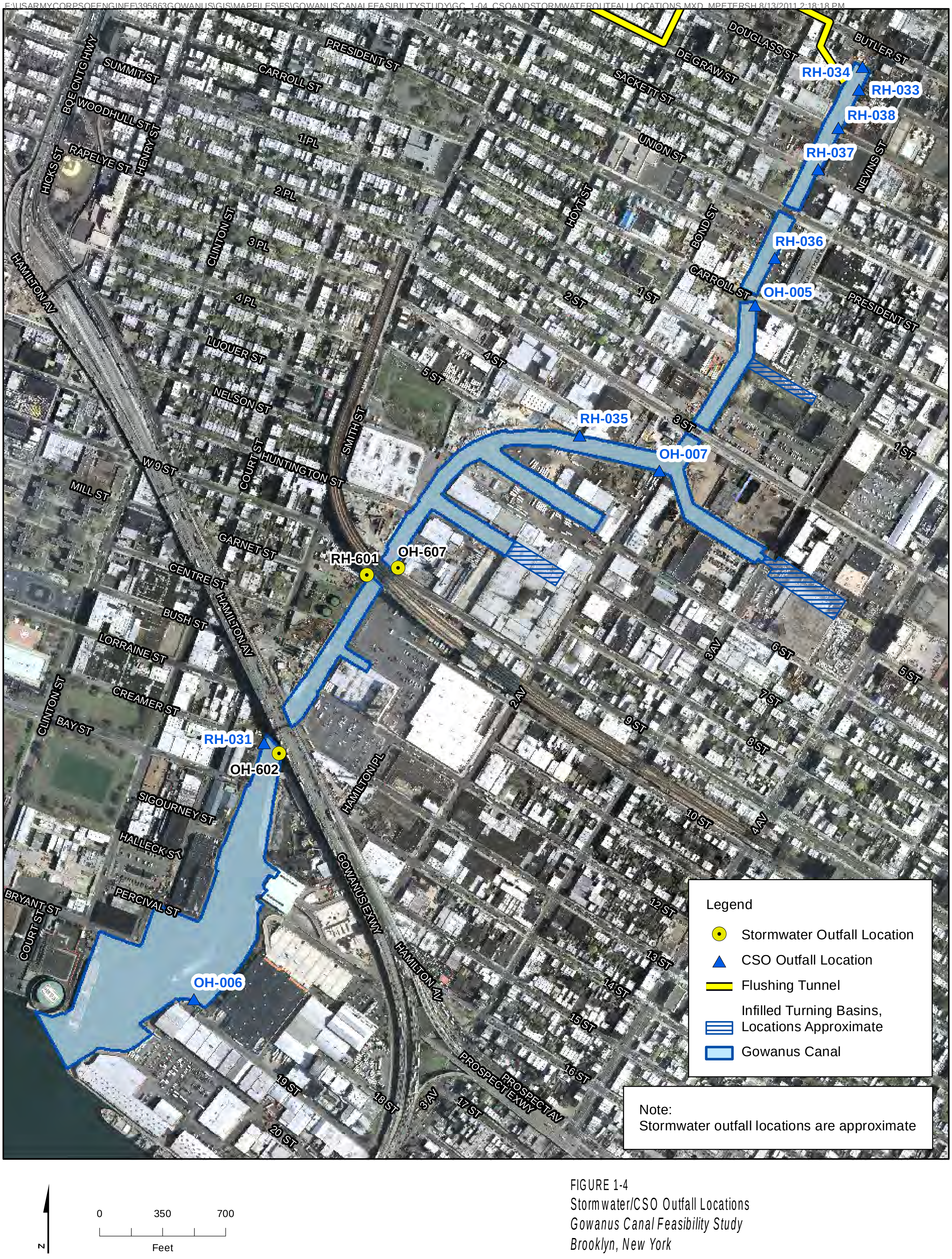

FIGURE 1-4
Stormwater/CSO Outfall Locations
Gowanus Canal Feasibility Study
Brooklyn, New York

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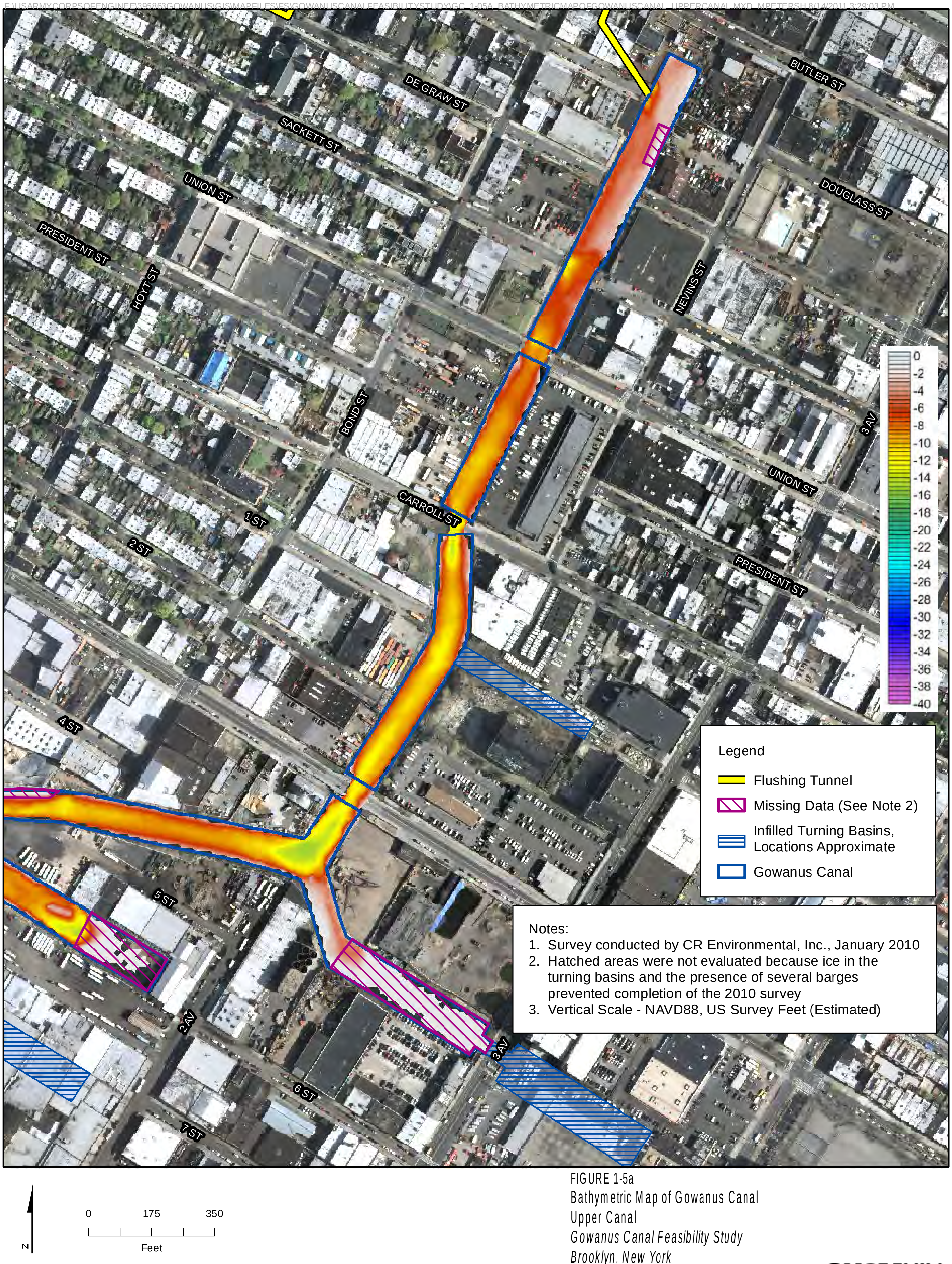

FIGURE 1-5a
Bathymetric Map of Gowanus Canal
Upper Canal
Gowanus Canal Feasibility Study
Brooklyn, New York

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Feet

FIGURE 1-5b
Bathymetric Map of Gowanus Canal
Middle Canal
Gowanus Canal Feasibility Study
Brooklyn, New York

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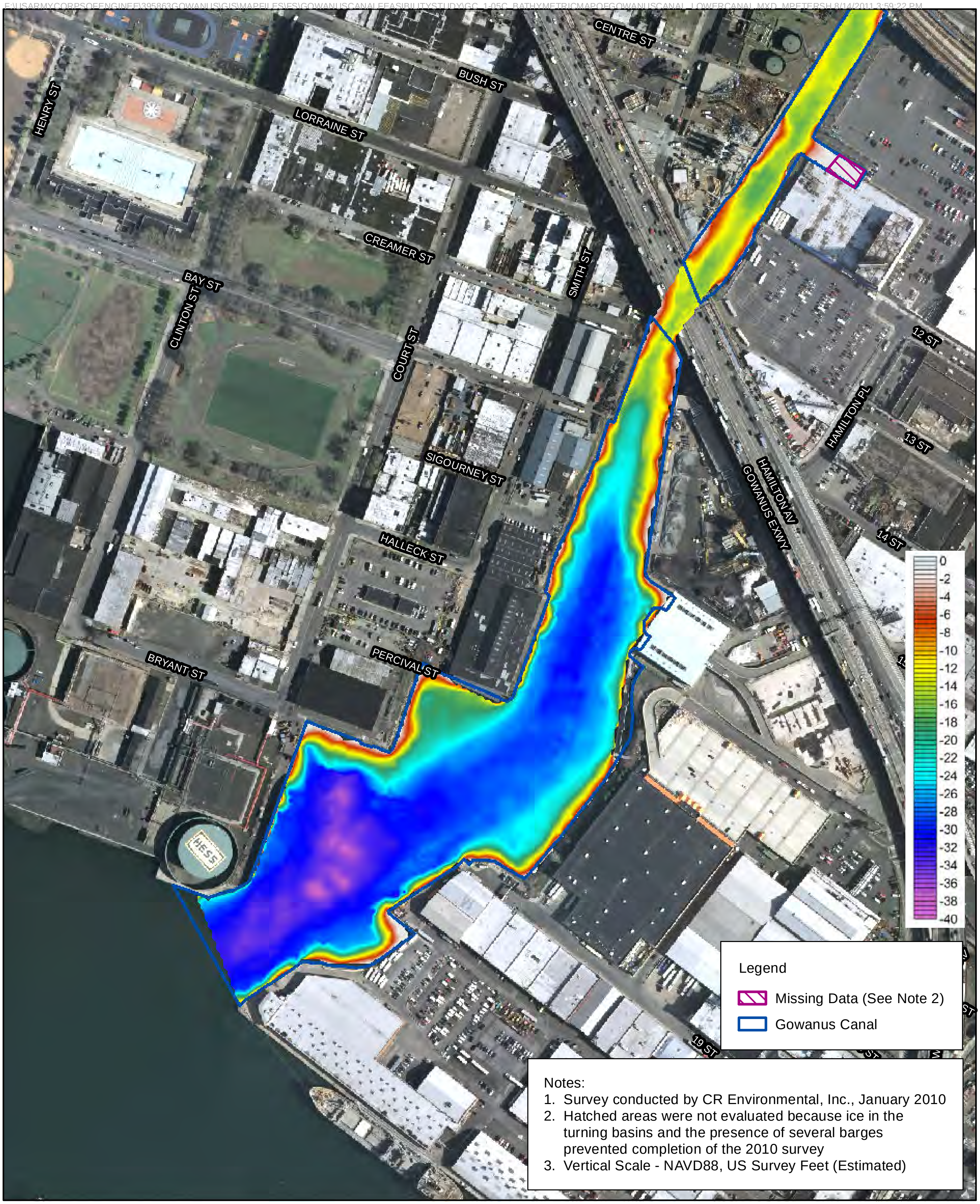

Notes:
1. Survey conducted by CR Environmental, Inc., January 2010
2. Hatched areas were not evaluated because ice in the turning basins and the presence of several barges prevented completion of the 2010 survey
3. Vertical Scale - NAVD88, US Survey Feet (Estimated)

N

0 175 350

Feet

FIGURE 1-5c
Bathymetric Map of Gowanus Canal
Lower Canal
Gowanus Canal Feasibility Study
Brooklyn, New York

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N

0 175 350

Feet

FIGURE 1-6a
Map of Debris and Obstructions in Gowanus Canal in 2005
Upper Canal
Gowanus Canal Feasibility Study
Brooklyn, New York

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FIGURE 1-6b
Map of Debris and Obstructions in Gowanus Canal in 2005
Middle Canal
Gowanus Canal Feasibility Study
Brooklyn, New York

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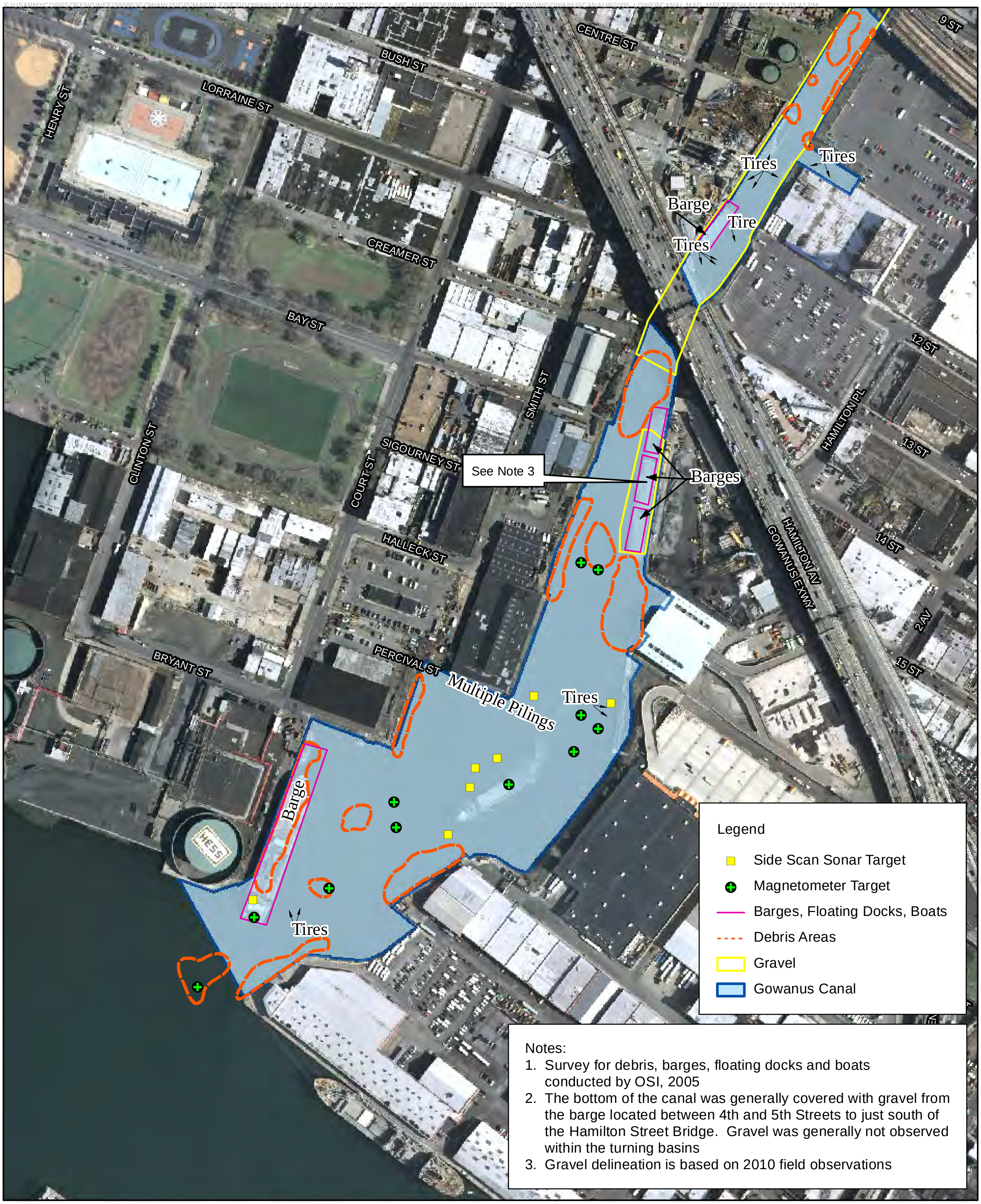

FIGURE 1-6c
Map of Debris and Obstructions in Gowanus Canal in 2005
Lower Canal
Gowanus Canal Feasibility Study
Brooklyn, New York

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Side Scan Sonar Target No.	Description
11	Pile of large blocks and debris
11a	Pile of debris
11b	Long pile of rip rap
17	Pile of hard, square debris
24	Suspected part of a tree
26	U-shaped object
28	Linear object
31	Small boat wreck
31a	Sunken boat hull
31b	Hard, rectangular feature
31c	Two rectangular features
37	Long section of rubble and rip rap
37a	Sunken barge
37b	Barge hull and small boat wreck
37c	Two hard rectangular features
39	Two rectangular objects

The complete side scan sonar survey report with imagery is provided in Appendix M.

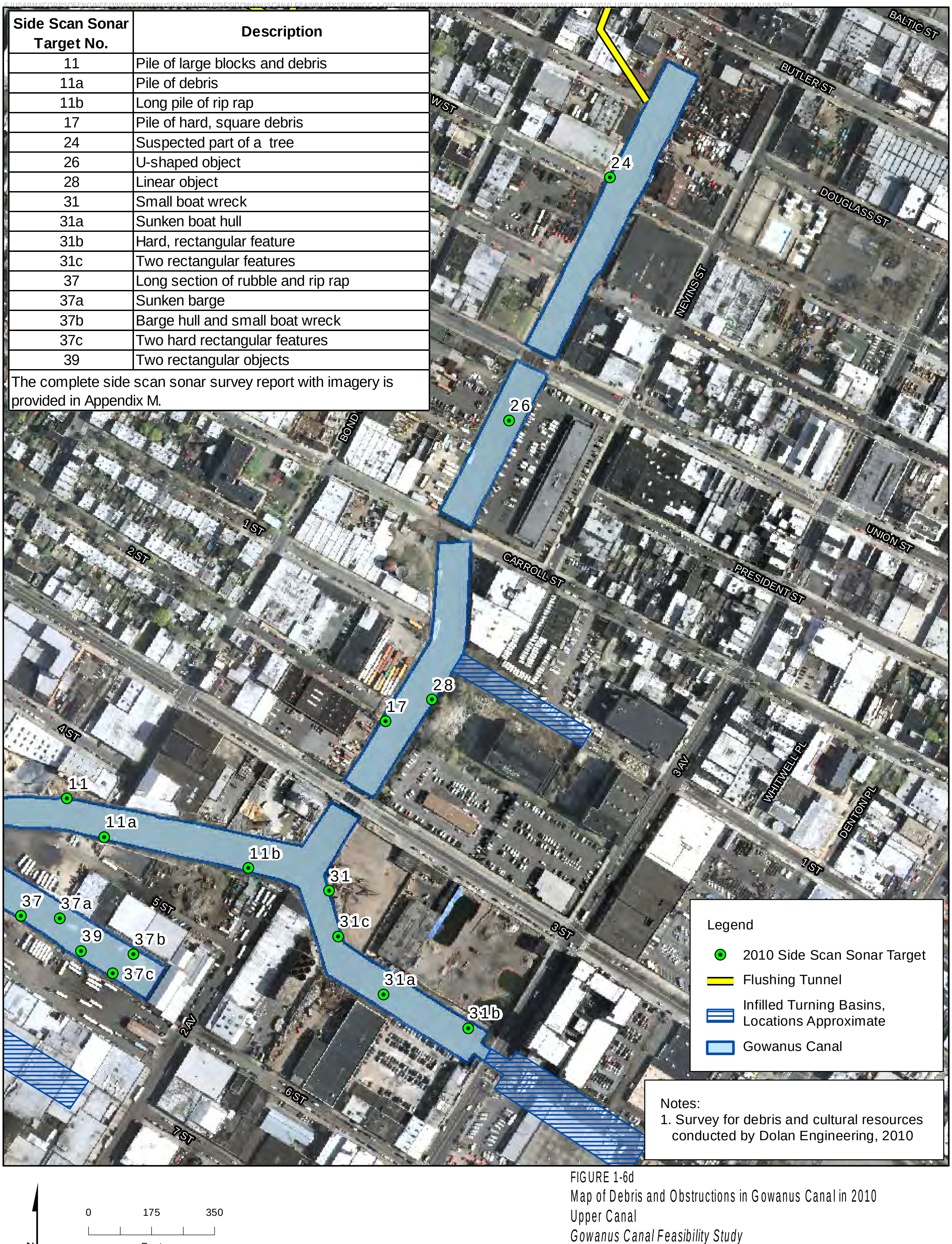

FIGURE 1-6d
Map of Debris and Obstructions in Gowanus Canal in 2010
Upper Canal
Gowanus Canal Feasibility Study
Brooklyn, New York

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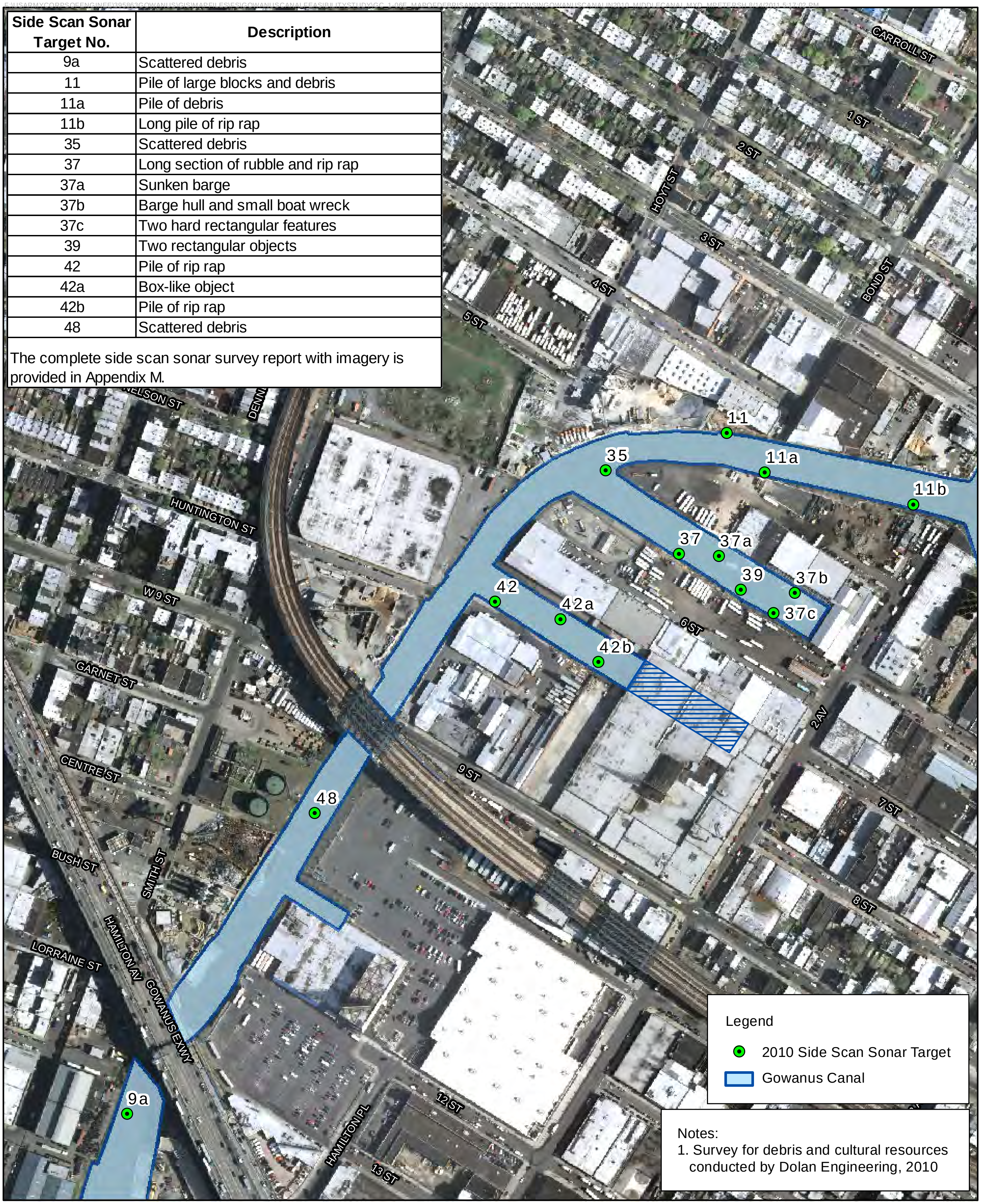
Side Scan Sonar Target No.	Description
9a	Scattered debris
11	Pile of large blocks and debris
11a	Pile of debris
11b	Long pile of rip rap
35	Scattered debris
37	Long section of rubble and rip rap
37a	Sunken barge
37b	Barge hull and small boat wreck
37c	Two hard rectangular features
39	Two rectangular objects
42	Pile of rip rap
42a	Box-like object
42b	Pile of rip rap
48	Scattered debris

The complete side scan sonar survey report with imagery is provided in Appendix M.



N

0 175 350

Feet

FIGURE 1-6e
Map of Debris and Obstructions in Gowanus Canal in 2010
Middle Canal
Gowanus Canal Feasibility Study
Brooklyn, New York

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Side Scan Sonar Target No.	Description
2	Hard square object
2a	Rectangular object - possible automobile
2b	Rectangular object - possible automobile
3	Hard linear feature
5	Linear scattered debris
9	Rectangular feature
9a	Scattered debris
48	Scattered debris
52	Numerous circular features, suspected tires

The complete side scan sonar survey report with imagery is provided in Appendix M.

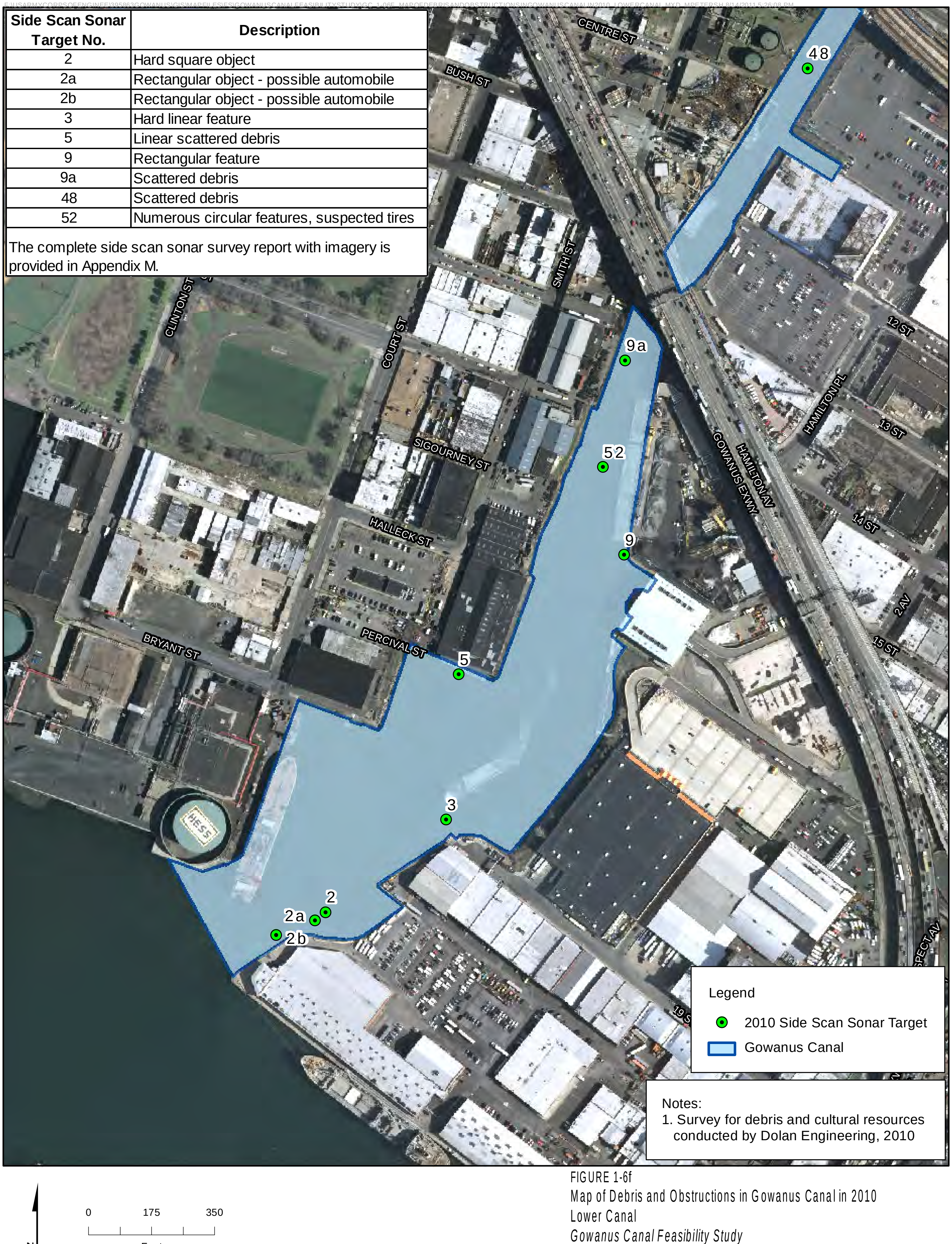

FIGURE 1-6f
Map of Debris and Obstructions in Gowanus Canal in 2010
Lower Canal
Gowanus Canal Feasibility Study
Brooklyn, New York

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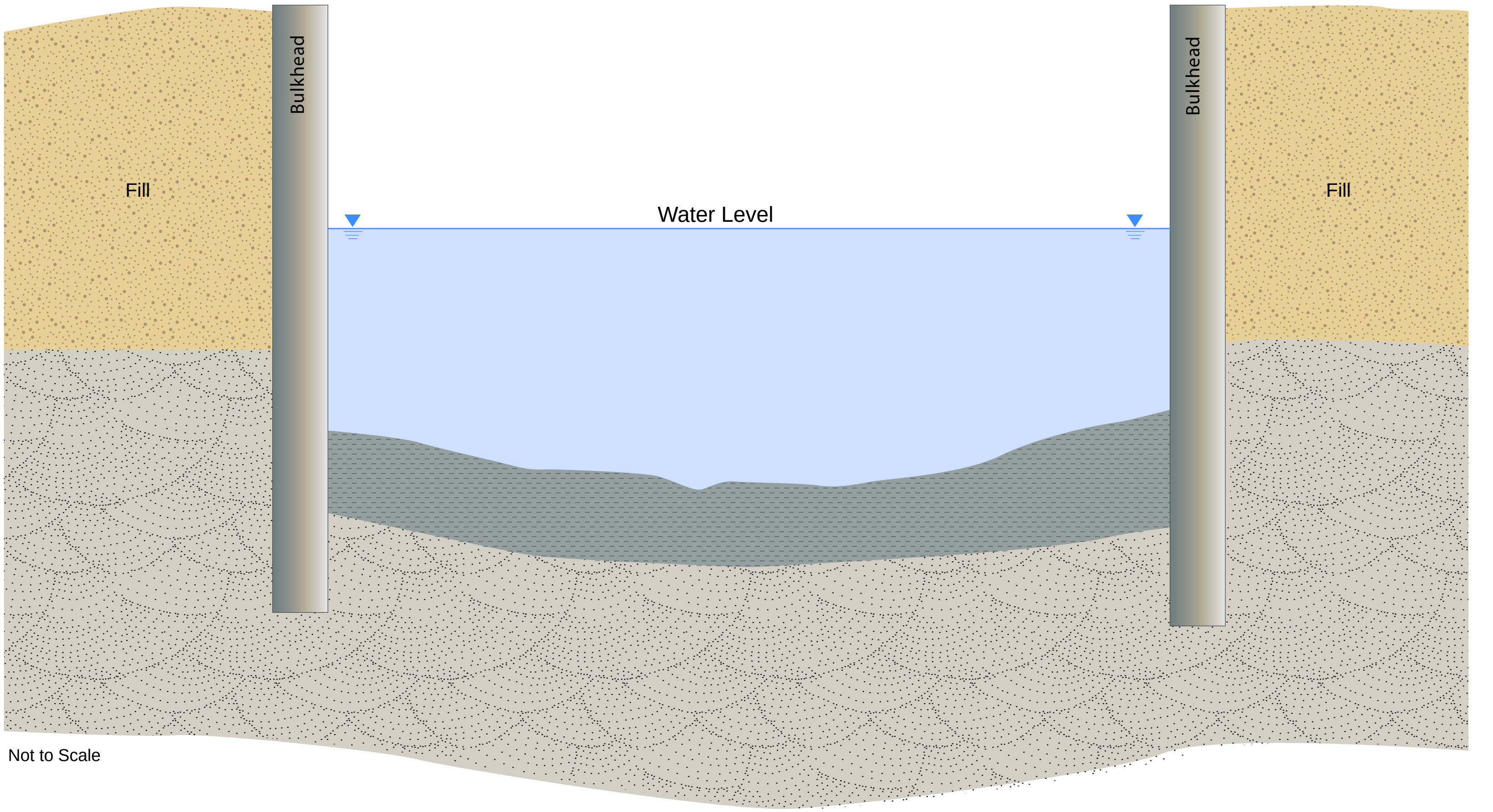

LEGEND

Fill

Soft sediment (deposited after canal was created)

Gowanus Creek native sediments

FIGURE 1-7
Conceptual Diagram of Sediment Deposits in the Gowanus Canal
Gowanus Canal Feasibility Study
Brooklyn, New York

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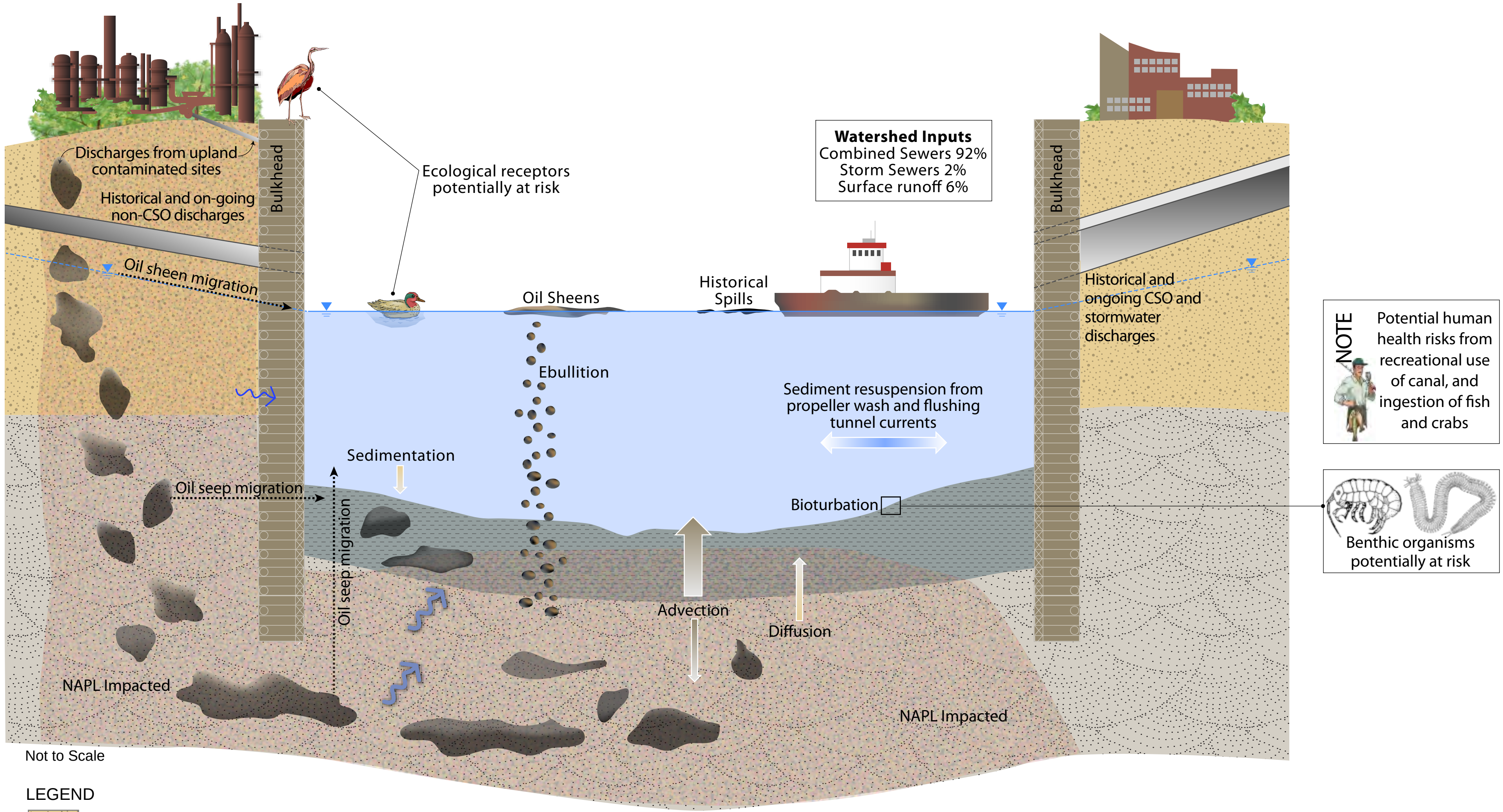

LEGEND

- Fill
- Soft sediment (deposited after canal was created)
- Gowanus Creek native sediments
- NAPL impacted sediment/soil
- Groundwater Flow Direction
- Groundwater seepage through bulkhead
- NAPL-saturated sediment/soil

FIGURE 1-8
Conceptual Site Model
Gowanus Canal Feasibility Study
Brooklyn, New York

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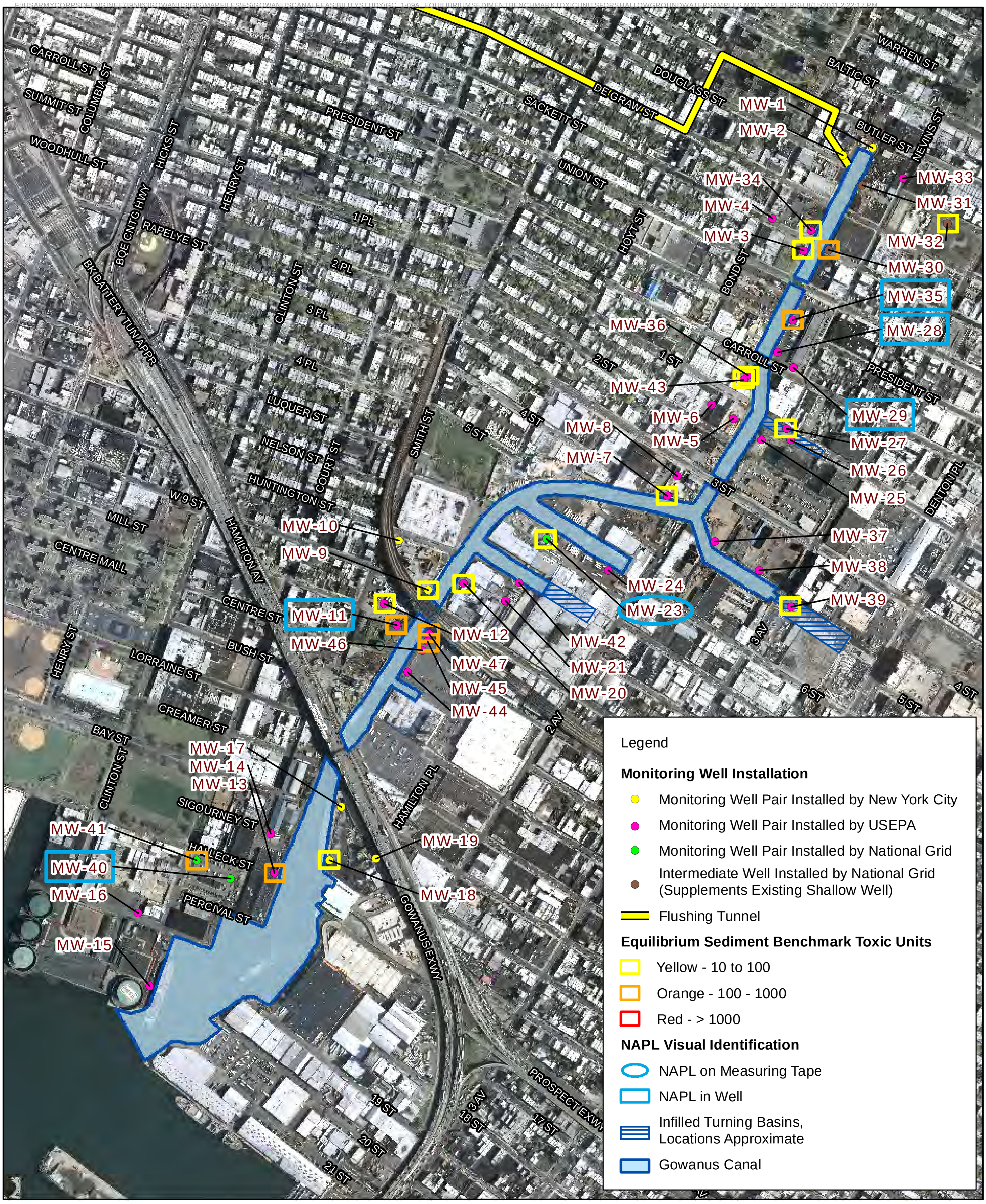

N

0 400 800

Feet

FIGURE 1-9a

Equilibrium Sediment Benchmark Toxic Units for Shallow Groundwater Samples

Gowanus Canal Feasibility Study

Brooklyn, New York

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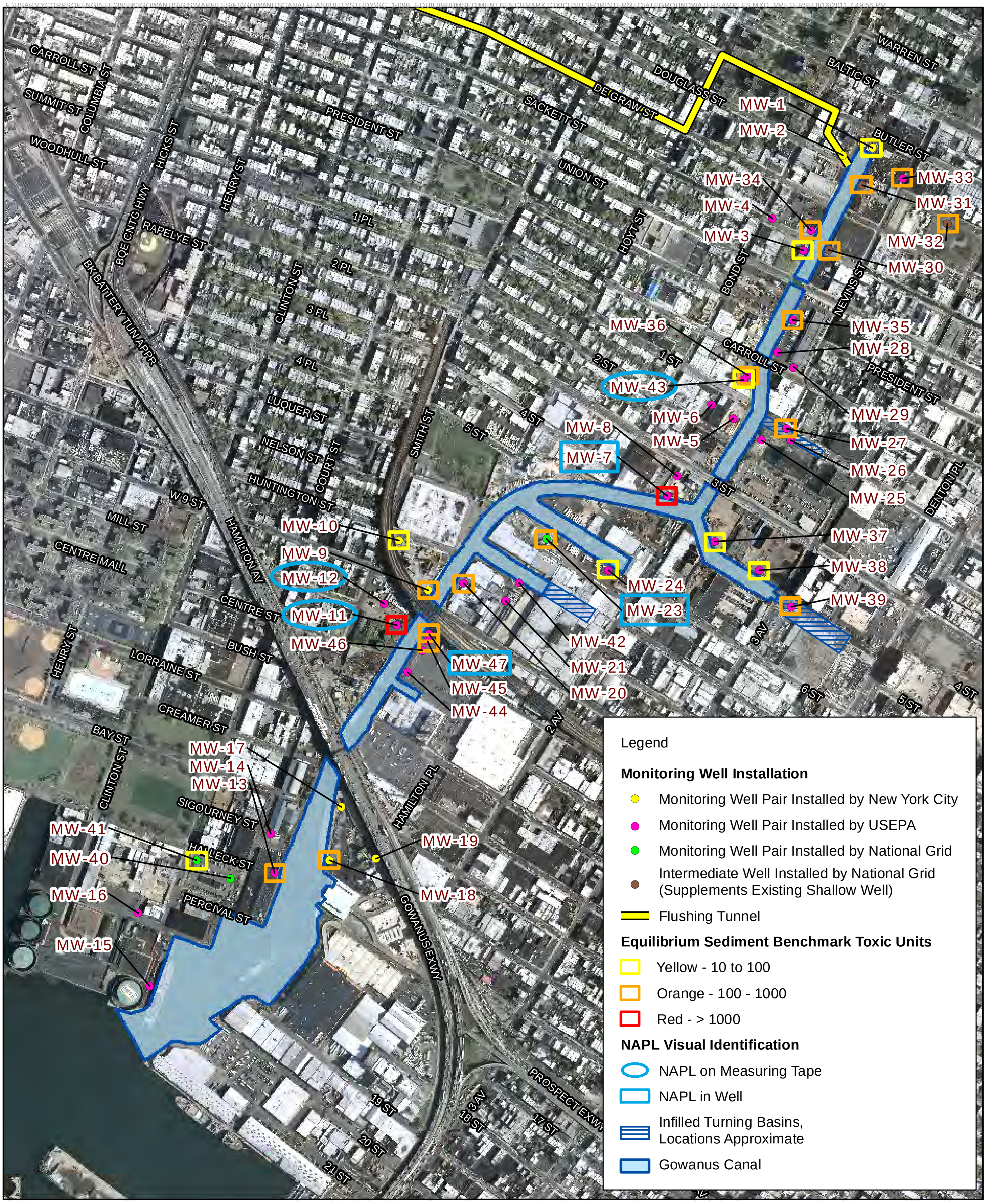

N

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Feet

FIGURE 1-9b

Equilibrium Sediment Benchmark Toxic Units for Intermediate Groundwater Samples

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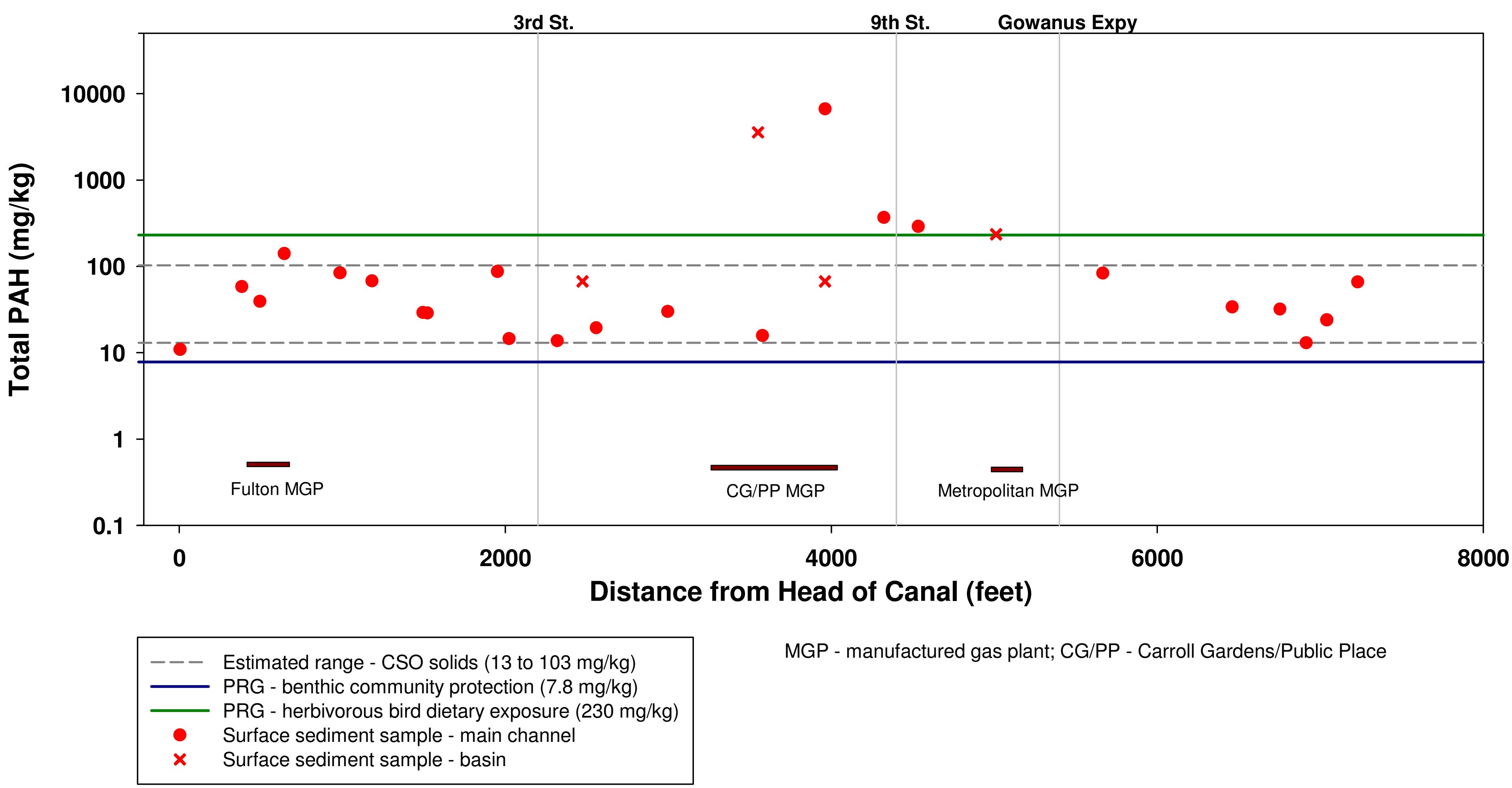
Total PAHs in Surface Sediment



MGP - manufactured gas plant; CG/PP - Carroll Gardens/Public Place

FIGURE 2-1a
Total PAH Concentrations in Surface Sediment
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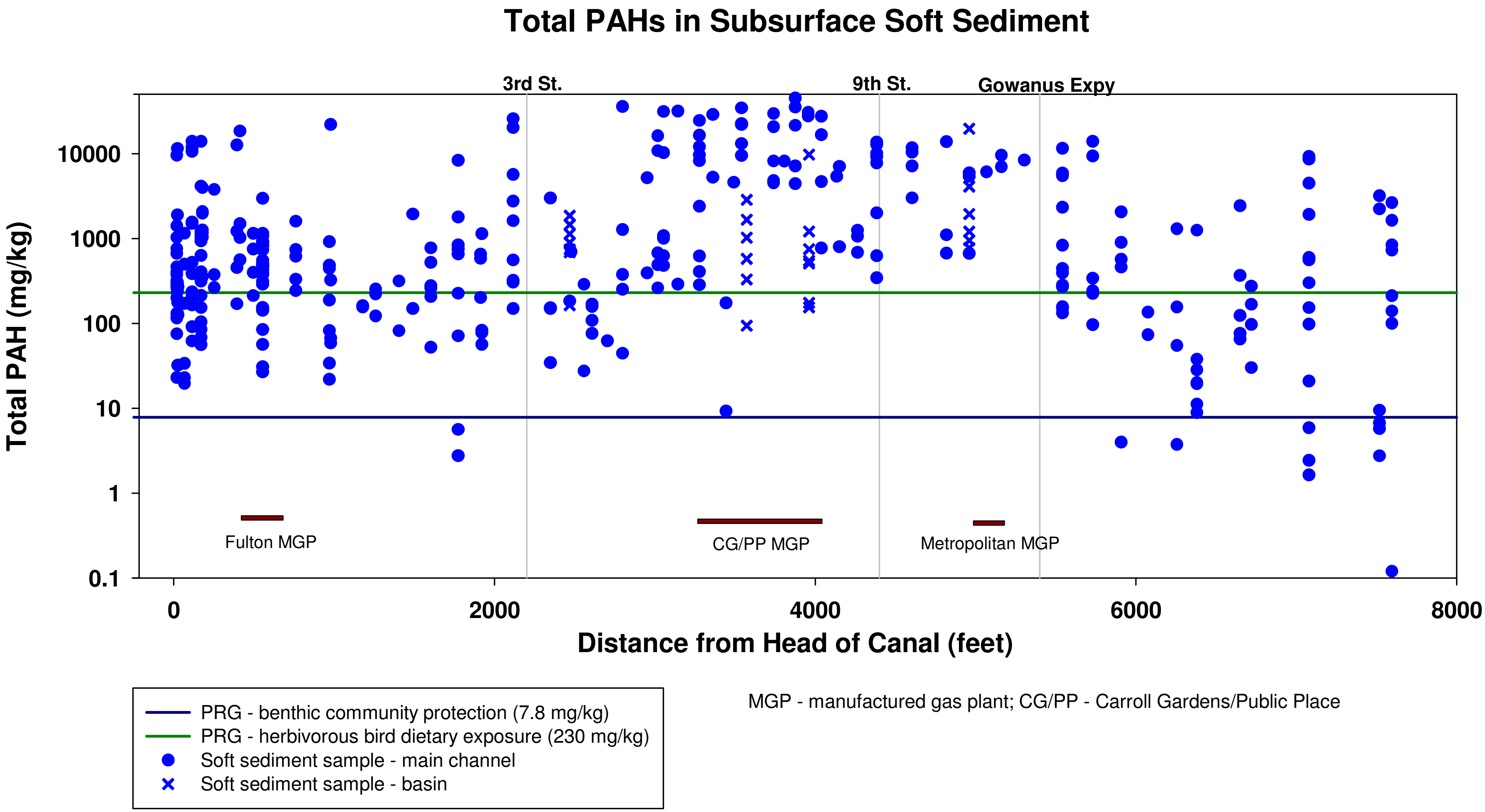

MGP - manufactured gas plant; CG/PP - Carroll Gardens/Public Place

FIGURE 2-1b
Total PAH Concentrations in Subsurface Soft Sediment
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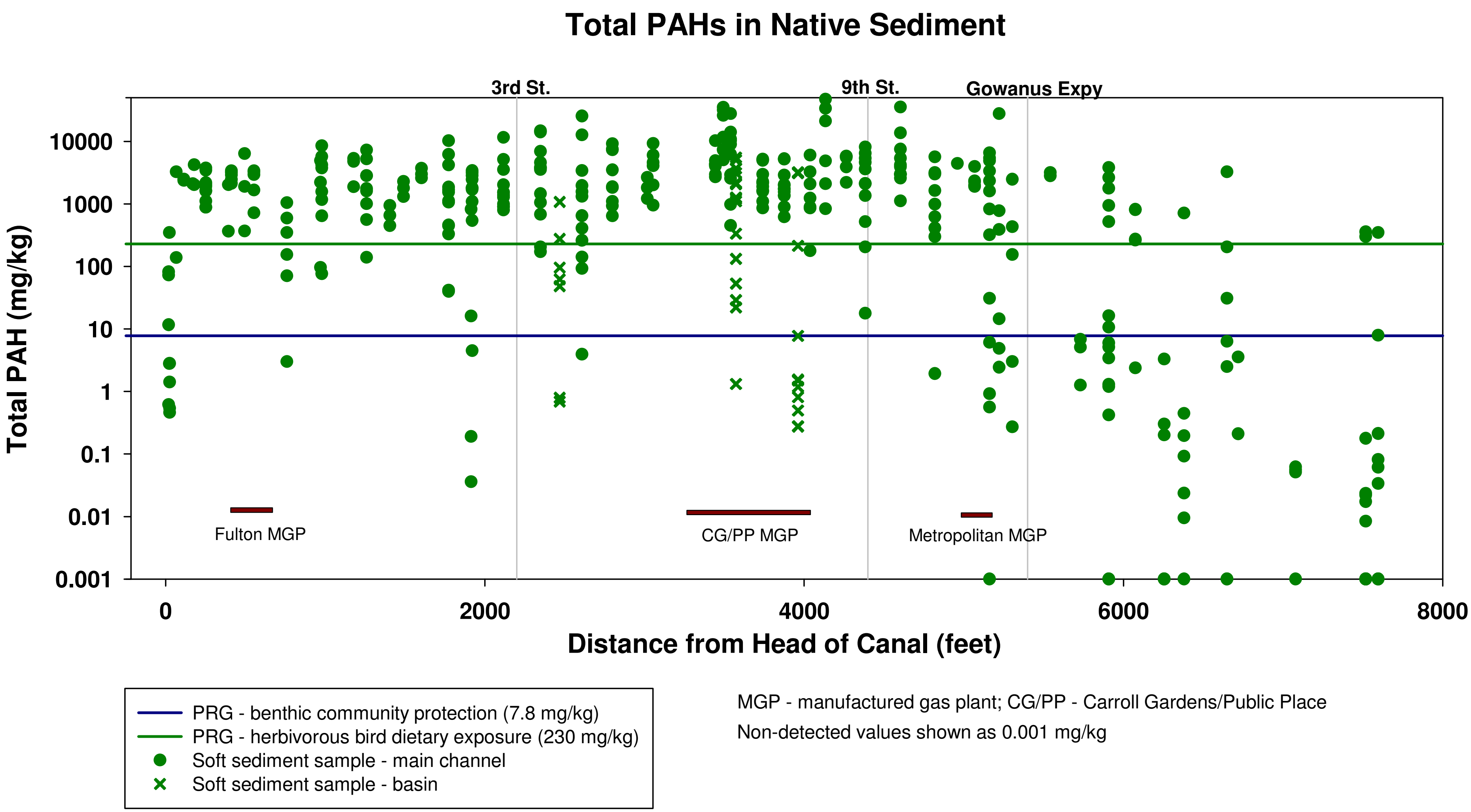

FIGURE 2-1c
Total PAH Concentrations in Native Sediment
Gowanus Canal Feasibility Study
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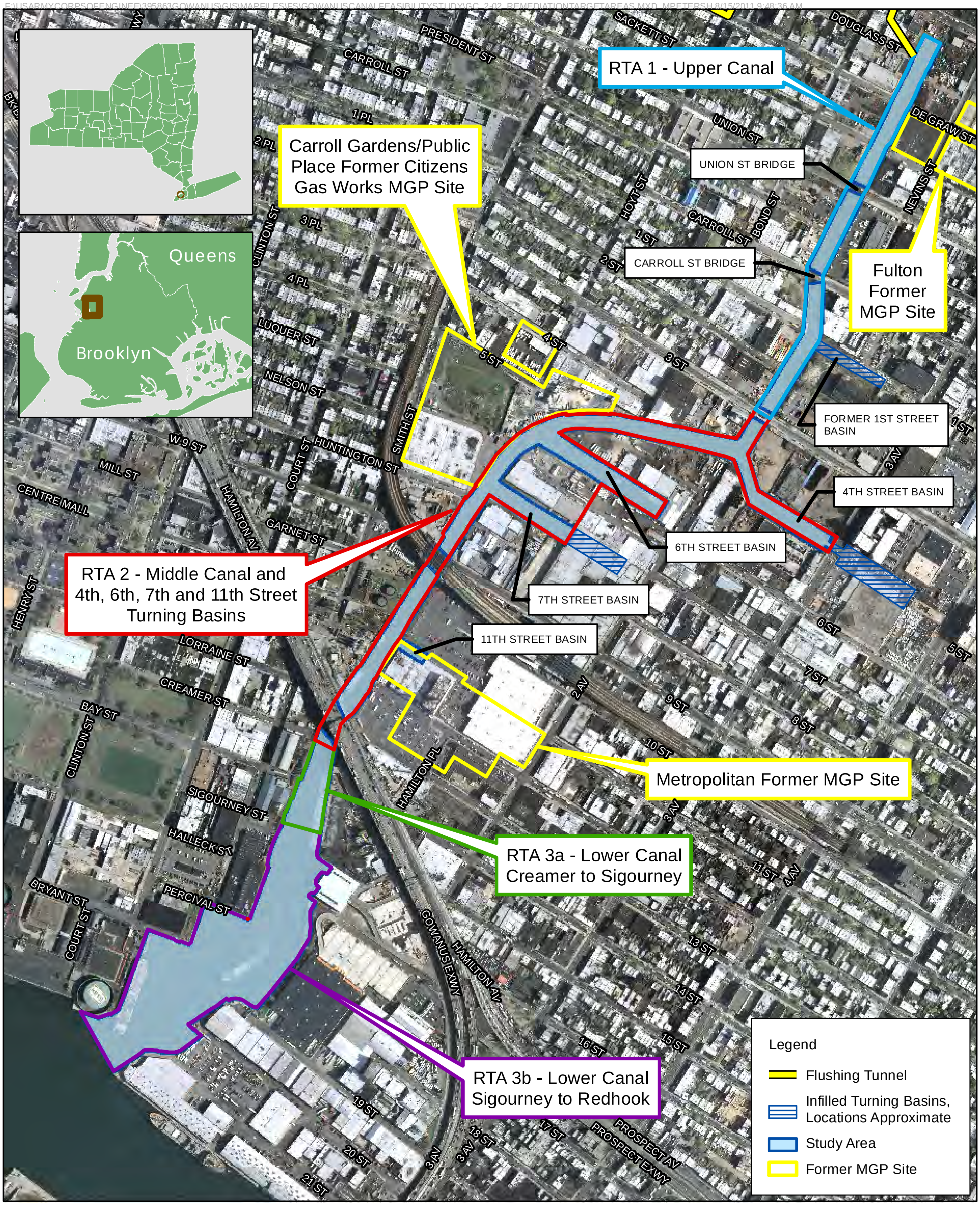

N

0 350 700
Feet

FIGURE 2-2
Remediation Target Areas
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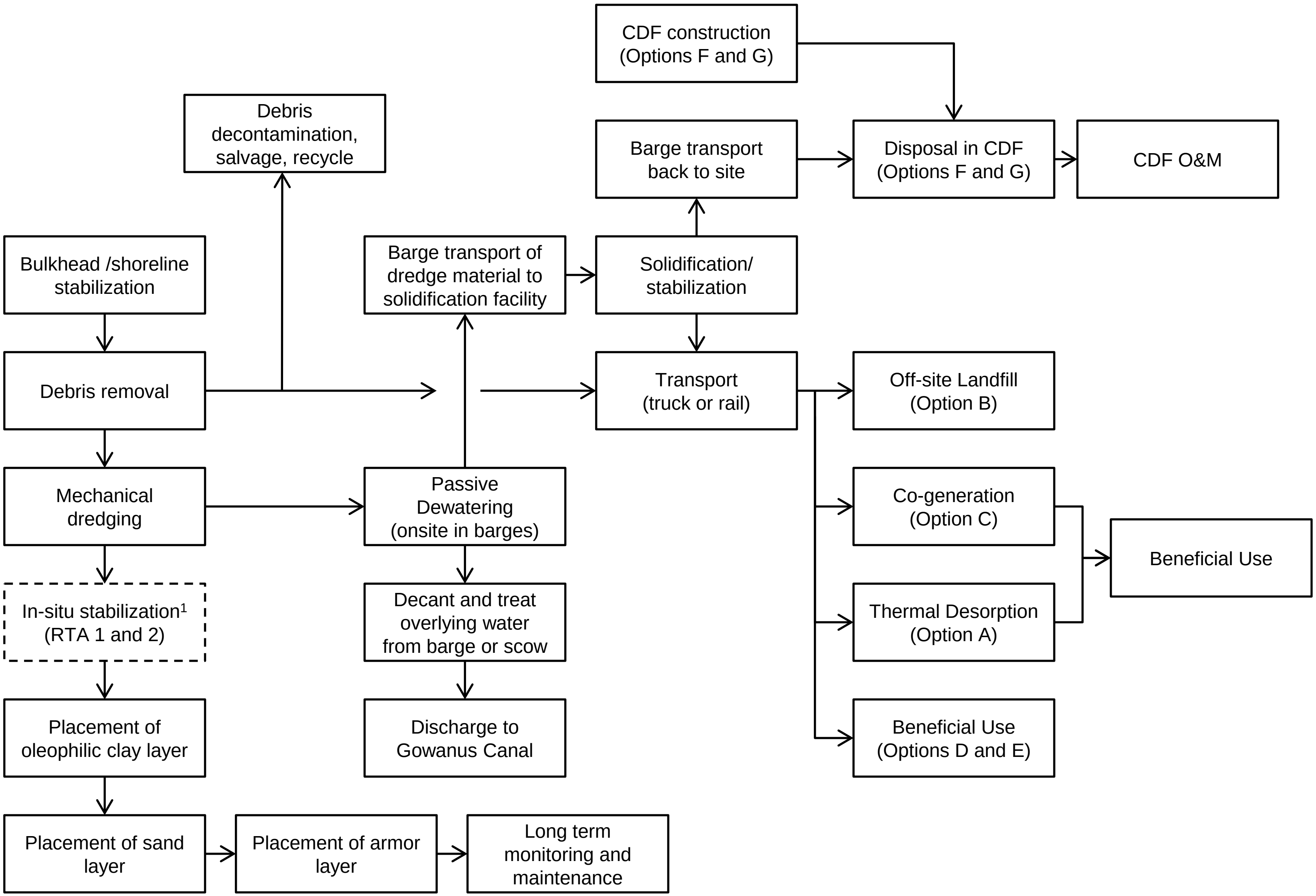

Notes:
1. In-situ stabilization step is the primary difference between Alternative 5 and Alternative 7.

FIGURE 4-1a
General Process Diagram for Remedial Alternatives 5 and 7 with Offsite Stabilization
Gowanus Canal Feasibility Study
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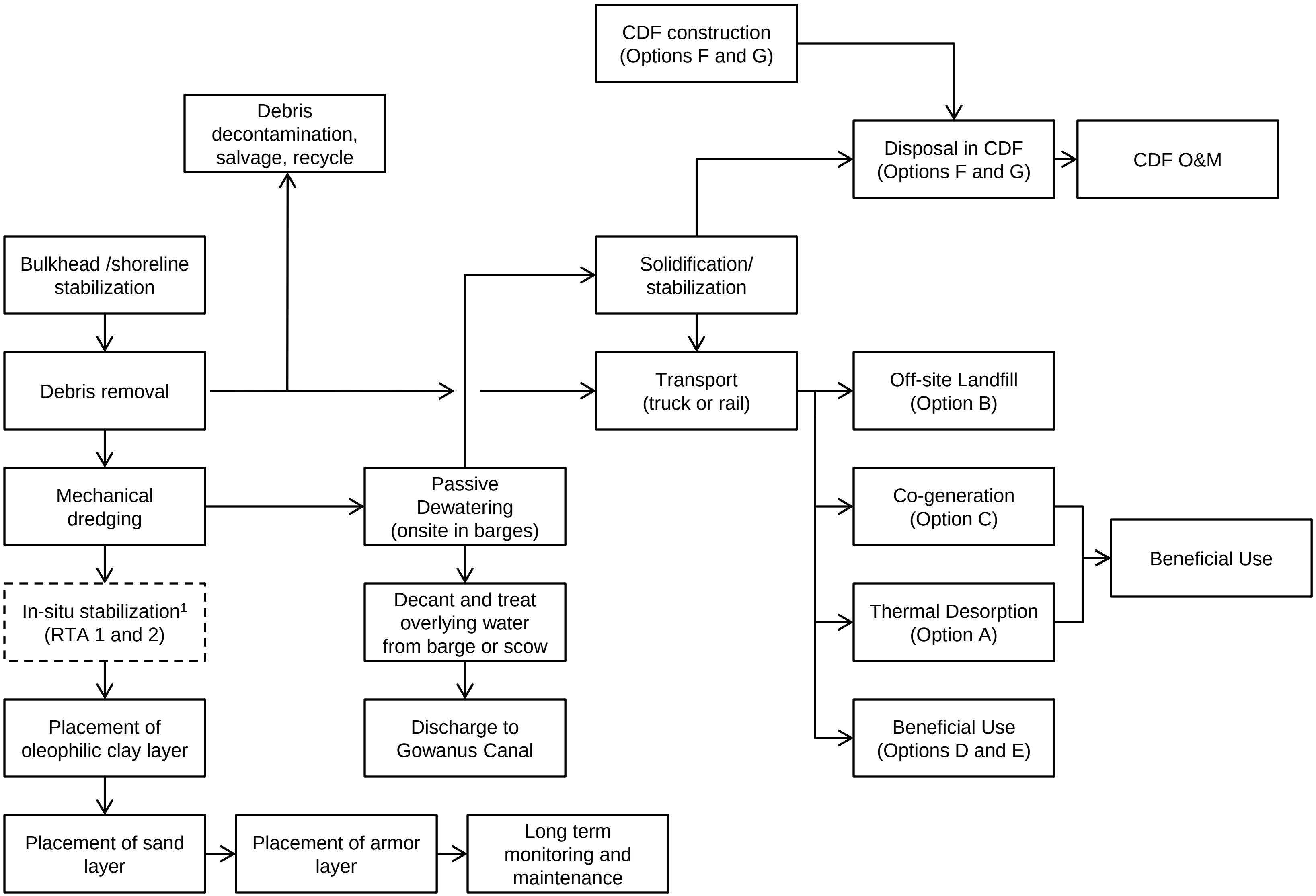

Notes:
1. In-situ stabilization step is the primary difference between Alternative 5 and Alternative 7.

FIGURE 4-1b
General Process Diagram for Remedial Alternatives 5 and 7 with Onsite Stabilization
Gowanus Canal Feasibility Study
Brooklyn, New York

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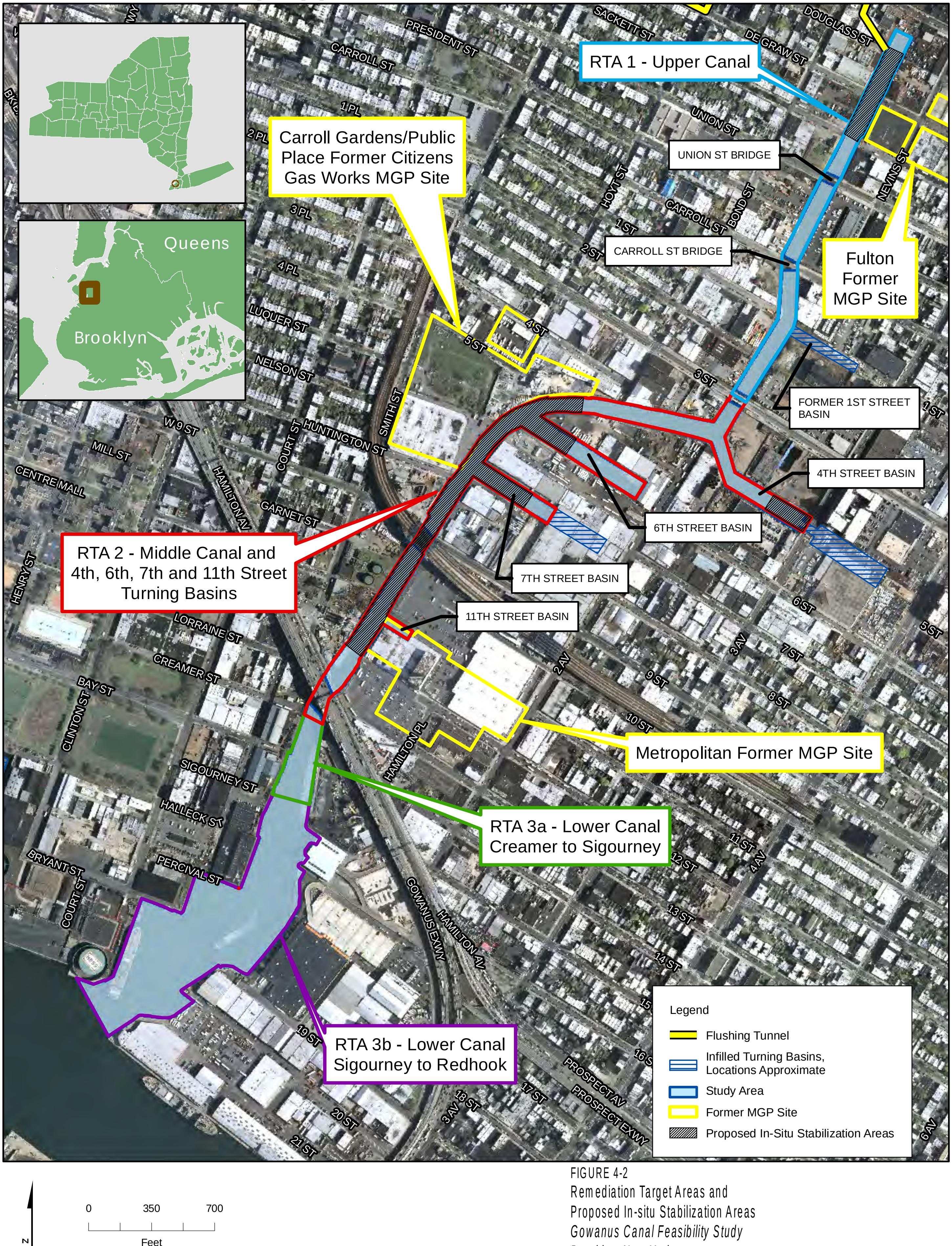

FIGURE 4-2
Remediation Target Areas and
Proposed In-situ Stabilization Areas
Gowanus Canal Feasibility Study
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