Focused Feasibility Study

for the

Former Brooklyn Borough Gas Works Site

prepared for

KEYSPAN ENERGY dba BROOKLYN UNION

May 2000

FOSTER WHEELER ENVIRONMENTAL CORPORATION

CERTIFICATION STATEMENT

This Feasibility Study has been prepared in accordance with the Order on Consent between KeySpan Energy d.b.a. Brooklyn Union and the State of New York Department of Environmental Conservation (Index #D2-001-94-12).

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Date

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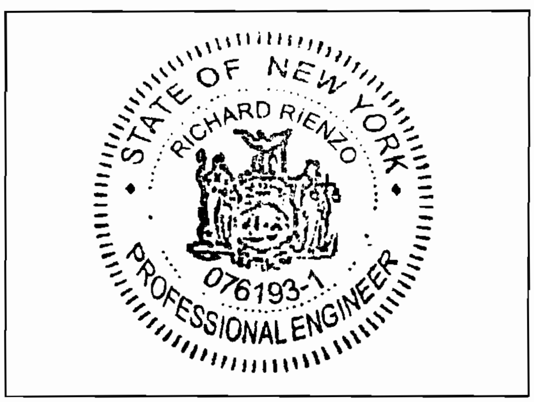

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LIST OF ACRONYMS

ACGs	Annual Guideline Concentrations
ARARs	Applicable and/or Relevant and Appropriate Requirements
BDAT	best demonstrated available technology
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene,and xylenes
BTU	British Thermal Unit
BU	Brooklyn Union Gas Company
CCLs	compacted clay liners
CEQR	City Environmental Quality Review
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COCs	Contaminants of Concern
COPCs	Chemicals of Potential Concern
CPI	corrugated plate interceptor
CWA	Clean Water Act
EEI	Edison Electric Institute
EPA	United States Environmental Protection Agency
EPRI	Electric Power Research Institute
FEMA	Federal Emergency Management Agency
FFS	Focused Feasibility Study
GCLS	geosynthetic clay liners
GMs	geomembrane liners
HSWA	Hazardous and Solid Waste Amendments
IRMs	Interim Remedial Measures
LDRs	Land Disposal Restrictions
LNAPL	light nonaqueous phase liquid
MCLs	maximum contaminant levels
MGP	Manufactured Gas Plant
MTA	Metropolitan Transit Authority
NCP	National Contingency Plan
NYCDOS	New York City Department of Sanitation
NYSDEC	New York State Department of Environmental Conservation
NYSEG	New York State Electric and Gas
OSWER	Office of Solid Waste and Emergency Response
PAHs	polycyclic aromatic hydrocarbons
PCBs	polychlorinated biphenyls
POTW	Public Owned Treatment Works
PRGs	Preliminary Remediation Goals
RA	Risk Assessment
RAOs	Remedial Action Objectives
RBCs	Risk-based cleanup levels
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation

LIST OF ACRONYMS (Cont'd)

RME	Reasonable Maximum Exposure
ROD	Record of Decision
ROW	Right-of-Way
SCGs	Standards, Criteria, and Guidelines
SEQRA	State Environmental Quality Review Act
SPDES	State Pollution Discharge Elimination System
SGCs	Short-Term Guideline Concentrations
SVOCs	Semivolatile Organic Compounds
TAGM	Technical and Administrative Guidance Memorandum
TBC	To Be Considered
TC	Toxicity Characteristic
TCLP	Toxicity Characteristic Leaching Procedure
TI	Technical Impracticability
ULURP	Uniform Land Use Review Procedure
USACE	United States Army Corps of Engineers
USTs	underground storage tanks
UTSs	Universal Treatment Standards
VOCs	volatile organic compounds

EXECUTIVE SUMMARY

This Focused Feasibility Study (FFS) report has been prepared in accordance with the terms of the Consent Order, Index No. D2-001-94-12, that Brooklyn Union Gas Company (BU) signed with the New York State Department of Environmental Conservation (NYSDEC) regarding the former Brooklyn Borough Gas Works property. The property is located between Neptune Avenue and Shore Parkway, just north of Coney Island in Brooklyn, New York. According to the Consent Order (§IV ¶A), cleanup objectives and cleanup goals are to be developed as part of the FFS, based on the findings of a site-specific and use-specific risk assessment. These objectives and goals are to be used for the purpose of selecting appropriate response measures that will allow the site to be used for the purposes identified in the FFS.

The NYSDEC Consent Order requires completion of this FFS in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) [42 USC 9601 et seq.], as amended, the National Contingency Plan (NCP) of March 8, 1990 [40 CFR Part 300], the EPA guidance document entitled "Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA," (USEPAa, 1988) and other applicable guidance, such as the NYSDEC Technical and Administrative Guidance Manual for the Selection of Remedial Actions at Inactive Hazardous Waste Sites (TAGM 4030). These requirements and guidance documents prescribe a step-wise approach to the identification, evaluation, comparison and recommendation of remedial alternatives. This approach anticipates consideration of preliminary remediation goals (PRGs), which stem from cleanup criteria published by agencies, in the development of remedial alternatives. This FFS differs from a typical feasibility study by considering site-specific and use-specific risk-based cleanup levels (RBCs) instead of published PRGs. The Consent Order explicitly allows the use of RBCs.

To calculate protective RBCs, the Consent Order requires consideration of different exposure scenarios to contaminants present on-site. These exposure scenarios are intended to be consistent with the end use of the site as identified in the FFS. As such, the step-wise manner used typically in the remedial alternative development focuses towards a protective end-use of the site. Specifically, remedial alternatives address the preference to reduce contaminant concentrations to levels consistent with calculated RBCs while controlling the exposure pathways that yield elevated or unacceptable risks. Reduction of contaminant concentrations and control of exposure pathways are key components of the desired site end use: brownfield development.

E.1 Brownfield Approach

A brownfield may be defined as an abandoned, idled, or under-used industrial or commercial facility or site that has actual or perceived contamination and potential for reuse or redevelopment. Both the EPA and NYSDEC have programs and initiatives in place that are designed to encourage and empower states, communities, owners and other stakeholders in economic redevelopment to effectively work together in the investigation, remediation, and redevelopment of brownfields.

Brownfield development has a high probability for success at the former Brooklyn Borough Gas Works site due its desirable location, availability of space, and the current lack of commercial/retail establishments in the area relative to population density. The redeveloped site would include one or several buildings with room for several potential commercial retail tenants, parking areas, and improved access to both Neptune and Shell Avenues, among other utility and landscape improvements. BU is currently negotiating for the redevelopment of the site for commercial/retail use after implementation of approved remedial measures. At the core of these negotiations is a long-term agreement that has the property owner responsible for operation and maintenance of remedial systems; control of site use, improvements and construction; and implementation of institutional controls.

E.2 FFS Approach

The former Brooklyn Borough Gas Works site has been the subject of investigations, risk assessments, and interim remedial measures (IRMs). With NYSDEC acceptance of the Final Remedial Investigation (RI) and Baseline Risk Assessment (RA), BU is required to submit a FFS for mitigation of site risks in conjunction with redevelopment activities. The Consent Order governing project activities establishes a risk-based framework for development and execution of remedies as long as acceptable remedial action objectives (RAOs) are identified and met.

To safely and effectively use the site again as required under the Consent Order, BU must mitigate identified risks associated with health and environmental hazards that may exist or may arise in the future. With brownfield development as the desired endpoint for this site, hazards and risks must be mitigated without precluding the construction and viability of planned establishments. This FFS balances the objectives of the risk reduction measures mandated by the Consent Order with the long-term beneficial reuse plans for the site by:

- Preferentially considering proven technologies and constructable solutions which have demonstrated effectiveness and reliability at other similar sites over the long-term;
- Avoiding unproven or innovative technologies and remedial measures with protracted testing or implementation schedules which could affect the success of brownfield development negotiations;
- Using a range of calculated site-specific RBCs to establish acceptable cleanup criteria or risk reduction measures appropriate for the site and future land use plans;
- Developing relatively few remedial alternatives focused on meeting the RAOs with consideration of No Action as a baseline for comparison;
- Eliminating the need for discrete IRMs across the site by executing specified remedial measures on a fast-track basis which, in turn, expedites the conversion of the site from a brownfield to a viable commercial enterprise; and
- Following TAGM 4030 to provide a sound decision, with minor adjustments to focus feasibility evaluations and to accommodate the risk-based approach stipulated in the Consent Order.

E.3 Summary of Remedial Investigation

The RI Report was prepared in 1997 by Ecology and Environment (E&E, 1997). The site has been investigated in several phases since 1984, including preliminary and voluntary assessments, as well as the RI. In addition, two IRMs have already occurred to address specific health and environmental hazard concerns. The RI report (E&E, 1997) concluded the following:

- The soils and groundwater at the site contain various chemical constituents related to the gas manufacturing process that occurred previously at the site.
- The extent of distribution of these chemical constituents involves large portions of property.
- The presence of some of the observed contamination, especially along the northern boundary of the site, appears to be due to off-site sources.
- Of the more than 50 detected chemicals, principal chemical constituents were selected based upon their association with manufactured gas plant (MGP) feedstocks, by-products, and wastes; frequency of detection; observed concentrations; trends in spatial distribution; and environmental significance (i.e., toxicity, potential to bioaccumulate, persistence, and mobility potential). The principal chemical constituents were: polycyclic aromatic hydrocarbons (PAHs), benzene, toluene, ethylbenzene, and xylenes (BTEX), styrene, PCBs, total cyanide, arsenic, chromium, copper, lead, manganese, mercury, nickel, and zinc.

- The site is generally underlain by coal tar (typically PAHs) deposits that occur primarily at a depth of 4 to 12 feet bgs across the site, although material was observed from the surface to a depth of 172 feet bgs in one deep well (DW-04) on the western side of the site. BTEX and styrene were among the volatile organics detected.
- Inorganic constituents included lead, chromium, and arsenic. These appear to be associated with the industrial activity that has occurred at the site and its proximity to a railroad yard and a major roadway arterial. The distribution of inorganic chemicals generally follows that of the organic chemicals.
- Several potential off-site sources may contribute to the chemical constituents found at the former Brooklyn Borough Gas Works site. These sources include the Shore Parkway, which borders the site to the north; the train yard to the north; and an unknown source across the MTA ROW to the northwest. The observation of PCBs in soil explained by the former natural gas distribution gate station in the middle of the site that operated from 1960 to approximately 1979.
- Groundwater under the site has measurable levels of various chemical constituents due to the deposition of these chemicals at depth. The groundwater in this area is not used as a potable water source. The creek water contains elevated levels of organics and inorganic substances, some of which may be site-related. Although the site may contribute chemical constituents to the creek, there are other significant sources (e.g., outfalls or seeps) to the creek that occur upstream (to the east of the site).
- Free product of varying viscosities was found throughout the site. Consultants working at the site also observed oil floating in wells and in soil borings. These appear to be several different oils from different sources associated with the MGP processes.
- Observations of subsurface soils excavated during numerous test pit and borehole installations indicate that the horizontal limits of subsurface coal tar infiltration are not bounded by the current property line. Data suggest that there is an off-site petroleum hydrocarbon source at the northwest corner and total cyanide was detected along the north-central perimeter of the site. Previous studies have shown the highest concentrations of lead and arsenic occurred at the site perimeter. Also, low concentrations of PCBs have been found along the western site perimeter and may be due to the activity along the MTA ROW.
- A discontinuous clay/peat/silt layer underlying the fill appears to be acting as a vertical hydraulic barrier, inhibiting, but not necessarily stopping, the downward migration of organic constituents.
- Several wooden structures extending at least 25 feet inland support the wooden bulkhead. The exact numbers, consistency, and integrity of these structures are unknown. The bulkhead appears to be inhibiting, and perhaps preventing, large-scale migration of site constituents into the creek.
- Hydrogeologic behavior observed to date suggests that light nonaqueous phase liquid (LNAPL) is preferentially directed to the central part of the site, and small amounts of it seep into the creek along the southwest-central shore of the site.
- The lower concentrations of metals in the filtered samples collected during the June 1997 Phase VI groundwater sampling event indicate that the metal concentrations are largely associated with the suspended particulates. Filtering the groundwater samples effectively lowered the turbidity levels created by the suspended particulates.

E.4 Previous Interim Remedial Measures

Two IRMs were conducted previously at the site. First, an IRM to mitigate the release of LNAPL from the seep along the Coney Island Creek was evaluated, designed and constructed from July to November 1994 as follows:

- Installation of inland recovery wells
- Installation of a hard boom and end connections in Coney Island Creek
- Installation of LNAPL skimmer system and hookup of oil collection system

The IRM will continue to be in operation until the site is remediated.

In October 1997, a second IRM was conducted to mitigate high concentrations of lead in surface soils. This action removed the highest levels of lead contamination on the site, by removing the top 1 foot of soil from about 4 acres on the western portion of the site. This included the removal and proper disposal of approximately 250 tons of nonhazardous soil and over 1500 tons of hazardous soil. The IRM achieved its goal of removing the most highly lead-contaminated soil that was not simultaneously contaminated with high levels of coal tar.

E.5 Summary of Baseline Risk Assessment

A site-specific and use-specific RA was prepared based on current contemporary data from the RI report. The scope of the risk assessment was limited to evaluating exposure to chemicals in the upland portion of the site from the mean high water mark along Coney Island Creek, shoreward (§II ¶C of the Consent Order). The assessment considered the potential for adverse risks posed from current land use, and in the future if the site is reused and no remedial action occurs.

Under current site conditions (undeveloped, uncontrolled), the calculated estimates of excess potential cancer risk for each of the evaluated exposure scenarios (including the Reasonable Maximum Exposure [RME] and Average exposure cases) do not indicate significant risk to off-site human receptors. Only in the RME exposure for site workers does the current risk or hazard exceed unacceptable levels. Under future site reuse as a commercial/retail configuration, the calculated estimates of excess potential cancer for the evaluated exposure scenarios only exceed the minimal level of significance under RME exposure cases for potential noncarcinogenic effects to a construction worker performing uncontrolled excavation into the subsurface soil.

While there may be exposure to plants and wildlife generally at the site, there has never been any evidence of animal kills, nor is there any now. There may be some impacts to individual plant and wildlife species currently (for example, areas of sparse vegetation), but these impacts appear to be limited or non-existent. In the future, the redevelopment of the site will completely change its landscape and nature. This will eliminate or cover the surficial contamination, minimizing future ecological exposure.

E.6 Media of Concern

The findings of the various investigations were analyzed to define those environmental media that are of greatest concern due to the level of contamination and/or potential for risk to the public health and/or the environment. The following media are of concern:

Source Areas. While there are currently no classic waste or contaminant sources existing on the property, there are areas containing elevated concentrations of various organic chemical constituents on the property (that formerly received past leaks, spills, or other releases of coal tar or other by-products or waste). These areas themselves may act as secondary sources of these chemical constituents.

Soils. The investigations performed previously at the site show that soil, and especially subsurface soil, at the site is contaminated by substances common to the operations of MGP sites. Therefore, it is a medium of concern requiring appropriate management.

Air. Ambient air is not a medium of concern. Indoor air does not pose a potential incremental health risk; however, it is prudent to consider this medium as being of concern due to future commercial activities after brownfield development.

Groundwater. There is an LNAPL layer present in the groundwater and some product is released from the site into Coney Island Creek via a seep (which is currently under an IRM). Some action should be taken to permanently abate this release. Therefore, groundwater is a medium of concern.

Surface Water. This FFS will concentrate on controlling releases from the site to the creek.

E.7 Contaminants of Concern

Based on the findings of the RA, several chemicals were identified as being of concern because of the potential risks or hazards that they posed. These contaminants of concern (COCs) are:

PAHs. Based on the findings of the risk assessment (GEI/Atlantic, 1998) PAHs are a potential hazard with respect to health risk and form the major group of COCs.

Pesticides. Pesticide residues are most likely associated with historic area-wide pesticide applications that were common in the 1940s through the 1960s. Because of the persistence of these compounds in the environment, low levels are still detected at the site. The RA indicates that these low concentrations in subsurface soils may pose some risk to construction workers who may work on site in the future. For this reason, they were retained as soil COCs.

PCBs. PCBs were also retained as soil COCs because the RA indicated that there may be some risk to construction workers working on the site in the future.

Total Cyanide. The RI reported that total cyanide was detected in subsurface soils, primarily in the north central portion of the site. The cyanide-containing compound due to MGP residuals is ferric ferrocyanide ($Fe_4[Fe(CN)_6]_3$), also called Prussian Blue, which has very low toxicity. The RA did not find a significant health risk associated with total cyanide. Nevertheless, it was retained as a COC in order to ensure that the cumulative health risks from all of the COCs were within safe levels.

Arsenic. Although the RA did not find a significant health risk associated with arsenic, it also was retained as a soil COC to ensure that the cumulative health risks from all of the COCs were within safe levels.

Lead. Because of high concentrations in surface soil (E&E, 1997), lead also was retained as a COC.

E.8 Remedial Action Objectives

Risk-based RAOs have been developed for the purpose of evaluating the applicability of remedial technologies and the effectiveness of remedial alternatives. These objectives consist of media-specific goals for protecting human health and the environment and for meeting standards, criteria, and guidelines (SCGs) to the extent practicable in a cost-effective manner. RAOs are based on site-specific information including the nature and extent of site constituents, human and ecological risk assessment results, RBCs, existing site conditions, and future land use plans. RAOs typically focus on controlling ecological receptor (humans, wildlife, aquatic life) exposure to chemicals of concern via exposure routes such as dermal contact, ingestion, and inhalation, and on controlling the release of hazardous substances into the environment (groundwater, surface water, soils, and sediments).

Preliminary RAOs for the site have been established based on the nature and extent of contamination and the RA results. Protecting human health and the environment, technical feasibility, and practicability of achieving these goals were considered in their development. Consistent with §IV ¶D of the Consent

Order, future land use was also factored into the development of RAOs. The following four risk-based RAOs are deemed appropriate for site remediation:

- Control potential future exposures of construction workers to subsurface soil
- Control potential future indoor air exposure pathways
- Minimize the further degradation of the Coney Island Creek
- Facilitate expedited brownfield development

E.9 Identification and Screening of Technologies

In order to develop feasible alternatives that address RAOs for the former Brooklyn Borough Gas Works site, potentially applicable technologies were identified and screened. Technologies were categorized into general response actions. General response actions include no action, institutional controls, containment, source removal, treatment, and disposal. Each general response action considers the media of concern at the site, including soil, groundwater/NAPL, and air emissions. Consistent with the focused approach of this FFS as stipulated in the Consent Order, only proven processes and technologies were identified and screened within each general response action. Innovative, emerging, and unproven technologies, or those with extended implementation schedules were not considered. Table ES-1 presents the results of the technology screening and lists the potentially applicable technologies and process options retained for alternative development.

E.10 Development, Evaluation, and Comparison of Remedial Alternatives

Remedial alternatives were developed by combining the technologies listed in Table ES-1. The No Action alternative was included as a baseline for comparing other alternatives. Assembling alternatives required an assessment and understanding of significant differences between technologies. By evaluating the differences between technologies and their relative contribution to risk-based brownfield development, it was possible to select the best candidates for alternative evaluation, comparison, and cost estimating. The effect of differences can be assessed through sensitivity analyses or addressed during detailed remedial design, as appropriate.

The significant differences between the technologies led to the following conclusions related to alternative development:

- Excavation of site soils to RBC levels versus excavation of coal tar source areas should be evaluated in separate alternatives.
- NAPL/groundwater treatment system effluent discharge to the POTW versus discharge to the Coney Island Creek should be evaluated in separate alternatives.
- Evaluation of the No Action alternative is a statutory requirement; therefore, a separate alternative for No Action is required.
- All other recommended technologies represent elements common to all alternatives, except No Action.

In addition to the No Action alternative, four additional alternatives were assembled by various combinations of the options being considered:

Alternative #	Excavation	Discharge	Remaining Technology Elements
1	No Action is a statutory requirement.		
2	RBCs	Coney Island Creek	✓
3	RBCs	POTW	✓
4	Coal Tar Source Areas	Coney Island Creek	✓
5	Coal Tar Source Areas	POTW	✓

Alternative 1 is the statutory No Action alternative, providing a basis of comparison for all other alternatives. Alternative 2 includes excavation of site soils with contaminant levels in excess of RBC concentrations, installation of a vertical barrier wall around the site, construction of a low permeability cover system across the site, placement of a clean fill work zone on top of the cover system stabilization and restoration of the Coney Island Creek bank, collection and treatment of NAPL, institutional controls, and discharge of treatment system effluent to the Coney Island Creek. Alternative 3 is the same as Alternative 2 except treatment system effluent is discharged to the POTW. Alternative 4 is the same as Alternative 2 except excavation is limited to coal tar source areas identified during the RI. Alternative 5 is the same as Alternative 4 except treatment system effluent is discharged to the POTW.

The following sections present a brief comparison of the five alternatives using the seven criteria required by NYSDEC to evaluate remedial alternatives. Since many of the elements within Alternatives 2 through 5 are similar, comparisons focus on the significant differences resulting from the two excavation and the two discharge options.

E.10.1 Compliance with New York SCGs

Chemical-specific SCGs. The No Action alternative does not comply with chemical-specific SCGs.

Alternatives 2 and 3 can achieve compliance with applicable chemical-specific SCGs for soils by removal of contaminated materials with concentrations in excess of RBCs. Alternatives 4 and 5 do not achieve compliance with applicable chemical-specific SCGs for soils because concentrations of contaminants in excess of RBCs would remain on-site after excavation of coal tar source areas.

For Alternatives 2, 3, 4, and 5, contaminants in groundwater would persist. This is acceptable because the groundwater has the characteristics suitable for designation as GSB saline.

Action-specific SCGs. The only action-specific SCG associated with Alternative 1 relates to issuance of a deed notice or deed restriction on the property. Alternatives 2, 3, 4, and 5 can achieve compliance with applicable action-specific SCGs equally.

Location-specific SCGs. There are no location-specific SCGs triggered by the No Action Alternative. Alternatives 2, 3, 4, and 5 can achieve compliance with applicable location-specific SCGs equally.

E.10.2 Overall Protection of Human Health and the Environment

Use of the site after remediation. There would be no changes to the current idle use of the site under the No Action alternative. After remediation under Alternatives 2, 3, 4, and 5, the site will be used for commercial development.

Potential for exposure to contaminants after remediation. There is some potential for exposure to contaminants under the No Action alternative. Alternatives 2, 3, 4, and 5 control exposure to contaminants equally by use of a cover system, installation of a perimeter barrier wall, addition of fill across the site with overlying structures and asphalt pavement, and venting of vapors from the waste matrix through carbon treatment systems.

Magnitude of residual risks to human health and the environment after remediation. Unacceptable risks to unprotected construction workers would persist at the site by implementing the No Action alternative. Residual contaminants would present nominal ecological risks. Any seepage of contaminated groundwater into the Coney Island Creek would present some level of risk to inhabitants of the creek.

By controlling the exposure pathways to subsurface contaminants and controlling the release of volatile emissions through passive venting systems, residual risks to human health and the environment after implementation of Alternatives 2, 3, 4, and 5 are reduced equally. The four alternatives meet all RAOs equally.

E.10.3 Short-Term Effectiveness

Protection of workers and the community during remedial actions. Remedial actions are not planned for Alternative 1; therefore, there is no protection afforded workers or the community during the short-term other than existing security measures. The existing IRM hard boom and skimmer would continue to capture seeping contaminants and minimize their release into the creek.

Truck traffic poses greater concern for Alternatives 2 and 3 relative to Alternatives 4 and 5 due to the additional volume of excavated material to be transported for off-site disposal. While the traffic would not vary significantly on a daily basis, it would persist for approximately four additional months under Alternatives 2 and 3. A traffic control plan would be implemented as part of any selected remedial alternative.

Environmental impacts. Environmental impacts during the short-term are considered negligible for Alternative 1. Alternatives 2, 3, 4, and 5 address erosion, dust control, and short-term adverse effects to the Coney Island Creek; due to the significant additional excavation associated with Alternatives 2 and 3, there is an increased likelihood of environmental impacts as compared with Alternatives 4 and 5.

Time to implement the remedy. The No Action alternative can be implemented immediately. For Alternatives 2 and 3, 20 to 24 months are estimated for implementation of remedial measures. The duration of Alternatives 4 and 5 is approximately four months shorter due to the decreased quantity of material subject to excavation, materials handling, off-site transport, and disposal.

E.10.4 Long-Term Effectiveness and Permanence

Use of on-site versus off-site remedies. There are no remedies with the No Action alternative. Alternatives 2, 3, 4, and 5 rely on on-site and off-site remedies, with long-term protection provided by surface and perimeter barriers. Alternatives 2 and 3 result in off-site transport of approximately 85,000 cubic yards of contaminated material for recycling or treatment. Approximately 22,000 cubic yards of contaminated material would be shipped to off-site facilities under Alternatives 4 and 5.

Use of treatment versus land disposal. There is no treatment with No Action and contaminants remain uncontrolled in site soils and groundwater. Alternatives 2, 3, 4, and 5 use treatment and land disposal for contaminants. Alternatives 4 and 5 would result in on-site land disposal of more residual contaminants than Alternatives 2 and 3. The residual mass of contaminants left under Alternatives 4 and 5, which would pose risks to unprotected construction workers, would be a relatively small fraction of the most concentrated contaminant mass currently in the upper six feet of site soils.

Permanence of the remedial alternative. There is no permanent remedy with No Action. Alternatives 2, 3, 4, and 5 provide permanent remedies for the site equally.

Expected lifetime or duration of the remedial alternative. No Action can continue indefinitely. The remedial components in Alternatives 2, 3, 4, and 5 would have an expected lifetime beyond the 30-year evaluation period used by EPA when remedial actions are evaluated.

Quantity and nature of waste or residual left on-site after remediation. There is no change in the quantity or nature of waste left on-site if No Action is taken. RBC-excavation under Alternatives 2 and 3 would remove the bulk of waste in the unsaturated zone and reduce significant health risks to unprotected construction workers. While a large percentage of contaminant mass would be removed from the site under Alternatives 4 and 5, residual concentrations of contaminants would pose risks to unprotected construction workers if they penetrate the cover system and conduct work without proper oversight or adherence to a site health and safety plan.

Residual contaminants, along with isolated occurrences of coal tar, would be present in site groundwater after implementation of Alternatives 2, 3, 4, or 5. Concentrations of contaminants would be expected to decline over time due to natural attenuation and the collection and treatment of NAPL.

Adequacy and reliability of controls. For Alternative 1, fences and security guards provide adequate protection against trespassers. Routine maintenance of the hard boom, skimmer, and other IRM components can provide adequate and reliable collection of seeping contaminants. The technologies proposed for Alternatives 2, 3, 4, and 5 are proven and used routinely as reliable measures to control MGP-related wastes.

E.10.5 Reduction of Toxicity, Mobility, and Volume

Quantity of waste destroyed or treated. There is no waste destroyed or treated with No Action. Approximately 85,000 cubic yards of RBC-excavated soil and coal tar sources would be excavated from the site and transported for treatment under Alternatives 2 and 3. This quantity would be reduced to approximately 22,000 cubic yards for coal tar source area removal only under Alternatives 4 and 5. The recycling and thermal desorption technologies considered for the waste in all four alternatives either destroy the waste material or bind it in a new matrix suitable for commercial applications.

Approximately 72,000 gallons per day of contaminated groundwater/NAPL would be removed, treated, and discharged under Alternatives 2, 3, 4, and 5. The treatment plant provides reductions in contaminant concentrations to meet preliminary creek discharge criteria under Alternatives 2 and 4 and preliminary POTW discharge requirements under Alternatives 3 and 5.

Management of untreated wastes. Untreated wastes remain uncontrolled in site soils and groundwater under the No Action alternative. Contaminants may impact into the Coney Island Creek in areas where the IRM systems are not operating if No Action is implemented.

For Alternatives 2, 3, 4, and 5, untreated wastes would remain on-site, encapsulated within a multi-layer cover system and a perimeter barrier wall. The same management approach for untreated waste is used for the four alternatives.

Reduction in contaminant mobility by treatment or containment. There is no reduction in contaminant mobility with No Action. The recycling, treatment, and containment technologies described for Alternatives 2, 3, 4, and 5 either treat contaminants, convert them into products with commercial application, or prevent their movement beyond defined barriers. The same technologies to reduce contaminant mobility are used in the four alternatives.

Irreversibility of treatment. There is no treatment in Alternative 1. Recycling and thermal desorption technologies considered for Alternatives 2, 3, 4, and 5 provide essentially irreversible treatment of soil and coal tar wastes. Groundwater and NAPL treatment technologies in the four alternatives are also irreversible. The use of a low permeability geomembrane liner in the cover system common to the four alternatives minimizes the likelihood of cross-contamination of clean overburden soils from contaminated subsurface soils.

Type and quantity of treatment residuals. There is no treatment, and therefore no residuals, with No Action. Treatment residuals from off-site recycling or thermal desorption vendors used as part of Alternatives 2, 3, 4, and 5 are expected to be materials suitable for commercial application. Residuals from natural attenuation processes are generally less toxic compounds, carbon dioxide, methane, or water. The on-site treatment plant considered in the four alternatives would generate secondary sludge and oil residuals, as well as solid wastes such as filters, seals, tubes, and other parts. Activated carbon from the treatment plant and the gas venting system would be regenerated off-site for future use.

E.10.6 Implementability

Ability to construct technologies. Maintaining fences and the IRM systems under Alternative 1 can be accomplished readily. For Alternatives 2, 3, 4, and 5, work along the Coney Island Creek presents the greatest construction challenge. Constructable solutions have been developed conceptually for the remedial components of the four alternatives.

Reliability of technologies. For Alternative 1, security and fences are reliable deterrents to trespassers. The IRM system at the groundwater seep has been operating reliably and can continue to do so with simple, routine maintenance.

For Alternatives 2, 3, 4, and 5, the remedial systems are comprised of reliable and proven technologies which can be designed to perform for several years as long as routine maintenance is performed.

Potential delays resulting from technologies. Delays are not anticipated for any of the activities or technologies considered for the five alternatives.

Need to undertake additional remedial action. No Action does not provide any risk reduction and does not meet RAOs. Therefore, some additional remedial action is required. Additional on-site remedial action would not be required after implementation of Alternatives 2, 3, 4, and 5.

Permit approvals. There are no permits required as part of No Action. Pursuant to 6 NYCRR 375-1.7 and the Consent Order, all on-site remedial activities for Alternatives 2, 3, 4, and 5 need only comply with substantive technical requirements of applicable state and local city permits; the permits themselves would not have to be obtained. At the federal level, work along the Coney Island Creek and disturbance of tidal wetlands as part of the four alternatives would trigger United States Army Corps of Engineers (USACE) permit requirements.

Coordination with other agencies. Coordination with NYSDEC, New York State Department of Health (NYSDOH), New York City Department of Environmental Protection (NYCDEP), local city officials, and the U.S. Coast Guard would be necessary for all five alternatives. USACE involvement must be considered for tidal wetland and creek construction issues under Alternatives 2, 3, 4, and 5. Alternative 1 would require the least level of coordination under the No Action approach. More coordination with NYCDEP would be required for Alternatives 3 and 5 to permit, operate, and monitor the sewer connection to the POTW. Additional coordination with NYSDEC would be necessary with Alternatives 2 and 4 to permit and monitor discharge to the Coney Island Creek. The differences between permitting among Alternatives 2, 3, 4, and 5 are considered negligible.

Availability of technologies. The activities included as part of No Action are readily available. The technologies considered in Alternatives 2, 3, 4, and 5 are available and can be procured competitively.

Availability of necessary equipment and specialists. The activities and technologies required for all of the alternatives are not limited by the availability of special equipment or technicians.

E.10.7 Cost

Table ES-2 presents a summary of the estimated present worth costs for each of the five alternatives. The No Action alternative has the lowest estimated present worth, based on continuation of site security measures and O&M of IRM systems. The other four alternatives vary in estimated present worth from $26,440,000 for Alternative 4 to $39,147,000 for Alternative 3. The differences in cost are attributable to capital and O&M costs:

- The incremental cost to excavate soils with contaminant concentrations in excess of RBC concentrations relative to excavation of coal tar sources is approximately $11.2 million
- The difference between discharge to the POTW and discharge to the Coney Island Creek is approximately $81,000 annually, representing a difference in estimated present worth of approximately $1.5 million over 30 years

E.11 Selection of Recommended Remedial Action Alternative

The comparative analysis of remedial alternatives focused on significant differences between the four alternatives other than No Action. Alternative 1, No Action, failed to meet RAOs and did not permit brownfield development of the site. Therefore, Alternative 1 was eliminated from further consideration as a viable remedial action alternative.

Alternatives 2, 3, 4, and 5 each met RAOs; however, significant differences existed between the alternatives. The differences between the excavation methodologies for the four alternatives focused on:

Residual contaminant concentrations in excess of RBCs in unsaturated zone soils. Based on a cursory evaluation, Alternatives 2 and 3 would be preferred relative to Alternatives 4 and 5 because soils with contaminant concentrations in excess of RBCs are removed from the unsaturated zone. This removal to RBCs effectively meets SCGs for site soils; SCGs for groundwater in all four alternatives are not applicable because the groundwater has the characteristics suitable for designation as GSB saline. Since there is no expected beneficial use from the groundwater and it presents an acceptable human health risk, the GSB saline designation is appropriate. Alternatives 4 and 5 strive to remove the most significant sources of unsaturated zone contaminants and most of the contaminant mass; however, the residual concentrations remaining in the soil, which are a fraction of contaminant mass, present risks to unprotected construction workers. The installation of a multi-layer cover system across the site minimizes concerns relative to worker exposure, effectively negating the differences between the two excavation options as they relate to the risk-based approach for site remediation. Therefore, there is no clear advantage to implementing any of the four alternatives relative to the residual risks posed by buried and contained waste materials.

Short-term impacts. Alternatives 4 and 5 are preferred relative to Alternatives 2 and 3 due to less disturbance of the site, fewer trucks and related traffic, a shorter overall duration to complete remedial actions, and faster redevelopment of the site with associated economic benefits.

Cost-effectiveness. Alternatives 4 and 5 are preferred relative to Alternatives 2 and 3 due to the significant cost savings achieved by excavating coal tar source areas and not excavating the site to RBCs. The average estimated savings of $11.2 million between the different excavation options can be justified based on the ability of the four remedial alternatives to achieve RAOs. In effect, there is no benefit obtained by the unprotected construction worker if $11.2 million is expended to remove RBC soils other than coal tar sources from the site. With institutional controls in place and use of a clean fill zone above the cover system, future workers will either conduct their activities in clean soil or wear appropriate protection in accordance with a health and safety plan when breaches of the cover system into the site soils are required.

After considering the key issues of the excavation option, Alternatives 2 and 3 were eliminated from further consideration. As such, Alternatives 4 and 5 remained viable for further evaluation. To select a preferred alternative between the two, consideration of the discharge option factors included:

Coordination with agencies. The NYSDEC and USACE would have some level of involvement in the discharge of treated effluent into the Coney Island Creek. NYSDEC would have primary jurisdiction over the matter since they would be responsible for issuance of a SPDES permit. Discharge to the POTW requires approvals and coordination with the NYCDEP. Preliminary assessments of the options indicate that both discharge permits can be obtained with a similar level of effort. There is some question as to the ability of the Coney Island POTW to accept wastewater with a high chloride content, which could result in the need for additional treatment units to reduce levels suitable for facility acceptance. In addition to regular reporting required by NYSDEC and NYCDEP, the POTW option will also require regular service meter readings and payment of service fees. The level of coordination required for either discharge option does not present a clear advantage to either Alternative 4 or 5.

Cost-effectiveness. Discharge to the Coney Island Creek is preferred relative to the POTW discharge on the basis of cost-effectiveness. An estimated $81,000 each year, which represents a present worth of approximately $1.5 million over 30 years, can be saved by a direct discharge from the treatment plant to the creek.

On the basis of these evaluations, Alternative 4 was the recommended remedial action alternative. The alternative includes:

- Excavation of coal tar source areas down to the groundwater table. The technical difficulties of excavating coal tar sources and residual contaminants below the groundwater table makes such a cleanup effort impractical.
- Performing coal tar source area excavation, consolidation, and blending activities under temporary enclosures, as appropriate, to control the releases of volatile emissions and odors.
- Off-site transport and recycling of blended source area materials at a permitted facility, such as a cement kiln, thermal desorber, asphalt plant, utility boiler, or brick manufacturer.
- Installation of a protective coffer dam along the Coney Island Creek perimeter to minimize potential releases from the site during creek bank excavation and restoration efforts.
- Use of a temporary construction enclosure along the creek bank when trenching or excavation activities may release significant volatile emissions or odors into the atmosphere.
- Installation of a perimeter barrier around the site to minimize the migration of NAPL from the site into the Coney Island Creek while diverting upgradient groundwater around this site to the Coney Island Creek.
- Removal of the existing wooden bulkhead and contaminated materials between the barrier wall and the coffer dam with subsequent construction of a stabilized creek bank.
- Installation of a NAPL collection trench along the interior the creek barrier wall section to capture migrating NAPL and reduce hydrostatic pressure exerted on the wall by tidally influenced fluctuating groundwater levels.
- Treatment of captured aqueous waste in a system designed to reduce contaminant concentrations such that treated effluent may be discharged to the Coney Island Creek.
- Use of a subsurface relieving platform constructed on piles to provide structural bearing capacity for a planned commercial development.
- Installation of a multi-component cover system to act as a low permeability barrier to minimize both infiltration and the potential for direct contact of workers with concentrations of residual contaminants in excess of RBCs.
- Passive venting of vapors, which may form under the cover system, using risers equipped with carbon adsorption canisters.
- Restoration of the Coney Island Creek bank to provide a 50-foot ecological buffer zone. Monitoring wells would be installed immediately outside of the barrier within the buffer zone to assess the long-term performance of the barrier wall.

- Use of institutional controls, such as notifications, deed restrictions, fencing, a health and safety plan, a contingency plan, and long-term monitoring, after implementation of remedial actions.

Alternative 4 meets RAOs at the lowest estimated present worth cost of the four alternatives, approximately $26.4 million. It includes institutional controls, containment, source area removal, and off-site treatment to effectively mitigate the principal risks posed by the site. Identified remedial actions are consistent with Brooklyn Union's plans for brownfield development and do not preclude the performance of future remedial actions in the Coney Island Creek.

Alternative 4 is protective of human health and the environment. The proposed actions achieve most SCGs and reduce risk as required by CERCLA and the NCP. Identified risk pathways of concern, including direct contact by unprotected construction workers and inhalation of indoor air in a planned commercial development, are addressed adequately by source removal, containment, and engineering controls. Additional source removal and engineering controls protect the Coney Island Creek from residual contaminants contained within the site.

Alternative 4 is effective, implementable, and reduces the toxicity, mobility, and volume of contaminants. Short-term control measures can be instituted to minimize adverse impacts to the community, workers, and the environment during remedial construction. Remedies provide long-term protection as demonstrated by use of the identified technologies at other similar sites. These technologies and remedies can be monitored and assessed over time to measure their integrity. Vendors, equipment, and materials are available for installation of identified controls and performance of off-site treatment efforts. The expertise needed to install and maintain remedial systems on-site is expected to be available for many years.

1.0 INTRODUCTION

This Focused Feasibility Study (FFS) report has been prepared in accordance with the terms of the Consent Order, Index No. D2-001-94-12, that Brooklyn Union Gas Company (BU) signed with the New York State Department of Environmental Conservation (NYSDEC) regarding the former Brooklyn Borough Gas Works property. The property is located between Neptune Avenue and Shore Parkway, just north of Coney Island in Brooklyn, New York. According to the Consent Order (§IV ¶A), cleanup objectives and cleanup goals are to be developed as part of the FFS, based on the findings of a site-specific and ·se-specific risk assessment. These objectives and goals are to be used for the purpose of selecting appropriate response measures that will allow the site to be used for the purposes identified in the FFS.

The feasibility study process is conducted in three phases: definition of remedial objectives and goals, alternative development, and evaluation of alternatives. Remedial objectives define the contaminants and media of concern, exposure pathways to be addressed, and propose numerical remediation goals that permit a range of alternatives to be developed. The purpose of the alternative development process is to identify a range of remedial measures that are appropriate for the site and its future use. The final stage of the feasibility study process is the evaluation of the alternatives against predetermined criteria that provide guidance for evaluating the technical effectiveness and cost of the alternatives, such that a preferred option can be selected.

1.1 Project Understanding

The NYSDEC Consent Order requires completion of this FFS in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) [42 USC 9601 et seq.], as amended, the National Contingency Plan (NCP) of March 8, 1990 [40 CFR Part 300], the EPA guidance document entitled "Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA," (USEPAa, 1988) and other applicable guidance, such as the NYSDEC Technical and Administrative Guidance Manual for the Selection of Remedial Actions at Inactive Hazardous Waste Sites (TAGM 4030). These requirements and guidance documents prescribe a step-wise approach to the identification, evaluation, comparison and recommendation of remedial alternatives. This approach anticipates consideration of preliminary remediation goals (PRGs), which stem from cleanup criteria published by agencies, in the development of remedial alternatives. This FFS differs from a typical feasibility study by considering site-specific and use-specific risk-based cleanup levels (RBCs) instead of published PRGs. The Consent Order endorses the use of RBCs.

To calculate protective RBCs, the Consent Order requires consideration of different exposure scenarios to contaminants present on-site. These exposure scenarios are intended to be consistent with the end use of the site as identified in the FFS. As such, the step-wise manner used typically in the remedial alternative development focuses towards a protective end-use of the site. Specifically, remedial alternatives address the preference to reduce contaminant concentrations to levels consistent with calculated RBCs while controlling the exposure pathways that yield elevated or unacceptable risks. Reduction of contaminant concentrations and control of exposure pathways are key components of the desired site end use: brownfield development.

1.1.1 Brownfield Approach

A brownfield may be defined as an abandoned, idled, or under-used industrial or commercial facility or site that has actual or perceived contamination and potential for reuse or redevelopment. Both the EPA and NYSDEC have programs and initiatives in place that are designed to encourage and empower states, communities, owners and other stakeholders in economic redevelopment to effectively work together in the investigation, remediation, and redevelopment of brownfields.

Inherent in the FFS process is consideration of important criteria for site development: schedule, aesthetics and economics. These criteria play a role in the identification, evaluation and selection of remedial measures for the site because environmental benefits must be integrated into the brownfield redevelopment.

The former Brooklyn Borough Gas Works site was the location of a facility that manufactured gas from coal. Manufacturing operations started in 1908 and discontinued in the 1950s; and while parts of the facility were used over a period of about 20 years, the majority of it was dismantled and demolished in the 1960s. The remaining gas storage facility was finally demolished in 1981. Since that time the manufacturing (western) portion of the site has been inactive with no improvements made to it. In the early 1970s, the area to the immediate east (of the manufacturing portion of the site) was covered with fill material from various sources and developed into two baseball fields in the late 1980s for use by the community. These fields were decommissioned in late 1996 and are no longer used (E&E, 1997).

The property is currently zoned M3 by the New York City of Department of City Planning (Map 28, 1990). This zoning permits heavy manufacturing used and certain commercial and retail uses.

During the remediation and redevelopment process for the site, BU has evaluated a variety of future land reuse options. These options represent a range of potential land use objectives. BU is currently negotiating for the redevelopment of the site for commercial/retail use after implementation of approved remedial measures. At the core of these negotiations is a long-term agreement that has the property owner responsible for operation and maintenance of remedial systems; control of site use, improvements and construction; and implementation of institutional controls.

Brownfield development has a high probability for success at the former Brooklyn Borough Gas Works site due its desirable location, availability of space, and the current lack of commercial/retail establishments in the area relative to population density. The redeveloped site would include one or several buildings with room for several potential commercial retail tenants, parking areas, and improved access to both Neptune and Shell Avenues, among other utility and landscape improvements. Figure 1-1 depicts a conceptual development plan for the site.

1.1.2 FFS Approach

The former Brooklyn Borough Gas Works site has been the subject of investigations, risk assessments, and interim remedial measures (IRMs). With NYSDEC acceptance of the Final Remedial Investigation (RI) and Baseline Risk Assessment (RA), BU is required to submit a FFS for mitigation of site risks in conjunction with redevelopment activities. The Consent Order governing project activities establishes a risk-based framework for development and execution of remedies as long as acceptable remedial action objectives (RAOs) are identified and met.

To safely and effectively use the site again as required under the Consent Order, BU must mitigate identified risks associated with health and environmental hazards that may exist or may arise in the future. With brownfield development as the desired endpoint for this site, hazards and risks must be mitigated without precluding the construction and viability of planned establishments. This FFS balances the objectives of the risk reduction measures mandated by the Consent Order with the long-term beneficial reuse plans for the site by:

- Preferentially considering proven technologies and constructable solutions which have demonstrated effectiveness and reliability at other similar sites over the long-term;
- Avoiding unproven or innovative technologies and remedial measures with protracted testing or implementation schedules which could affect the success of brownfield development negotiations;
- Using a range of calculated site-specific RBCs to establish acceptable cleanup criteria or risk reduction measures appropriate for the site and future land use plans;

- Developing relatively few remedial alternatives focused on meeting the RAOs with consideration of No Action as a baseline for comparison;
- Eliminating the need for discrete IRMs across the site by executing specified remedial measures on a fast-track basis which, in turn, expedites the conversion of the site from a brownfield to a viable commercial enterprise; and
- Following TAGM 4030 to provide a sound decision, with minor adjustments to focus feasibility evaluations and to accommodate the risk-based approach stipulated in the Consent Order.

1.2 Background Information

The RI Report was prepared in 1997 by Ecology and Environment (E&E, 1997). The RA Report was prepared by GEI/Atlantic and became final in 1998 (GEI/Atlantic, 1998). Based on these data and the current and future uses planned for the site and the surrounding area, it can be concluded that some action is required to stop further movement of contaminants from the site and to minimize potential health and environmental impacts. This section summarizes the findings of the reports and presents the risk-based cleanup objectives and goals to be used in the FFS.

1.2.1 Site Description and History

The site is bordered by the right-of-way (ROW) of the Shore Parkway and a New York Metropolitan Transit Authority (MTA) railyard to the north and west, and Coney Island Creek to the south and east. An overall location map is presented in Figure 1-2 and a site plan is depicted in Figure 1-3. The property owned by BU is approximately 16.4 acres in size. The area surrounding the property is a relatively flat, densely populated commercial/residential zone. The property is covered by vegetation, except for several concrete foundations of former gas holders, process vessels, tanks and buildings and various construction debris. Coney Island Creek borders the site, flowing into Gravesend Bay, which empties into Lower Bay and, ultimately, the Atlantic Ocean.

According to as-built drawings supplied by BU, Brooklyn Borough Gas began construction of the first generator at the facility in 1908. Over the next four years, additional parcels of land were added, the facility was enlarged, and its gas production capability increased. The available information suggests that the operation was most likely a carbureted-water gas plant.

In the 1930s, two large-capacity gas holders, a station metering house, two underground gas oil tanks, tar conditioners, tar seal pumps, and a tar separator were located in the western portion of the site. The main gas manufacturing operations were located in the central portion of the site and contained four generators, a coal storage yard and off-loading, pump rooms, booster and exhauster rooms, two condensers, eight purifier boxes, two relief holders, an electric tar precipitator, a tar dehydrator system, two tar separators, tar storage tanks, water tanks, oil pumps, and drip oil tanks. Various storage and work buildings were also located in the central area of the property, including a blacksmith shop in the south-central area. To the east was the gas oil pump house and five gas oil tanks (E&E, 1997).

The physical facility and property changed little from the 1930s through 1960. Brooklyn Borough Gas transformed its gas delivery operations to a natural gas-based system, and production of manufactured gas at the Coney Island facility ceased in November 1951. According to Brooklyn Borough Gas documents, gas deliveries to customers in 1952 were natural gas. Between 1952 and 1959, the site's MGP capability may have been maintained and operated for the purpose of peak shaving. BU acquired the Brooklyn Borough Gas Company in 1959. According to BU, they did not manufacture gas at this facility.

From 1960 to 1966, the facility was almost completely decommissioned and demolished. In 1974, a few buildings associated with a gate station, which included an axial compressor, a small gas holder, and the largest gas holder, remained operational for providing natural gas service. BU believes the gate station and gas holders were taken off line at the end of the 1970s and were subsequently decommissioned and demolished in the early 1980s.

In the early 1970s, the easternmost portion of the property was topped with fill and two baseball fields were constructed on top of the fill in the late 1980s. These fields were decommissioned in 1996 and are no longer in use.

1.2.2 Nature and Extent of Contamination

The site ha been investigated in several phases since 1984, including preliminary and voluntary assessments, as well as the RI. In addition, two IRMs have already occurred to address specific health and environmental hazard concerns. This work and the associated findings are summarized briefly in Table 1-1. A more comprehensive summary of the investigational history may be found in the RI report (E&E, 1997). Various volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), pesticides, polychlorinated biphenyls (PCBs), and inorganic compounds and elements were tested for and detected in the previous investigations (E&E, 1997). Table 1-2 presents those chemicals detected in surface soils at the site. The chemicals of potential concern (COPCs) were developed during the performance of the RA (GEI/Atlantic 1998).

The different phases of investigation evaluated potential contamination throughout the site and down to a depth of approximately 170 feet below ground surface (bgs) (E&E, 1997). Table 1-3 presents those chemicals detected in subsurface soils at the site.

The RI report (E&E, 1997) concluded the following:

- The soils and groundwater at the site contain various chemical constituents related to the gas manufacturing process that occurred previously at the site.
- The extent of distribution of these chemical constituents involves large portions of property.
- The presence of some of the observed contamination, especially along the northern boundary of the site, appears to be due to off-site sources.
- Of the more than 50 detected chemicals, principal chemical constituents were selected based upon their association with manufactured gas plant (MGP) feedstocks, by-products, and wastes; frequency of detection; observed concentrations; trends in spatial distribution; and environmental significance (i.e., toxicity, potential to bioaccumulate, persistence, and mobility potential). The principal chemical constituents were: polycyclic aromatic hydrocarbons (PAHs), benzene, toluene, ethylbenzene, and xylenes (BTEX), styrene, PCBs, total cyanide, arsenic, chromium, copper, lead, manganese, mercury, nickel, and zinc.
- The site is generally underlain by coal tar (typically PAHs) deposits that occur primarily at a depth of 4 to 12 feet bgs across the site, although material was observed from the surface to a depth of 172 feet bgs in one deep well (DW-04) on the western side of the site. BTEX and styrene were among the volatile organics detected.
- Inorganic constituents included lead, chromium, and arsenic. These appear to be associated with the industrial activity that has occurred at the site and its proximity to a railroad yard and a major roadway arterial. The distribution of inorganic chemicals generally follows that of the organic chemicals.
- Several potential off-site sources may contribute to the chemical constituents found at the former Brooklyn Borough Gas Works site. These sources include the Shore Parkway, which borders the site to the north; the train yard to the north; and an unknown source across the MTA ROW to the northwest. The observation of PCBs in soil explained by the former natural gas distribution gate station in the middle of the site that operated from 1960 to approximately 1979.

- Groundwater under the site has measurable levels of various chemical constituents due to the deposition of these chemicals at depth. The groundwater in this area is not used as a potable water source. The creek water contains elevated levels of organics and inorganic substances, some of which may be site-related. Although the site may contribute chemical constituents to the creek, there are other significant sources (e.g., outfalls or seeps) to the creek that occur upstream (to the east of the site).
- Free product of varying viscosities was found throughout the site. Consultants working at the site also observed oil floating in wells and in soil borings. These appear to be several different oils from different sources associated with the MGP processes.
- Observations of subsurface soils excavated during numerous test pit and borehole installations indicate that the horizontal limits of subsurface coal tar infiltration are not bounded by the current property line. Data suggest that there is an off-site petroleum hydrocarbon source at the northwest corner and total cyanide was detected along the north-central perimeter of the site. Previous studies have shown the highest concentrations of lead and arsenic occurred at the site perimeter. Also, low concentrations of PCBs have been found along the western site perimeter and may be due to the activity along the MTA ROW.
- A discontinuous clay/peat/silt layer underlying the fill appears to be acting as a vertical hydraulic barrier, inhibiting, but not necessarily stopping, the downward migration of organic constituents.
- Several wooden structures extending at least 25 feet inland support the wooden bulkhead. The exact numbers, consistency, and integrity of these structures are unknown. The bulkhead appears to be inhibiting, and perhaps preventing, large-scale migration of site constituents into the creek.
- Hydrogeologic behavior observed to date suggests that light nonaqueous phase liquid (LNAPL) is preferentially directed to the central part of the site, and small amounts of it seep into the creek along the southwest-central shore of the site.
- The lower concentrations of metals in the filtered samples collected during the June 1997 Phase VI groundwater sampling event indicate that the metal concentrations are largely associated with the suspended particulates. Filtering the groundwater samples effectively lowered the turbidity levels created by the suspended particulates.

1.2.3 Previous Interim Response Measures

Two IRMs were conducted previously at the site. First, an IRM to mitigate the release of LNAPL from the seep along the Coney Island Creek was evaluated, designed and implemented. This IRM was constructed from July to November 1994 as follows:

- Installation of inland recovery wells
- Installation of a hard boom and end connections in Coney Island Creek
- Installation of LNAPL skimmer system and hookup of oil collection system

The system was tested and demonstrated to be operational in late 1994. It also was observed and accepted verbally by the U.S. Coast Guard in May 1995. The IRM will continue to be in operation until the site is remediated.

In October 1997, a second IRM was conducted to mitigate high concentrations of lead in surface soils. This action removed the highest levels of lead contamination on the site, by removing the top 1 foot of soil from about 4 acres on the western portion of the site. This included the removal and proper disposal of approximately 250 tons of nonhazardous soil and over 1500 tons of hazardous soil. The IRM achieved its goal of removing the most highly lead-contaminated soil that was not simultaneously contaminated with high levels of coal tar. After removal and testing of the remaining soil, the work area was covered with a geotextile filter fabric to control and minimize odors and the release of dust. The NYSDEC approved of and oversaw the IRM, and indicated its acceptance in a faxed letter dated 7 April 1998 from David Crosby to Agnes Antonian of Brooklyn Union (GEI/Atlantic, 1998).

1.2.4 Risk Assessment

The occurrence of contaminants, their potential to migrate, and the possibility of people encountering them results in the potential for hazards or risks to health and the environment. The selection of media of concern is based upon the identification of these potential significant and unacceptable health risks. Selection of contaminants of concern is based upon identification of those chemical contaminants that pose the most significant and unacceptable potential risks. Significant and unacceptable first means that potential carcinogenic risks estimated in the baseline risk assessment exceed 1×10^{-4} and/or non-carcinogenic risks exceed a Hazard Index of unity (1.0). Lower carcinogenic risks may be judged as unacceptable depending upon site characteristics such as potentially exposed significant or sensitive populations.

A site-specific and use-specific RA was prepared based on current contemporary data from the RI report. The scope of the risk assessment was limited to evaluating exposure to chemicals in the upland portion of the site from the mean high water mark along Coney Island Creek, shoreward (§II ¶C of the Consent Order). The assessment considered the potential for adverse risks posed from current land use, and in the future if the site is reused and no remedial action occurs.

The findings of the RI (E&E, 1997) indicate that chemicals typically associated with the operation of MGPs occur in the soils of the site. The concentrations of various chemicals, especially PAHs, occur in site soils at levels exceeding typical urban background. PAHs are found universally throughout the environment in ambient air and water, and they are usually detected in soil samples collected in urban areas unrelated to specific industrial sites or processes. These concentrations are referred to as "background levels." The former Brooklyn Borough Gas Works site is in an urban area and is zoned as heavy industrial. Industrial activity has occurred on and adjacent to the site for well over 100 years. Furthermore, the site is bordered to the north by the Belt Parkway. This road is a major traffic arterial which can serve as a source of a variety of contamination including PAHs, lead, and petroleum hydrocarbons from the operation of motor vehicles. Because PAHs are widespread in urban environments, a significant level of exposure to PAHs comes from local background concentrations in soil and air. It is also important to note that the site itself does not contribute substantially to this background via the release of fugitive dust or vapor (as demonstrated by the off-site residential exposure scenario evaluation in the RA [GEI/Atlantic, 1998]). These facts must be kept in mind when considering the findings of the RA.

Under current site conditions (undeveloped, uncontrolled), the calculated estimates of excess potential cancer risk for each of the exposure scenarios (including the Reasonable Maximum Exposure [RME] and Average exposure cases) do not indicate significant risk to off-site human receptors. The total hazard indices for potential noncarcinogenic effects for the same exposure scenarios and cases were equal to or less than unity. This shows that site contaminants pose no potential for adverse noncarcinogenic effects. Only in the RME exposure for site workers does the risk or hazard exceed unacceptable levels.

Under future site reuse as a commercial/retail configuration, the calculated estimates of excess potential cancer for the evaluated exposure scenarios only exceed the minimal level of significance under RME exposure cases. Only the total hazard index for potential noncarcinogenic effects to the construction worker (performing uncontrolled excavation into the subsurface soil) exposed under the RME case was significant.

While there may be exposure to plants and wildlife generally at the site, there has never been any evidence of animal kills, nor is there any now. There may be some impacts to individual plant and wildlife species currently, but these impacts appear to be limited or non-existent (for example, areas of sparse vegetation). In the future, the redevelopment of the site will completely change its landscape and nature. This will eliminate or cover the surficial contamination, minimizing future ecological exposure.

1.3 Media of Concern

The findings of the various investigations were analyzed to define those environmental media that are of greatest concern due to the level of contamination and/or potential for risk to the public health and/or the environment. The following media are of concern: source areas, soil, groundwater, surface water, and future on-site indoor air. Each investigated medium and the justification of its selection or elimination from being of concern is discussed below.

Source Areas. Source areas are typically defined as zones of contamination associated with structures or equipment, storage areas, or by-product management areas. Much of the manufacturing area and tank farm was decommissioned and demolished in the early 1960s, and the balance of the above ground structures were demolished in the early 1980s. Therefore, typical sources or areas (e.g., drums, tanks, impoundments, waste piles, or landfills) are no longer present on the property. In addition to the few remaining aboveground structures (e.g., building and tank foundations), several underground structures (i.e., two gas oil underground storage tanks [USTs] and piping) have been identified and, according to BU, emptied of their contents, or, in the case of piping, sealed. While there are currently no classic waste or contaminant sources existing on the property, there are areas containing elevated concentrations of various organic chemical constituents on the property (that formerly received past leaks, spills, or other releases of coal tar or other by-products or waste). These areas themselves may act as secondary sources of these chemical constituents.

Soils. The investigations performed previously at the site show that soil, and especially subsurface soil, at the site is contaminated by substances common to the operations of MGP sites. Although the list of detected substances is long, the contaminants of particular note are the various PAHs due to their concentration. BTEX and heavy metals also occur in significant amounts. With regard to potential risk posed by these contaminants, the RA (GEI/Atlantic, 1998) indicates that there are no significant potential human health risks to any off-site person. In contrast, the possible pathways for exposure to those on site include: direct contact with soil, incidental ingestion, and inhalation of contaminated soil particles or vapors. Therefore, soil, and in particular subsurface soil, on the site is a medium of concern requiring appropriate management.

Air. A characteristic coal tar odor may occasionally be detected on the site. Although some soil gas and fugitive dust may emanate from the site under appropriate wind conditions, several studies showed that the potential health risks posed by this release are insignificant (E&E, 1997 and GEI/Atlantic, 1998). Moreover, environmental management action taken to abate potential hazards associated with soils and groundwater will mitigate related ambient air concerns. Therefore, ambient air is not a medium of concern.

The baseline RA also evaluated potential indoor air concentrations of volatile contaminants for on site buildings after redevelopment of the site in a commercial/retail fashion (GEI/Atlantic, 1998). Only benzene resulted in an estimated potential risk level to indoor workers above 1×10^{-6}. However, it is important to note that this estimated concentration was **not** above the background level (off-site, typical of urban environments) measured by the NYSDOH (1997). Therefore, while indoor air does not pose a potential incremental health risk, it perhaps is nevertheless prudent to consider this medium as being of concern.

Groundwater. The groundwater at the site is contaminated by various substances, in particular, BTEX and PAHs.

Due to its salinity, the groundwater can be classified as a saline groundwater (Class GSA, according to 6 NYCRR Part 701.18(a)). Pursuant to NYSDEC regulations, the usage for Class GSA groundwater is as a source of potable mineral waters, for conversion to fresh potable waters, or as raw material for the manufacture of sodium chloride or its derivatives (6 NYCRR Part 701.16). However, the groundwater at the site meets the classification criteria for GSB saline groundwater in accordance with NYSDEC requirements, namely a chloride concentration in excess of 1,000 mg/L or a total dissolved solids concentration in excess of 2,000 mg/L (6 NYCRR Part 701.17). According to NYSDEC regulations, the usage for Class GSB groundwater is as receiving water for the disposal of waste. The classification of groundwater as GSB cannot be made unless NYSDEC finds that such a classification would not impair adjacent and tributary waters. Furthermore, the surficial groundwater downgradient of the site flows immediately into Coney Island Creek, thereby mitigating any traditional groundwater exposure (E&E, 1998); and groundwater in the vicinity of the site is not a source of drinking water. Consequently, because of the lack of use, classification, and characteristics of the groundwater at the site, the typical standards or criteria applicable to potable groundwater (Class GA) are not relevant to this site.

Nevertheless, because there is an LNAPL layer present in the groundwater, and because some product is released from the site into Coney Island Creek via a seep (which is currently under an IRM), some action should be taken to permanently abate this release. Therefore, groundwater is a medium of concern.

Surface Water. Although there is no surface water on the site, Coney Island Creek is immediately adjacent to the site, and has received contaminants from the site (E&E, 1998). This brackish creek is defined by the NYSDEC (6 NYCRR 890.6) as a Class I (saline), Type A (for the protection of aquatic life and for wildlife consumers of fish) surface water body. The best use classification of the creek is secondary contact recreation and fishing, and propagation and survival of fish. These waters are not a source of drinking water, therefore potential for human exposure is low. Because the creek also receives contamination from a number of off-site sources, this FFS will concentrate on controlling releases from the site to the creek.

1.4 Chemicals of Concern

As described previously, various chemicals were detected at the site and in various environmental media. For the purposes of the baseline RA (GEI/Atlantic, 1998), a sub-group of chemicals was selected from the detected group of chemicals. This sub-group represented those chemicals that potentially may pose health or environmental risks, and this sub-group was called contaminants or COPCs. Based on the findings of the RA, several chemicals were identified as being of concern because of the potential risks or hazards that they posed. These contaminants of concern (COCs) are shown for different environmental media in Table 1-4.

PAHs. Based on the findings of the risk assessment (GEI/Atlantic, 1998) PAHs are a potential hazard with respect to health risk and form the major group of COCs.

Pesticides. Although pesticides were only infrequently detected and only at low concentrations in soils, these residues are most likely associated with historic area-wide pesticide applications that were common in the 1940s through the 1960s. The residuals are not a result of the former MGP operations. Because of the persistence of these compounds in the environment, low levels are still detected at the site. Moreover, because of their potential toxicity, the risk assessment indicates that these low concentrations in subsurface soils may pose some risk to construction workers who may work on site in the future. For this reason, they were retained as soil COCs.

PCBs. PCBs were also retained as soil COCs, again because the RA indicated that there may be some risk to construction workers working on the site in the future.

Total Cyanide. The RI reported that total cyanide was detected in subsurface soils, primarily in the north central portion of the site. The analytical method used to obtain this data provides a concentration value that represents the sum of various forms of cyanide, including: ionic forms, hydrogen cyanide, simple cyanide salts, and cyanide-metal complexes. These different forms have different chemical, physical, and toxicological properties. However, the cyanide-containing compound due to MGP residuals is ferric ferrocyanide ($Fe_4[Fe(CN)_6]_3$), which is also called Prussian Blue (Theis, *et al.,* 1994 and Shifrin, *et al.,* 1996). Although this complexed form of cyanide has very low toxicity (Shifrin, *et al.,* 1996), the risk assessment made the simple and very health-protective assumption that all of the total cyanide was as toxic as free cyanide (or CN^-). The assessment did not find a significant health risk associated with total cyanide. Nevertheless, it was retained as a COC in order to ensure that the cumulative health risks from all of the COCs were within safe levels. Brooklyn Union will provide notification to neighboring properties regarding the known extent and calculated risks of total cyanide as part of an institutional control plan.

Arsenic. Although the RA did not find a significant health risk associated with arsenic, it also was retained as a soil COC to ensure that the cumulative health risks from all of the COCs were within safe levels.

Lead. Because of high concentrations in surface soil (E&E, 1997), lead also was retained as a COC. An IRM was implemented to remove lead-contaminated surface soil from an area of approximately four acres.

1.5 Organization of Report

In addition to this introduction, the following sections are included in this FFS report:

- ***Section 2.0, Risk-Based Remedial Action Objectives and Goals***, provides the risk-based framework for implementing remedial actions at the site and identifies RAOs.
- ***Section 3.0, Identification and Screening of Technologies***, presents technical issues related to site cleanup and brownfield development. After technical issues are identified, remedial technologies are identified and screened for use in remedial alternatives.
- ***Section 4.0, Development, Evaluation, and Comparison of Remedial Alternatives***, presents the remedial alternatives, including No Action, and evaluates them relative to criteria established by NYSDEC.
- ***Section 5.0, Recommended Remedial Action Alternative***, summarizes the comparison of alternatives, recommends the best candidate alternative, and provides additional considerations for future implementation of remedial actions.
- ***Section 6.0, References***, lists the sources of information used in the preparation of the FFS report.

There is one appendix at the end of this FFS report. Appendix A presents the detailed cost estimate prepared for the remedial alternatives evaluated in Section 4.0.

2.0 RISK-BASED REMEDIAL ACTION OBJECTIVES AND GOALS

2.1 Introduction

The purpose of this section is to specify federal and state statutes, regulations, and guidelines that are potentially applicable to the development of remediation goals and remedy selection for the site and to identify RAOs for remedial alternatives to be applied at the site. The use of potentially applicable statutes, regulations, and guidelines is balanced in this FFS by the requirements in the Consent Order, particularly §IV ¶A. This section of the Consent Order endorses the use of site-specific and use-specific risk assessment techniques to determine site cleanup levels and to evaluate remedial technologies appropriate for the potential risks, exposure pathways, contaminant levels and future use of the site. Potentially applicable, relevant, or appropriate requirements that are superseded by the Consent Order are noted in this section.

2.1.1 Approach

The development of viable remedial alternatives considers the nature and extent of contaminants, media of interest, exposures pathways and probable risk. Section 1.0 of this FFS summarized available information related to these topics. Before technologies can be assembled into alternatives, RAOs must be identified. Section 2.0 concludes with the presentation of risk-based RAOs after reviewing federal, state, and local statutes, regulations, and guidelines. Consideration is given to requirements that may have some bearing on the RAOs as well as statutes, regulations, and guidelines which may be triggered by taking action to meet RAOs.

The Consent Order advocates a risk-based approach not specifically identified in many of the requirements cited herein. Section 2.0 strives to create a regulatory framework for development and future attainment of risk-based RAOs. If a known site condition or foreseeable remedial action potentially triggers a federal, state, or local requirement, the requirement is identified and its applicability is assessed. The assessment of applicability considers both the strict interpretation and the spirit of a particular requirement, particularly when the requirement does not embody or reflect generally accepted risk-based methods. In a situation where a requirement can be implemented reasonably within the risk-based framework, the assessment is straightforward and the requirement is applicable. However, if the assessment determines that the applicability of a requirement conflicts with the risk-based approach, the requirement does not apply but may be considered in the development of a complete and balanced regulatory framework.

Chemical-, action-, and location-specific standards, criteria, and guidelines (SCGs) that may be applicable or relevant to the site are discussed in Section 2.2. This includes both New York State SCGs, as well as federal standards that are more stringent than state SCGs. Regulations and guidance to be considered (TBC) are presented in Section 2.3. The development of RBCs is discussed in Section 2.4. RAOs, consisting of goals for protecting human health and the environment and for meeting RBCs to the extent practicable and cost effectively, are discussed in Section 2.5.

2.1.2 Regulatory Requirements

2.1.2.1 Federal Goals and Requirements

In accordance with the National Contingency Plan (NCP Section 300.430(e)(2)(i)), remediation goals should be established based on exposure levels that are protective of human health and the environment and should be developed by considering Applicable or Relevant and Appropriate Requirements (ARARs) under federal environmental or state environmental laws and by using appropriate risk analysis. EPA guidance for Superfund sites specifies that remedial actions should be evaluated, in large part, based on the standard of protection of human health and the environment and compliance with ARARs.

Section 121 of CERCLA (42 U.S.C. Section 9621) establishes requirements for the selection of remedial actions at Superfund sites. Section 121 establishes the fundamental requirement that actions be selected and carried out consistent, to the extent practicable, with the NCP in a manner that provides for a "cost-effective response." Section 121(d) generally requires that remedial actions attain a degree of cleanup and control of future releases that ensures protection of human health and the environment. Section 121(d)(2) further provides that selected remedial actions, or the completion of actions, must attain a level or standard of control that attains "legally applicable or relevant and appropriate standards." At a minimum, such actions are to attain a level of protection or standard of control which is equivalent to ARARs promulgated under federal and state laws.

Unlike CERCLA, where actual permits are not required for on-site work (CERCLA Section 121(e), all identified federal SCGs must be complied with fully, including the necessity to obtain all applicable federal permits and approvals.

2.1.2.2 New York State Standards, Criteria and Guidelines

New York State SCGs are standards or requirements that implement the New York State Environmental Conservation and Public Health Law. Since New York State does not have ARARs in its statute, SCGs are used to avoid misinterpretation of New York State requirements. Remedial actions conducted in New York State are required to attain SCGs to the extent practicable as presented in the NYSDEC TAGM #HWR-90-4030 (NYSDEC, 1990).

In addition to SCGs, related advisories, criteria, and guidelines "to be considered" (TBCs) may be identified during the review process. TBCs include guidance documents, advisory criteria, and guidelines issued by federal or state agencies that are not promulgated or binding under federal or state law and do not have the status of SCGs.

SCGs may be categorized as contaminant-, location-, or action-specific:

- Contaminant-specific SCGs set health or risk-based concentration limits or ranges in various environmental media for specific hazardous substances, pollutants or contaminants.
- Location-specific SCGs set restrictions on activities within specific locations, such as wetlands and floodplains and depend on the characteristics of a site and its immediate environs.
- Action-specific SCGs set controls or restrictions on particular kinds of remedial activities that may be selected to accomplish a remedy. These SCGs may specify particular performance levels, actions or technologies to be used to manage hazardous substances, pollutants or contaminants.

The three types of SCGs listed above, along with any appropriate TBCs, are discussed in Sections 2.2.1, 2.2.2, and 2.2.3, respectively, as they pertain to the site.

Pursuant to 6 NYCRR 375-1.7 (Permitting Remedial Activities), all on-site activities need only comply with the substantive technical requirements of the applicable permits. The Consent Order exempts Brooklyn Union from obtaining NYSDEC-issuable permits in §V ¶D.

2.1.2.3 Local Requirements

Remedial activities conducted on-site in accordance with the Consent Order and supplemental documentation do not require permits, consents, approvals or other authorizations under any local government zoning, land use, or other regulatory program (6 NYCRR 375-1.7(c)). As such, no New York City permits or approvals will be required for remediation work conducted on-site. However, post remediation development of the property will be subject to all applicable local development/construction approvals. A summary list of typical New York City approvals/authorizations is presented in Table 2-1 for reference purposes.

2.1.3 Risk-Based Cleanup Goals

Risk-based cleanup levels (RBCs) are media-specific contaminant concentrations derived from site-specific risk analysis. EPA in general uses the 1×10^{-4} to 1×10^{-6} carcinogenic risk range, and the non-carcinogenic hazard quotient less than unity (or 1.0) as the "target range" within which the agency strives to manage risks as part of a cleanup under CERCLA (EPA, 1991 and 1997). Where cumulative carcinogenic site risk to an individual based on RME for both current and future land use is less than approximately 10, and the non-carcinogenic hazard quotient less than unity (or 1.0), action generally is not warranted unless there is potential for adverse environmental impacts or other site-specific reasons. However, if chemical-specific ARARs are exceeded, action is generally warranted. RBCs are determined by calculations using exposure formulas similar to those for calculating risk estimate values in the RA (GEI/Atlantic, 1998). In contrast, however, instead of resulting in a risk value based on a contaminant concentration, the risk value is one of the input parameters and a medium-specific contaminant concentration is obtained from the calculation.

2.2 Standards, Criteria, and Guidelines

2.2.1 Chemical-Specific Requirements

Chemical-specific SCGs are health- or risk-based concentrations for specific hazardous substances, pollutants, or contaminants in various environmental media. Chemical-specific SCGs include remediation goals for COCs in designated media (such as soil or groundwater). These goals can be used to develop RAOs for site media. Statutes, regulations, and guidelines to be used in the identification of chemical-specific SCGs are listed in Table 2-2.

NYSDEC has developed soil cleanup objectives (NYSDEC TAGM 4046). These are not being applied at this site because the Consent Order advocates use of a site- and use-specific risk assessment for calculation of numerical soil cleanup goals.

The maximum contaminant levels (MCLs) for drinking water established under the Federal Safe Drinking Water Act and Part 5 of the New York State Public Health Law (10 NYCRR) are not applicable at the site because there appears to be no reasonable potential for future use of groundwater as a public water supply source.

2.2.2 Action-Specific Requirements

Action-specific SCGs are technology- or activity-based requirements or limitations. These SCGs are triggered by, and apply to, the implementation of particular remedial activities. Federal and state statutes, regulations, and guidelines used to identify action-specific SCGs for the site are listed in Table 2-3.

2.2.2.1 Resource Conservation and Recovery Act

The Resource Conservation and Recovery Act (RCRA) (and counterpart New York State regulations under 6 NYCRR Parts 370 through 375) provide several potentially applicable, action-specific SCGs. These regulations govern the management of hazardous waste in New York State. Soil in place is, in general, not a waste unless it is excavated and processed by being moved to another site, treated, or disposed of. RCRA guidance is available for determining what constitutes "generation" of a hazardous waste.

Toxicity Characteristic Leaching Procedure (TCLP) limits are specified in 40 CFR Part 261 and 6 NYCRR Part 371. These regulations also define the corrosivity, reactivity, and ignitability characteristics under RCRA. Federal regulations limit the corrosivity RCRA characteristic to liquids (40 CFR Part 261.22). The reactivity RCRA characteristic is defined in qualitative terms (see 40 CFR Part 261.23); however, disposal facilities currently use *de facto* limits of 250 parts per million (ppm) of releasable cyanide (i.e., hydrogen cyanide) and 500 ppm of releasable sulfide (i.e., hydrogen sulfide) based on EPA SW-846 test methods (EPA, 1994a). The ignitability characteristic is defined for a solid material in 40 CFR Part 261.21 as an oxidizer or a material causing fire and, when ignited under standard temperature and pressure, burns vigorously and persistently, creating a hazard.

Until 1990, MGP site remediation wastes could be disposed of under RCRA as nonhazardous solid wastes. Such wastes were not subject to regulation under Subtitle C (hazardous waste program) of RCRA because, during the mid 1980's, EPA had ruled that MGP wastes qualified for the Bevill Amendment exclusion for mineral processing wastes. In addition, MGP residuals typically did not exhibit any of the toxicity characteristics that were in force at the time.

Due to more recent regulatory changes, however, MGP site remediation wastes can be classified as hazardous waste subject to Subtitle C regulation. This is primarily due to a 1990 EPA ruling stating that remediation waste from "historic" sites no longer qualifies for the Bevill Amendment exclusion. As a result, MGP site remediation wastes can be subject to hazardous waste regulation if they exhibit a hazardous characteristic. Moreover, in 1990 EPA revised the requirements for the toxicity characteristics. The revised regulation established the Toxicity Characteristic (TC) Rule which expanded the regulated compound list for toxicity characteristics to include an additional 24 organic constituents, including benzene, a common component in coal tar residuals.

2.2.2.2 RCRA Closure Requirements

Generally, contaminated soils are not considered to be “generated” (and therefore not subject to RCRA) until excavated or otherwise removed from the ground surface. Soils remaining on site which fall below the site-specific risk-based cleanup criteria are therefore not subject to RCRA hazardous waste requirements. As such, a RCRA Subtitle C cap would not be required for containment purposes at the site. In the absence of federal Subtitle C closure regulations, federal or state solid waste landfill closure requirements generally govern CERCLA response actions as ARARs. State closure requirements that are more stringent than federal requirements must be attained. The New York State SCG in this case would be 6 NYCRR Part 360, in particular, Section 360-2.15, “Landfill Closure and Post-Closure Criteria”. These requirements may be applicable to remedial actions involving containment at the site.

2.2.2.3 Land Disposal Restrictions (LDRs)

The Hazardous and Solid Waste Amendments (HSWA) to RCRA were signed into law on November 8, 1984. These amendments include specific provisions, known as land disposal restrictions (LDRs), restricting the land disposal of RCRA-classified hazardous waste. The specific purpose of the LDRs is to minimize the potential for future risks to human health and the environment by requiring treatment of hazardous wastes prior to their land disposal. The only waste streams at the Brooklyn Borough Gas Works site that could possibly exceed hazardous waste regulatory standards once generated are benzene from coal tar residuals and lead from paint.

The LDRs are a complex set of regulations, presented in 40 CFR Part 268, and are applicable only to remedial actions constituting placement (land disposal) of hazardous waste. If a waste becomes subject to a land disposal restriction, its regulatory status is determined by its regulatory classification at the point of generation. Thus, waste excavated and found to be hazardous is subject to the LDR program even if later rendered nonhazardous. To become eligible for land disposal, the waste must be treated to specified concentration levels for each hazardous constituent present in the waste (not merely the constituent(s) that caused the waste to be classified as hazardous) using best demonstrated available technology (BDAT), or in some cases, a treatment methodology specified in the rule for a particular class of constituents. Variances have been allowed for this pre-treatment requirement.

In September 1994, EPA promulgated a list of Universal Treatment Standards (UTSs) specifying the concentrations to which the constituents in hazardous waste must be treated to be eligible for land disposal. In the same rulemaking, EPA promulgated treatment standards for the organic constituents covered by the expanded list of toxicity characteristic parameters, including benzene.

On May 26, 1996, the EPA adopted the Phase IV Final Rule on Land Disposal Restrictions for Metal Wastes and Mineral Processing Wastes (63 FR 28616). Among other items, the final rule identifies new universal treatment standards for toxicity-characteristic metal-bearing wastes and some characteristic mineral processing wastes, including MGP wastes. To meet specified LDR's, MGP wastes must be treated to meet UTS for any hazardous waste characteristics and for any underlying hazards constituents. The Phase IV LDR rule would apply to all of the hazardous wastes from MGPs that no longer have Bevill status. In addition, the rule prohibits the storage of MGP hazardous waste except to facilitate treatment or disposal and prohibits the use of dilution to meet UTS (dilution prohibition), unless pre-treatment or mixing is necessary to facilitate proper treatment (e.g., destruction or removal).

The New York State LDR program mirrors the federal LDR program with the exception of the LDR Phase IV rule.

2.2.2.4 Surface Water

NYSDEC has developed standards and guidance values to protect both groundwater and surface waters. These values were developed based on protection of drinking water sources, fish propagation/survival, and human and wildlife consumption of fish. The authority for these values is derived from Article 17 of the Environmental Conservation Law and 6 NYCRR Parts 700-705.

If the chosen remediation alternative at the site includes a discharge to surface water, discharge limits would need to be established for individual contaminants, based on site conditions and water quality SCGs. The NYSDEC guidance for estimating surface water discharge limits is described in the Division of Water's SPDES guidance for permit development contained in the following Technical and Operational Guidance Series documents (NYSDEC, various dates):

1.3.1	Waste Assimilative Capacity Analysis & Allocation for Water Quality-Based Effluent Limits	May 1990
1.3.1C	Development of Water Quality-Based Effluent Limits for Metals/Amendment	August 1991
1.3.2	Toxicity Testing in the SPDES Program	May 1990

Coney Island Creek is categorized as Class I saline waters by the NYSDEC. Designated use for Class I waters are for fishing and aquatic life survival and propagation. Only two elements being evaluated as part of the potentially proposed final effluent have corresponding aquatic life water quality criteria. These elements are copper and zinc. All remaining contaminants do not have corresponding water quality or effluent criteria for Class I saline waters. As a default value for organic compounds without numerical criteria, NYSDEC proposed a value of 50 ug/L in the absence of supporting data for a higher value. No default values are provided for metals. In an effort to better evaluate effluent quality, NYSDEC through Amendment 702.10 proposes use of supporting toxicity data from the scientific literature and an applicable application factor (ranging 0.01 to 0.05) to derive a guidance value for effluent limitations. These values rely upon 96-hour LC50 or EC% data for representative organisms expected to occur in the waterbody of concern. Primary and secondary literature was reviewed and 96-

hour LC50/EC% tests were compiled for various marine invertebrates and fish (depending upon which marine test data were available) which would be expected to be present in the waterbody by identical or similar species. The calculated values which appear in Section 4.0 of this FFS are for guidance consideration only and do not represent adopted nor accepted effluent criteria by the NYSDEC.

2.2.2.5 Air Emissions

NYSDEC's Division of Air Resources air quality guidelines for coal tar residuals are listed in Table 2-4. These guidelines are TBCs that are based on protecting public health from impacts due to inhalation. Short-Term Guideline Concentrations (SGCs) pertain to exposures of a few hours or less, whereas Annual Guideline Concentrations (AGCs) are applicable to long-term exposure. SGCs may need to be considered in assessing impacts due to excavation or material transport during site remediation. AGCs for dust and VOCs such as benzene may need to be considered depending upon the type of remediation being evaluated.

2.2.3 Location-Specific Requirements

Location-specific SCGs are restrictions placed on the concentration of hazardous substances or the conduct of activities solely because they are in specific locations. Potential location-specific SCGs for the former Brooklyn Borough Gas Works site include restrictions on certain land development activities in floodplains and near navigable waters (including wetlands) of the United States.

Statutes, regulations, and guidelines to be used in the identification of location-specific SCGs for the Brooklyn Borough Gas Works site are listed in Table 2-5.

2.2.3.1 100-Year Floodplain/Floodway

A review of the Federal Emergency Management Agency (FEMA) flood insurance rate map for the Brooklyn Borough Gas Works site shows that most of the site, particularly the former manufacturing area on the western side, is located within the 100-year floodplain. The former ball field area on the eastern portion of the site was constructed on several feet of fill, effectively raising the elevation of this area above the floodplain. Federal and state floodplain management laws and regulations are applicable SCGs in the event that remedial activities would involve excavation or fill within the 100-year floodplain or floodway. Depending upon the selected remedial action, hydraulic modeling may be necessary during design to more accurately define the floodway boundary and potential impacts on the site and adjoining properties.

2.2.3.2 Navigable Waters

Permitting requirements under Section 10 of the Rivers and Harbors Act and Section 404 of the Clean Water Act (CWA) would be applicable in the event that remedial activities at the Brooklyn Borough Gas Works site impinge on the Coney Island Creek.

The United States Army Corps of Engineers (USACE) has jurisdiction under Section 404 of the CWA over the discharge of dredge or fill material into waters of the United States. Certain remedial activities at the former Brooklyn Borough Gas Works site may impact the tidal flats/wetlands associated with Coney Island Creek. In addition, any structures placed into or across the Creek would also be subject to USACE review and approval pursuant to Section 10 of the Rivers and Harbors Act.

Parts of Coney Island Creek are identified by the U.S. Department of Interior as intertidal and subtidal estuarine wetlands. NYSDEC classifies the creek as a littoral zone with areas of coastal shoals and mud flats along the banks (GEI/Atlantic, 1998). The tidal flats associated with the Creek are mapped as tidal wetlands by the NYSDEC and any direct impacts to these wetlands would require compliance with the substantive requirements of the tidal wetland regulations. In addition, a buffer potentially extending up to a maximum of 150 feet landward of the tidal wetlands may be imposed by NYSDEC. The tidal wetlands buffer extends from the mean high water mark of the Creek to the first developed feature (i.e., bulkhead) or to a rise in slope greater than 10 feet. Given the physical features of this site, the buffer for the site is likely to be less than 150 feet for the Creek.

No upland, freshwater wetland area is currently listed by state or federal agencies. There is an area (approximately 1 to 3 acres) near the center of the property that demonstrates two wetland characteristics (namely, hydrophytic vegetation and wetland hydrology). This area may meet the definition of an atypical wetland as defined by the USACE. This wet area exists because of the previous industrial activity at the site which has led to hydrologic conditions favorable to the establishment of hydrophytic vegetation. Even if this area is determined to be a wetland, it is considered insignificant because of its small size and lack of criticality to both flora and fauna in the general area (CEI/Atlantic, 1998).

2.3 Regulations and Guidance To Be Considered

2.3.1 Technical Impracticability (TI) of Groundwater Restoration

With regard to restoration of groundwater aquifer systems to drinking water quality standards, the EPA has issued guidance on addressing sites where such remediation is not feasible nor technically practicable. The guidance is contained in an EPA memorandum titled, "Guidance for Evaluating the Technical Impracticability of Groundwater Restoration" (EPA, 1993a). One of the major focal points of this guidance is that sources of groundwater impacts need to be removed only where practicable, and in general, where significant reduction of current or future risk can be realized. This EPA guidance document also addresses DNAPL and the impracticability of its removal. While this guidance was prepared primarily for application to federal Superfund site cleanups, it can be considered for the former Brooklyn Borough Gas Works site. There have been over 20 Technical Impracticability (TI) waivers issued by the EPA at Superfund sites across the United States, including a former MGP site in New York State (Saratoga Springs). This site is undergoing a remediation consisting of capping, "hot spot" removal, installation of a vertical barrier and groundwater collection.

In order to obtain a formal TI determination, an evaluation must be performed based on site-specific information and analyses. This FFS does not comprise a request for a TI determination from NYSDEC, nor is the information within this report sufficient (per the guidance) to warrant the issuance of such a determination. The TI guidance is to be considered when developing the clean-up goals and provides the regulatory framework for allowing exceptions to restoring groundwater to drinking water quality standards.

2.3.2 Monitored Natural Attenuation

Natural attenuation involves *in situ* physical, biological, and chemical processes which reduce the mass, toxicity, mobility, volume, or concentration of contaminants in groundwater. In its Superfund program, EPA has recognized the use of natural attenuation as an element in a site's groundwater remedy since 1985. In its guidance document "Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action and Underground Storage Tank Sites" (EPA, 1997), EPA states that, "Following source control measures, natural attenuation may be sufficiently effective to achieve remediation objectives at some sites without the aid of other (active) remedial measures." The guidance further states that, "Source control actions should use treatment to address 'principal threat' wastes (or products) wherever practicable, and engineering controls such as containment for waste (or products) that pose a relatively low long-term threat, or where treatment is impracticable." EPA's remedy selection process accommodates monitored natural attenuation when it is packaged with other strategies which, collectively, attain remedial action objectives and protect human health and the environment.

In the preamble to the National Contingency Plan (EPA, 1990), EPA specifies that cleanup levels for the expected beneficial use of groundwater "should generally be attained throughout the contaminated plume, or at the edge of the waste management area when waste is left in place." As stated in Section 1.3, the groundwater below the former Brooklyn Borough Gas Works Site has the characteristics of GSB saline groundwater suitable as a receiving water for the disposal of waste. A GSB saline designation indicates the lack of a beneficial use for the groundwater and the irrelevance of MCLs or other cleanup levels within the boundaries of the Site.

2.3.3 MGP Site Remediation Strategy

A strategy for remediating soils containing MGP residuals has been developed by EPA and Edison Electric Institute (EEI). An EPA-approved document describing that strategy, consistent with the RCRA hazardous waste program, was published by EEI in April 1993 (EEI, 1993). The document applies only to the management of excavated MGP solid materials that are hazardous by characteristic, and covers relevant on-site activities including characterization, excavation, accumulation and treatment in 90-day units, as well as off-site disposal.

This strategy is predicated on the ability of soils containing MGP residuals to be burned with coal or other combustible blending materials in utility boilers, thermal desorption units, or other permitted treatment units. Remediation waste that exhibits a hazardous characteristic must be rendered non-hazardous before it leaves the generation site. This may be accomplished through the use of 90-day tanks, containers, or containment buildings covered by 40 CFR Section 262.34(a). Under federal regulations, waste may be treated in such units during the 90-day accumulation period without a permit, and if the waste thereafter no longer exhibits a hazardous characteristic, any further management of the waste, including the treatment of such materials at permitted facilities, no longer would be subject to Subtitle C of RCRA. Treatment in 90-day units can consist of blending characteristically hazardous MGP soils with relatively dry, combustible materials, such as coal, coal fines, less contaminated soil, and wood chips.

2.4 Risk-Based Cleanup Goals

The development of site- and use-specific numerical cleanup goals or RBCs was based on the methods, tools, and findings of the baseline RA (GEI/Atlantic, 1998). Considering the planned redevelopment of the site as a commercial/retail scenario, with buildings and parking lots, the most sensitive human receptor requiring protection against potential health hazards arising from contaminants at the site is an unprotected construction worker involved in subsurface excavation work. Therefore, the risks and exposure point concentrations of COCs occurring in soils were reviewed and the most significant exposures identified, namely, incidental ingestion of and dermal contact with soil by a construction worker in an uncontrolled subsurface environment.

To develop the RBCs, reduction in risk to human health or the environment to achieve acceptable levels was the primary objective. Reductions in risk were achieved by optimally reducing the concentrations of those contaminants having the greatest toxicity and/or for which the greatest level of exposure could occur. The development of the RBCs followed a three-step approach:

- Calculate individual COC RBCs based on its specific target risk goals;
- Calculate the cumulative COC RBCs based on the cumulative target risk goals; and
- Optimize the RBCs by adjusting the concentrations while ensuring that both individual and cumulative target risk goals are maintained and not exceeded.

Table 2-6 presents a series of specific numerical goals for each COC. At a minimum, concentrations in heavily tarred unsaturated soils must be reduced to levels below the chemical saturation levels shown in

Table 2-6. Tables 2-7, 2-8, and 2-9 present a range of contaminant concentrations that can be used as RBCs. These are based on various health risk target levels to protect against cancer and other toxic effects, and are optimized to achieve the target risk levels for individual COCs as well as cumulative target risk levels.

Lead is not addressed in Table 2-6. Lead has been observed at the site to occur at a range of concentrations, that is, in surface soils from 0.91 to 5,900 ppm and in subsurface soils from 0.74 to 3,000 ppm (E&E, 1997). The highest concentrations of lead occurred in surface soils on the western side of the former manufacturing area around the bases of the former gas holders. The most significant lead exposure source was mitigated by BU with a surface-soil removal IRM undertaken during October 1997. This action removed the highest levels of lead contamination on the site by removing the top one foot of soil from about four acres in this area.

The EPA Office of Solid Waste and Emergency Response (OSWER) originally concluded that cleanup of lead in soil at Superfund sites to concentrations of 500 to 1,000 mg/kg was adequately protective for direct contact of children at residential settings, and issued a directive to that effect (EPA, 1991c). OSWER revised the directive to account for the contribution of various media to total lead exposure of children as predicted by the lead uptake/biokinetic (UBK) model (EPA, 1994). The model estimates the blood lead concentrations in children expected to result from exposure to lead concentrations in soil and other media (air, water, diet, dust, and paint). EPA recommends a benchmark of either 95% of the sensitive population of children having blood lead levels below 10 μg/dl or a 95% probability of an individual child having a blood lead level below 10 μg/dl. When the model is run using this benchmark and all default parameters, a soil level of 490 ppm is predicted for lead.

Because of the lead IRM that has already occurred to remove the highest levels of lead in surface soil and because the site will likely be capped and either paved or built upon, the lead contamination will not be accessible for exposure. Furthermore, lead in urban areas may range up to 500 or 700 mg/kg (NYSDEC, 1994 and Shacklette and Boerngren, 1984). Therefore, if the soils are removed, paved, or covered over, then no further action is warranted. If soils with elevated levels are to be exposed at the surface, then a concentration of 490 ppm is recommended as a goal.

2.5 Remedial Action Objectives

Risk-based RAOs have been developed for the purpose of evaluating the applicability of remedial technologies and the effectiveness of remedial alternatives. These objectives consist of media-specific goals for protecting human health and the environment and for meeting SCGs to the extent practicable in a cost-effective manner. RAOs are based on site-specific information including the nature and extent of site constituents, human and ecological risk assessment results, RBCs, existing site conditions, and future land use plans. RAOs typically focus on controlling ecological receptor (humans, wildlife, aquatic life) exposure to chemicals of concern via exposure routes such as dermal contact, ingestion, and inhalation, and on controlling the release of hazardous substances into the environment (groundwater, surface water, soils, and sediments).

Preliminary RAOs for the site have been established based on the nature and extent of contamination and the risk assessment results summarized in Section 1.2.4. Protecting human health and the environment, technical feasibility, and practicability of achieving these goals were considered in their development. Consistent with §IV ¶D of the Consent Order, future land use was also factored into the development of RAOs. The following four risk-based RAOs are deemed appropriate for site remediation:

- Control potential future exposures of construction workers to subsurface soil
- Control potential future indoor air exposure pathways
- Minimize the further degradation of the Coney Island Creek

- Facilitate expedited brownfield development

Final RAOs are usually presented, along with the preferred remedy, by the lead agency (NYSDEC) in the Proposed Remedial Action Plan and the subsequent Record of Decision.

3.0 IDENTIFICATION AND SCREENING OF TECHNOLOGIES

3.1 Introduction

In order to develop feasible alternatives that address RAOs for the former Brooklyn Borough Gas Works site, potentially applicable technologies must first be identified. This section describes the following steps that lead to the development of viable remedial alternatives:

- Assessment of technical issues posed by the site and the project
- Identification of potentially applicable technologies and available process options
- Preliminary screening of the technologies and process options with respect to implementability, effectiveness, and cost

Technologies have been categorized into general response actions. General response actions include no action, institutional controls, containment, source removal, treatment, and disposal. Each general response action considers the media of concern at the site, including soil, groundwater/NAPL, and air emissions. Consistent with the focused approach of this FFS as stipulated as the Order on Consent, only proven processes and technologies are identified and screened within each general response action. Innovative, emerging, and unproven technologies, or those with extended implementation schedules are not considered herein.

The NYSDEC TAGM HWR-90-4030 specifies that individual remedial technologies should be screened preliminarily on their ability to meet media-specific RAOs, implementability, and short- and long-term effectiveness. Site-specific RAOs were discussed in Paragraph 2.5.

Implementability encompasses technical feasibility, availability of the technologies, and the administrative feasibility of implementing a technology or process (EPA, 1988 and NYSDEC, 1990). If a technology or process requires equipment, specialists, or facilities that are not available within a reasonable period of time, it may be eliminated from further consideration (EPA, 1993).

Screening for effectiveness considers three important aspects:

1. The ability of the process to handle estimated volumes or areas and meet the RAOs
2. The potential for the process to impact human health and the environment during implementation
3. The reliability and record of performance for the process

The EPA National Oil and Hazardous Substances Pollution Contingency Plan (NCP) under CERCLA states in 40 CFR Section 300.430 that cost can be used as a criteria to preliminarily screen remedial alternatives. The NCP states that grossly excessive costs, compared to the overall effectiveness of alternatives, may be used as one of several factors to eliminate alternatives. In addition, similar alternatives providing effectiveness and implementability equivalent to that of another alternative, but at a greater cost, may also be eliminated. Screening based on cost focuses on both the costs of construction and any long-term operation and maintenance costs (EPA, 1993c). Cost screening information is provided in the text and tables and represents the technology cost only, not the overall remedial cost to achieve a cleanup objective.

3.2 Technical Issues

BU recognizes that state and community acceptance of the recommended remedial alternative is needed before steps can be taken to design and implement a remedy and is especially relevant in the site redevelopment process. Wherever practical, beneficial use and reuse of resources, the property, and waste materials are incorporated into the selection of technologies and remedial activities. This approach represents a conscious decision on BU's part to be a good corporate citizen and neighbor.

While it is desirable to render the site into a commercial establishment of significant benefit to the community, there are a number of factors that may hinder anticipated brownfield development. Identification of the remedial technologies considering the potential reuse of the site, integration of the remedy with the development, incremental costs arising from developers' needs, and critical scheduling of activities are examples of issues which must be factored into any brownfield project. These issues cannot supercede the intended goal of achieving risk-based brownfield development at the former Brooklyn Borough Gas Works site. Within the context of this FFS, the focus on risk reduction first and brownfield development second results in the selection of proven remedies which meet RAOs, protect human and ecological resources, and create an environment that is able to host commercial development in a safe and compliant manner.

There are several technical issues complicating risk-based brownfield development of the former Brooklyn Borough Gas Works site. These issues must be considered when identifying and screening technologies, evaluating alternatives, and preparing recommendations to meet RAOs. Table 3-1 presents technical issues, organized topically, and their relative importance to the project endpoints of risk reduction and brownfield development.

3.3 General Response Actions

Five categories of general response actions are applicable to the site. The general response actions evaluated herein include: No Action, Institutional Controls, Containment, Source Removal, Treatment, and Disposal. Technologies and process options are presented by media for each of the general response actions.

3.4 No Action

The No Action general response action provides the baseline case for comparison of alternatives. In a No Action scenario, subsurface conditions remain unchanged and current site controls, including security fencing and the Coney Island Creek hard boom and skimmer, are maintained indefinitely. This approach includes the use of selected existing on-site monitoring wells to conduct a long-term groundwater monitoring program. Reviews of site conditions would be performed at defined intervals in accordance with NYSDEC requirements. While the No Action alternative would not achieve RAOs or reduce existing risks posed by the site, it is retained for consideration in the FFS as a baseline for comparison of alternatives.

3.5 Institutional Controls

This general response action includes access control measures, long-term monitoring, and various institutional controls specifying conditions of transfer, development, and allowable uses of the property to minimize behaviors that may result in exposures to contaminants above acceptable risk-based concentrations. This approach relies on the responsibilities and liabilities of the stakeholders (BU, NYSDEC, NYSDOH, NYCDEP) for enforcement. As part of a long-term protection plan, and in conjunction with No Action or other selected remedies, the following institutional controls would be considered appropriate for the site:

- Access controls, particularly the prevention of unauthorized access to remedial systems and remedial system components
- Deed restrictions, which in conjunction with BU's agreement with a developer, will prevent unauthorized use of the property which could place workers or occupants at risk

- Long-term monitoring of multi-media discharges, including ambient air, groundwater, and storm water
- Health and Safety Plan, including dig permit, to be implemented whenever routine subsurface utility construction or other maintenance operations are necessary within the property boundaries
- Notifications to neighboring property owners, utilities, and local governing bodies.

Institutional controls are important to the success of any remedial alternative. Considered individually, institutional controls will not meet RAOs. However, as part of comprehensive remedial alternatives, they can help achieve long-term risk reduction by preventing exposures to residual contaminants after remedial measures are implemented. Therefore, institutional controls are retained for consideration as part of remedial alternatives.

3.6 Containment

3.6.1 Soil Containment Technologies

Soil containment systems generally refer to specially designed cover systems or caps. Cover systems are a critical component in the overall process of managing liquid and gas movement into and out of the underlying contaminated material. The main objectives in designing a cover system are to separate the buried waste or contaminated material from the surface environment, to restrict infiltration of water into the waste, and to control release of volatile compounds from the waste. This section addresses these objectives by presenting an overview of typical cover system components, an approach suitable for the control of vapor emissions which may emanate from buried wastes at the site, and two process options which may be used as part of a remedial alternative.

Cover systems are comprised generally of a surface layer, protective layer, drainage layer, barrier layer, and gas collection layer. Table 3-2 presents typical unit costs associated with construction of cover systems.

Surface Layer

There are four alternative materials that can be used for the surface layer:

- Soil
- Soil with a geosynthetic erosion control layer placed at the surface
- Cobbles
- Paving Material

Of the four options for the surface layer, soil has been the most commonly used material. Paving material is considered a good candidate for use as cover material at the former Brooklyn Borough Gas Works site due to the proposed brownfield development and associated need for parking areas. A combination of soil, cobbles, or other structural materials may be employed along the Coney Island Creek boundary as a transition zone from the parking area to the creek.

Protective Layer

A protective layer (which will generally be some type of local soil or structural fill may serve several functions:

- To store water that has infiltrated into the cover until the water is later removed by natural mechanisms
- To physically separate the waste from burrowing animals, plant roots, or humans
- To protect underlying layers in the cover system from excessive wetting/drying or freezing (which could cause cracking)

Additional functions that may be served by a protective layer are structural support and elevation gains. The preference for a clean construction zone and locating commercial development above the 100-year floodplain are technical issues identified in Section 3.2. A protective layer of sufficient thickness can provide structural bearing capacity for a proposed commercial development while raising the elevation of the site above the 100-year floodplain elevation, a gain of approximately five feet across the western former manufacturing area.

If the protective layer is placed directly on a barrier layer, a plane of potential slippage exists at the interface between the protective layer and the barrier layer. The engineer must ensure that an adequate factor of safety exists at this and all other interfaces in the cover system. The steps that are usually taken to increase the factor of safety include use of different materials (stronger soils or textured geomembranes), addition of a drainage layer, flattening of slopes, or reinforcement of cover soils with geogrids or high-strength geotextiles.

Drainage Layer

A drainage layer is sometimes placed below the protective layer and above the barrier layer. There are three reasons why a drainage layer might be desirable:

- To reduce the pressure exerted by water on the barrier layer, which minimizes infiltration
- To drain the overlying protective layer, which increases the water-storage capacity of the protective layer
- To reduce pore water pressures in the cover soils, which improves slope stability

The materials used for drainage layers are:

- Sand or gravel with either a soil filter or a geotextile filter
- A thick geotextile, which serves as both a drain and a filter
- A geonet with a geotextile filter/separator
- A geocomposite drain, which consists of a polymeric drainage core and an overlapping geotextile filter/separator

Selection of the material type is usually based on economics; all the materials listed above will function adequately if designed properly. Proper design recognizes that water must discharge freely from the drainage layer at the base of the cover. If the outlet plugs or is of inadequate capacity, the toe of the slope will become saturated, develop excess pore water pressure, and potentially become unstable. Drainage pipes that commonly surround a site at its low elevations must have adequate capacity and cannot be allowed to plug.

Barrier Layer

The barrier layer is often viewed as the most critical engineered component of the final cover system. The barrier layer minimizes percolation of water through the cover system directly by impeding infiltration through it. It minimizes percolation indirectly by promoting storage or drainage of water in the overlying layers and eventual removal of water by runoff, evapotranspiration, or internal drainage.

There are seven options for the barrier layer component of a cover system that a designer may consider. They consist of compacted clay liners (CCLs), geomembrane liners (GMs), and geosynthetic clay liners (GCLs), or combinations thereof:

- A single compacted clay liner, or CCL
- A single geomembrane, or GM
- A single geosynthetic clay liner, or GCL

- A 2-component composite GM/CCL
- A 2-component composite GM/GCL
- A 3-component composite liner consisting of GM/CCL/GM
- A 3-component composite liner consisting of GM/GCL/GM

Design considerations for selecting a particular barrier system include:

- Design hydraulic conductivity of 1 x 10^{-7} cm/s or less
- Compaction on a gas collection layer or a soft foundation (e.g., waste materials or compressible soils)
- Desiccation
- Vulnerability to freezing
- Differential settlement of underlying materials
- Maintenance and repair criteria

Gas Collection Layer

The purpose of a gas collection layer is to collect gas for processing or discharge. Gases may be formed by microbiological degradation of organic matter and/or by volatilization of organic liquids. Organic gases can also be present in gas by volatilization of volatile organic liquids (solvents, fuels, etc.) or by biological decomposition of mixtures of organic matter and organic liquids.

The relative ease with which gas is capable of migrating through soil, often to significant distances, exacerbates the hazards of explosion and exposure. Movement of the gas will occur in sand, silt, or clay soil as long as there are connected voids. However, the rate of movement decreases as pore size decreases; therefore, movement will be greatest through highly permeable sand/gravel and least in clay soils. Utility and drainage corridors often provide pathways for gas migration.

The gases originating at MGP sites vent to the atmosphere by vertical migration and/or lateral migration. If the vertical path is sealed by a clay or synthetic liner, there is a greater tendency toward lateral migration. In general, waste disposal sites constructed in sand-gravel environments experience greater lateral movement of gases than sites in clay environments. Since gas migration and venting can result in significant hazard, special control systems are developed to minimize potential problems.

One form of control is gas collection and venting. Gas flows from the gas collection layer to vents that may be equipped with carbon adsorption canisters. Flow of gas may occur passively under the pressure gradient generated naturally or actively with assistance from a vacuum pump at the surface. A gas collection layer is only necessary for capped wastes that can produce gas or volatiles that must be released in a controlled manner to avoid pressurizing the containment cover.

The gas collection layer must have a high in-plane gas flow rate and must not become plugged with fine-grained materials. The usual materials are:

- Sand or gravel with a soil filter
- A thick geotextile that serves as both drain and filter
- Geonet drain and a geotextile filter

Any of these materials will function well if designed properly. Design considerations include an estimation of the quality and quantity of gas which may be generated, knowledge of local wind conditions, permitted discharge criteria, and proximity to sensitive receptors.

3.6.1.1 Thin Cover System

Construction of a thin cover system is one option to contain residual waste materials at the former Brooklyn Borough Gas Works site. This approach involves placement of selected cover system layers directly on top of the existing ground surface and underlying contaminated materials. Other than placement of individual cover system components of minimum specified thickness, this process option does not consider use of additional fill to satisfy developer needs or to raise the elevation of the site above the 100-year floodplain elevation. Subsurface utilities required as part of a commercial development would be installed in trenches excavated within "clean" utility corridors throughout the site. The bottom and sidewalls of the utility trenches would be incorporated into the cover system to minimize exposure of workers to contaminants that pose risks.

BU is actively pursuing brownfield development for the site. Technical issues identified in Section 3.2 include the need to provide developers with a clean construction zone and to raise the elevation of the site above the 100-year floodplain elevation. Use of a thin cover system is not consistent with brownfield development; therefore, it is not retained for consideration in remedial alternatives.

3.6.1.2 Fill on Cover System

This approach represents the preferred process option for containment of contaminated soils. In addition to construction of a multi-component cover system on top of a prepared surface, additional structural fill would be imported and placed over the cover. This additional fill would satisfy developer's needs for a clean construction zone and raise the elevation of the site above the 100-year floodplain elevation.

A critical aspect of this process option is the ability to provide soil bearing capacity to proposed structures without diminishing the protection provided by the cover system. On-site foundations for tanks and gas holders and nearby piers for the elevated Belt Parkway are built on piles which appear to terminate at varying depths. The need for these piles stems from the layers of organic and unconsolidated soils underlying the area. Piles transmit the loads of overlying structures across the depth of the soil column and use bearing or friction to provide necessary stability and support. If new commercial structures are built directly on piles, it will be necessary to engineer penetrations in cover system components that can effectively achieve design permeability criteria and still be constructed using conventional techniques. It may not be feasible technically to construct a low permeability liner of this complexity.

The use of a subsurface relieving platform can mitigate concerns about the ability to support structures while maintaining the integrity of a low permeability cover system. A relieving platform is essentially a large spread footing constructed on piles which can withstand forces exerted by overlying loads such as structural fill and buildings. By placing a relieving platform under and/or connected to cover system components, it is not necessary to design and construct multiple penetrations for piles. This simplifies construction while providing adequate structural bearing capacity on the surface for planned buildings and improvements. Alternatives to use of a relieving platform include in situ consolidation of soils by surcharging or dynamic compaction techniques. Design level studies and simulations can provide detailed information to select the best approach for achieving structural support objectives.

3.6.2 NAPL Containment Technologies

Containment of NAPL is most readily accomplished using vertical cutoff walls. Vertical cutoff walls isolate groundwater and contaminants within their boundaries and effectively control their horizontal movement. When used in conjunction with a surface cover system and installed properly, vertical barrier walls provide long-term protection against the migration of contaminants and minimize pathways which lead to off-site risks.

Typical applications and objectives of vertical barrier walls include:

- Minimize or eliminate off-site transport of contaminants using low permeability barrier materials that are resistant to degradation in the presence of contaminants
- Minimize or eliminate transport on-site of contaminants using low permeability barrier materials that are resistant to degradation in the presence of contaminants
- Minimize or eliminate off-site movement of groundwater using a barrier with a low hydraulic conductivity
- Minimize or eliminate movement on-site of groundwater using a barrier with a low hydraulic conductivity
- Provide secondary protection against off-site contaminant migration when the primary mechanism for risk reduction is hydraulic control (as in pumping from wells or trenches)
- Provide a barrier of known conductivity and retention time which controls the movement of groundwater and contaminants across its path to permit desirable treatment processes in situ (as in a reactive barrier wall)

There are several process options available for vertical barrier walls. This FFS focuses upon three proven candidate vertical barrier wall techniques which can be used alone or in combination to meet RAOs:

- Conventional soil/bentonite slurry wall
- Vibrating beam cutoff wall
- Sheet pile barrier wall

Each of the three process options described herein is retained for further evaluation in the FFS. The preferred process option to be included in alternative evaluations is the sheet pile barrier wall. The other two process options will be assessed through a cost sensitivity analysis and comparison of constructability in Section 5.0.

Conventional Soil/Bentonite Slurry Wall

Conventional slurry walls require excavation of a trench and placement of a soil/bentonite mixture of specified slump, hydraulic conductivity, and contaminant compatibility. Backhoes are used to dig the trench to desired depths, although at depths greater than 60 feet it is often necessary to use specialized equipment. A bentonite/water slurry is added as the trench is excavated to maintain the structural stability of the open excavation. Excavated materials are moved to a processing area where they are segregated for disposal or blended with bentonite, water, slurry, and/or clean fill to meet specified backfill requirements. The soil/bentonite backfill is then slowly dumped into the open excavation, displacing the slurry mixture, and allowed to advance longitudinally along the trench. Displaced slurry can be recycled for future use as trenching continues or can be used in the backfill mixture process.

Operational Considerations

There are several operational considerations for installation of a high-quality and permanent soil/bentonite slurry wall. The following general issues apply to trench excavation:

- Subsurface obstructions, debris, and utilities must be identified along the wall alignment to prevent damage to existing functional structures and to maintain a steady, uninterrupted construction process
- A working platform of suitable width and compaction must be in place along the alignment to support heavy equipment

- Health and safety controls, including measures to monitor and prevent migration of volatile emissions, must be instituted continuously along the wall alignment, which frequently conforms to property boundaries
- The bottom of the excavation should be relatively flat and within the desired soil stratum, if necessary
- It is important to have some freeboard in the trench to accommodate fluctuating levels of slurry

During backfilling, the following need to be considered:

- Standby pumps should be available to remove displaced slurry which is not being allowed to flow into new trench along the wall alignment
- Careful construction quality controls must be maintained where backfill is mixed to prevent introduction of off-spec material into the trench
- Minor overlapping of the previous day's backfill is recommended to provide continuity and integrity along the alignment
- The slope of the backfill advancing face needs to be measured several times a day
- Observed cave-ins need to be cleaned out to prevent formation of "windows"

Applications and Cost

Conventional soil/bentonite slurry walls have been used widely as vertical barrier walls at contaminated sites across the United States. The technology is proven and there are several contractors with equipment and field experience who can install walls to a range of depths. This process option can be used at the former Brooklyn Borough Gas Works site as long as provisions are made to address the widespread construction debris and subsurface structures throughout the site. This is especially important along the Coney Island Creek boundary, where tie-backs were used to support the bulkhead and remnants of historic process piping may be present. Geotechnical data from the site supports the presence of a discontinuous low permeability layer at depths less than 20 feet below ground surface. Additional geotechnical data generated during a design investigation would optimize selection of bottom depths to minimize migration of contaminants where discontinuities exist.

The cost of conventional soil/bentonite slurry walls range from $5 to $10 per vertical square foot, depending upon depth of wall, width of wall, backfill characteristics, and presence of subsurface obstructions.

Pros

- Technology is widely used and accepted by regulatory agencies
- Several qualified contractors are available for installation
- Offers increased control of subsurface conditions, particularly integration of wall sections, based on use of excavation and trenching procedures
- Relatively low cost compared to other vertical barrier techniques

Cons

- Generates excavated spoils which may need to be segregated, treated, and/or disposed due to contaminant content
- Productivity is lost during adverse weather conditions
- Difficult to install when large quantities of rubble, debris, or other underground obstructions exist
- Stringent quality control inspections must be maintained to ensure proper mix is used and excavation cave-ins are cleaned or redug to prevent formation of "windows" in the wall.

- Tends to release volatile emissions, if contaminants are present, which can migrate off-site or affect worker productivity due to increased level of protection

Vibrating Beam Cutoff Wall

This method of cutoff wall construction uses a modified beam to displace subsurface soils which creates a space for injection of bentonite grout. A typical beam may be 20 feet long by four feet wide and approximately four inches thick. The bottom and sides of the beam are equipped with injection nozzles which are attached to hoses running through the interior of the beam. A vibratory pile driver advances the beam to the desired depth, usually with introduction of grout to facilitate driving. After the desired depth is obtained, grout is injected into the space created by the withdrawal of the beam.

Operational Considerations

In typical applications, beams are advanced with approximately six inches of overlap. Beams are equipped with electronic sensors and stabilizers to prevent shifting along and perpendicular to the wall alignment, which can result in discontinuities. Some trenching may be required if subsurface obstructions or buried utilities are in the path of the wall.

Vibrating beams can be installed effectively at shallow depths up to 40 feet below ground surface. Vendors have installed vibrating beam walls to depths below 100 feet below ground surface. Understanding the soil stratigraphy at depth is important because vibrations may change the characteristics of soil and complicate advancement of panels. The strength of the beam must be considered as wall depth increases.

Applications and Cost

Vibrating beam cutoff walls are gaining wide acceptance as acceptable subsurface barriers. The cost of vibrating beam technology ranges from $5 to $10 per vertical square foot when wall depths are less than 40 feet below ground surface. Cost rises dramatically as wall depths extend deeper.

Pros

- Does not require extensive trenching and management of excavated spoils
- Minimizes health and safety concerns
- Installation can occur during inclement weather

Cons

- Difficult to assess quality of wall as it is being installed, especially at "joints"
- Limited to relatively shallow depths
- Difficult to install when large quantities of rubble, debris, or other underground obstructions exist

Sheet Pile Barrier Wall

Sheet pile barrier walls use traditional pile installation techniques with modifications to minimize leakage of groundwater. In traditional applications, steel sheet piles or other material, such as polyethylene, of varying length, depth, and thickness are installed in interlocking sections along a selected alignment. The piles provide structural support of soils and reduce water flow in excavations. Leakage at section interlocks is handled in typical applications by removal of water using wellpoints or other similar excavation dewatering methods.

To overcome leakage concerns, specialty chemical companies have developed seals and coatings that can minimize leakage along interlocks. One product is applied in the field as a coating on the female portion of the interlock approximately one hour before the pile is driven. The coating becomes gelatinous and adheres to the pile. When driven, the material fills the void between the interlocking sections and expands when it comes in contact with subsurface water. After expansion, the material hardens and essentially seals the gap between the two pile members.

Operational Considerations

Sheet pile driving is a standard construction practice provided by several experienced contractors. Piles are routinely vibrated or hammer-driven to depths in excess of 50 feet. Vibratory methods are less expensive and facilitate faster installation. Hammer-driving is necessary when vibratory methods pose the potential to undermine nearby structures.

The width and thickness of the sheet vary according to the desired depth and the geotechnical properties of the subsurface soils. Subsurface obstructions such as rubble and utility pipes must be removed to facilitate smooth installation. Overhead clearance is a concern when driving long sheets or hammer-driving are involved.

Coatings are applied routinely to steel sheets. These coatings provide resistance to chemicals present in the environment and extend the life of steel driven in harsh environments. Cathodic protection systems are also available to minimize corrosion of steel if stray current or cathodic attack are concerns. Sheets are also available in plastic materials to provide additional corrosion and chemical resistance.

Applications and Cost

Sheet pile barriers have been used in a wide variety of applications. Historically, leakage from the interlocks has prohibited consideration of sheet piles as acceptable vertical barriers. With recent improvements to minimize leakage through sheet pile interlocks, this vertical barrier technique has overcome a major drawback. USEPA accepted consideration of sealable steel sheet piling in their Record of Decision for Niagara Mohawk Power Corporation's Saratoga Springs Former Manufactured Gas Plant Site (USEPA, 1995). A contractor in New York City reported the successful use of sealable steel sheet piling at the MTA railyard adjacent to the former Brooklyn Borough Gas Works site.

The cost for typical steel sheet pile barriers ranges from $15 to $25 per vertical square foot installed. Costs depend on depth, design modulus of the steel, driving method, subsurface obstructions, and coatings.

Pros

- Does not require extensive trenching and management of excavated spoils
- Minimizes health and safety concerns
- Installation can occur during inclement weather
- Piles can be installed rapidly using either vibratory or driving methods, depending on proximity to nearby structures
- Steel sheets can also provide structural support for backfill and cover system components

Cons

- Relatively expensive compared to other barrier technologies, although costs may be defrayed due to reduced materials handling concerns
- Difficult to assess continuity of barrier at sheet interlocks
- Special coatings and cathodic protection systems may be necessary to minimize corrosion induced by chemicals and harsh environments
- Difficult to install when large quantities of rubble, debris, or other underground obstructions exist

3.6.3 Air Emissions and Odor Containment Technologies

Odors and emissions from soil containing elevated concentrations of volatile organic compounds and NAPL represent a potential short-term risk to site workers during soil excavation, material handling, and other activities which disturb the subsurface. The potential for an adverse public reaction due to odors and emissions, particularly during warm weather months, must be considered in addition to the safety precautions needed for workers. The proximity of the site to the MTA ROW, Shore Parkway, and densely populated areas warrants an approach which can facilitate the performance of emission- and odor-producing activities safely and expediently.

Temporary construction enclosures provide safe and economical controls for releases of potentially harmful emissions and nuisance odors. Enclosures are supplied in a variety of sizes and shapes and may be inflated on-site or erected using conventional construction equipment. Temporary enclosures are light-weight and can be moved easily with cranes or pulled along tracks. Enclosure materials are typically high opacity fabrics which allow sunlight to pass through but help minimize the escape of emissions and odors. With a properly designed ventilation system, negative pressure can be maintained within the enclosure, providing clean air from the outside to displace contaminated air which is pulled under vacuum to a vapor treatment system before atmospheric discharge. Temporary enclosures are retained for emission and odor control purposes in the development of remedial alternatives.

Water sprays and odor-suppressing foams have been used with mixed success at other MGP sites. Sprays and foams, when successful, cover exposed materials and minimize the volatilization of contaminants. The sprays and foams pose secondary material handling concerns and can impede preparation of material for transport, treatment, or disposal. Selection of the best suppressing agent often requires field trials, which may be time-consuming and costly, particularly if the foam is successful in small trial applications but fails during widespread use. Recognizing there may be short-term or localized needs for odor and emission suppression outside of temporary enclosures, these technologies are retained for consideration as secondary controls.

3.7 Source Removal

This section presents approaches to satisfy the historical preference expressed by EPA and NYSDEC for removal of source materials which can pose continuing risks to human health and the environment. In the context of this FFS, source removal focuses on coal tar sources, soils with contaminant concentrations in excess of RBCs, and NAPL confined within a subsurface barrier.

3.7.1 Excavation

Excavation of source materials entails use of conventional equipment such as track and wheel excavators, backhoes, dozers, and trucks for removal, movement, and on-site transport of materials. This equipment is readily available and highly effective for the types of materials and depths being considered. As a conservative estimate, the unsaturated zone is assumed to extend uniformly six feet below ground surface across the site. Contaminants within the saturated zone will be handled as part of NAPL collection and treatment schemes due to the technical impracticability of removing the mass of contaminants within the saturated zone. Therefore, excavation is limited to a portion of the upper six feet of soil. At this assumed depth and without concerns for significant dewatering, excavation of source materials should proceed with relative ease. Detailed design optimization will consider the variability of site groundwater levels and contaminant distribution to refine the conservative assumption and excavation method described herein.

The options discussed in this section focus on different methods to attain of RAOs. Excavation of soils in the assumed unsaturated zone to RBC levels is presented as a means of addressing identified risks to unprotected future construction workers while also removing areas of significant contamination. The excavation of coal tar source areas identified and documented during the various field investigations conducted at the site represents an approach to risk management which can achieve identified RAOs when implemented in conjunction with a cover system. By providing a "clean" utility corridor with levels of soil contamination below RBC levels, it may be possible to implement the thin cover system described in Section 3.6.1.1.

3.7.1.1 Excavation to Risk-Based Cleanup Levels

This option entails removal of soils with concentrations of contaminants in excess of RBCs. Tables 1-7, 1-8, and 1-9 present the RBCs for attainment of risk goals of 1×10^{-4}, 1×10^{-5}, and 1×10^{-6}, respectively. By removing these soils, the RAO to control potential future exposures of construction workers to subsurface soils is addressed. The RAO may not be achieved to extent necessary for complete protection of workers if the potential for contact with saturated zone soils remains after implementation of remedial actions. Therefore, excavation to risk-based cleanup levels must be accompanied by other measures, such as institutional controls or a cover system, to satisfy the RAO.

Table 3-3 presents area and volume estimates for areas of excavation associated with 1×10^{-4}, 1×10^{-5}, and 1×10^{-6} risk goals for depth intervals ranging from 0 to 2 feet, 2 to 4 feet, and 4 to 6 feet below ground surface. These areas were determined by comparing available soil boring data at 2-foot intervals to RBC concentrations. Any exceedance of an RBC by any contaminant within a particular depth interval raised a "flag" for the interval. A 50-foot radius was drawn around each flagged boring at each depth interval. The edges of the radii were connected, as appropriate, to apply additional engineering judgment to the creation of RBC excavation zones. The total estimated volume of soil for removal, ranging from approximately 73,000 cy for the 1×10^{-4} case to approximately 85,000 cy for the 1×10^{-6} case, will require disturbance across approximately 60% of the site. Control of erosion and runoff from this large area will be critical during removal activities. A fairly large temporary water storage and treatment system will be needed to accommodate accumulating precipitation and standing water in excavations. The magnitude of site disturbance will require use of construction enclosures across the site to mitigate concerns from volatile emissions and odors.

Excavation to RBCs is viable for attainment of RAOs. Therefore, this approach is retained for consideration in alternative development.

3.7.1.2 Coal Tar Source Removal

Removal of coal tar source areas entails excavation and removal of observed coal tar sources to the assumed depth of groundwater six feet below ground surface. Subsurface boring data, test pit logs, field observations, and historical drawings were reviewed to develop the area and volume estimates associated with presented in Table 3-3. In general, a conservative 100-ft radius or buffer was drawn around a boring, test pit, or surface seep where coal tar has been noted. The edges of radii were connected to apply additional engineering judgment and conservatism to identification of source areas. Variability across discrete depth intervals was not examined due to the level of qualitative judgment and conservatism desired. Planned geophysical and geotechnical investigation during detailed design will refine the FFS estimates and define clear excavation boundaries for future remedial actions.

The estimated volume of material to be removed is approximately 22,000 cy. Approximately 15% of the surface soils across the site would be disturbed to accomplish coal tar source area excavation. Construction enclosures would be used to mitigate volatile emission and odor concerns. Erosion control measures and collection/treatment of accumulating water in and around excavations would be performed to maintain a safe and workable construction site.

By itself, the excavation and removal of coal tar sources does not satisfy the RAO for protection of construction workers. Soils in excess of RBC concentrations outside of the coal tar source areas would remain in place. However, where coal tar source area removal is performed in conjunction with installation of a cover system, construction workers would be protected. Institutional controls would be required as well to prevent uncontrolled disturbance of contaminated soils below the cover system in the future.

The removal of coal tar sources is consistent with NYSDEC directives for former MGP sites and is recognized by utilities in New York as a necessary measure to prevent further degradation of the environment. Removal of coal tar sources in the unsaturated soils at the former Brooklyn Borough Gas Works site will significantly reduce the contaminant load that may be exerted on the shallow aquifer. While this aquifer does not pose a human health risk, and a vertical barrier would address impacts to Coney Island Creek, it nevertheless is prudent to eliminate as much coal tar source material as technically practicable for treatment and disposal or recycling. Therefore, this option for source removal is retained for consideration in alternative development.

3.7.1.3 Clean Utility Corridor

This approach to source removal involves excavation of contaminated soils in excess of RBCs and coal tar sources along utility corridors in a proposed brownfield development. Removing these soils addresses the RAO for protection of future construction workers. The continued presence of contaminants in the saturated zone and the potential for generation of volatile emissions would preclude unhindered access to utility lines. Therefore, institutional controls and access restrictions would be necessary.

As discussed in Section 3.6.1, a clean utility corridor is appropriate when used in conjunction with a thin cover system. Thin cover systems were not retained for consideration in alternative development because they are not consistent with brownfield redevelopment plans for this site. Therefore, clean utility corridors are not considered viable for the site and are not retained for alternative development.

3.7.2 NAPL Capture (Collection)

There are several NAPL recovery options available for use at the site. These recovery technologies are typically used in conjunction with the long-term NAPL containment technique discussed in Section 3.6.2. NAPL can either be lighter than water (LNAPL) or denser than water (DNAPL). Previous investigations have identified the presence of both LNAPL and DNAPL at the site. DNAPL is present in isolated instances, relatively small quantities, and does not appear to be migrating into Coney Island Creek. LNAPL has been observed throughout the former manufacturing area and is known to seep into the Coney Island Creek. BU conducted an IRM in 1995 to control the LNAPL seep. The IRM, which includes extraction wells, a hard boom, and a collection tank, is still in operation.

Conventional technologies for the capture of NAPL include vertical wells, horizontal wells, and trenches used individually or in combination. Wells function by exerting energy in the subsurface environment to draw in liquids from a predictable radial distance. Trenches with collection piping typically represent a more passive longitudinal recovery approach. Recovery trenches are placed perpendicular and downgradient to the flow of NAPL. They are constructed to have a relatively high permeability which facilitates transport of captured water along the length of the trench via large diameter perforated collection piping to desirable extraction points (e.g. sumps).

Wells and trenches are very effective at removing NAPL from subsurface environments similar to those at the former Brooklyn Borough Gas Works site. Recognizing that a proposed NAPL recovery scheme will be installed in conjunction with a longitudinal perimeter barrier, it is prudent to consider the installation of a longitudinal trench as the primary means to recover NAPL. Tidally induced fluctuating groundwater levels can be accommodated simply in the trench by applying a conservative trench depth relative to the observed and predicted groundwater table elevations. By injecting steam or hot water periodically along the length of the trench it will be possible to mobilize trapped NAPL constituents and maintain system performance.

Trenches are installed with sloped bottoms to move captured fluids to desired extraction points. Sumps with controlled pumping and monitoring systems are located at extraction points along the length of the trench. Dual phase pumps with sophisticated sensors and controls respond to the accumulation of groundwater and floating NAPL within the sump to lift fluids from the subsurface and convey them to storage and treatment facilities. DNAPL and other settled sludges collecting at the bottom of the sump are removed manually using a vacuum truck.

Recovery trenches are retained for consideration in this FFS as the primary means of capturing NAPL. They provide the benefit of collecting groundwater that may accumulate under the cover system due to pressure exerted by the aquifer below the site. Trenches provide a passive means to dissipate the energy associated with groundwater mounding and maintain the desired upwelling of subsurface water. This controls downward flow and minimizes potential release of contaminants from the site. Vertical and horizontal wells are retained as process options. There may be complex subsurface phenomena, particularly in and near the seep, which may warrant use of active pumping to supplement the passive recovery measures inherent with a trench.

3.8 Treatment Technologies

Treatment technologies are presented for soils and groundwater/NAPL. After soil is excavated, it will need to be processed and handled to facilitate recommended treatment options. Soil may be reused, recycled, or treated in a permitted facility. Collected groundwater/NAPL will require some level of treatment prior to discharge after it is removed from the aquifer. Consideration is given to several processes which may be used individually or in combination to reduce the concentrations of chemical constituents identified in the RI.

3.8.1 Soil Treatment

3.8.1.1 Materials Handling and Processing

Preparation of excavated soils involves consolidation, screening, and/or blending for material handling purposes. Consolidation is the process of excavating and transporting materials from different locations to a central processing area. The potential for large volumes of excavated materials coupled with associated odors and emissions makes it desirable to reduce the number of material handling activities and to have these activities performed in a central, enclosed location. After staging soils in a central area, they can be consolidated for other handling or disposal activities.

Soil screening involves particle size reduction and debris removal from excavated soils to meet transport, treatment, or disposal requirements. Bulk solids are fed into a hopper and the materials pass through screens which remove material according to pre-defined size constraints. Separate piles are generated according to size. Debris, rocks, and boulders, which can often be steam-cleaned as a decontamination step, are subsequently managed separately from contaminated soils.

Blending can be accomplished by mixing RCRA hazardous soils with stabilizing compounds such as coal or another adsorbent solid material. During a typical MGP waste blending process, volatile constituents in soil and tar residues are adsorbed by the coal. New York State Electric & Gas Company (NYSEG) uses its utility boilers to recover heating value from nonhazardous wastes which have been rendered from hazardous wastes using coal blending. The quantity of soil in a typical mixture of nonhazardous coal blend constitutes approximately 4% to 5% of the material. Therefore, it is important to use other techniques, such as consolidation and screening, to minimize the volume of waste requiring treatment.

In a letter dated august 13, 1996, NYSDEC provided written assurance to Brooklyn Union that they would be granted authorization to blend coal tar wastes in a manner consistent with USEPA and NYSDEC policy (Eric R. Obrecht, P.E., Project Manager, Central Field Services Section, Bureau of Construction Services, Division of Hazardous Waste Remediation to Dennis Harkawik, Esq., Jaeckle, Fleischmann & Mugel, on behalf of Brooklyn Union). Central to this authorization was consideration of the EEI MGP Site Remediation Strategy Guidance document and use of 90-day accumulation units sanctioned by USEPA to blend coal tar materials with combustible media such as coal, coal fires, less contaminated soil, or other suitable media. In an August 21, 1998 letter by USEPA Acting Director, Office of Solid Waste, Elizabeth A. Cotsworth clarified concerns regarding the interpretation of blending as dilution. USEPA does not view the blending process as impermissible dilution as soon as blending processes produce chemical or physical changes in the contaminated soils. Better construction performance using coal fires in a blending process is an example of a chemical change. Blending with less contaminated soil is a physical change which can enhance contaminated soil feed rates and materials handling in thermal desoprtion or other units. Simple dilution with clean soil to reduce contaminant concentrations is not permissible.

These materials handling and processing techniques are employed routinely at contaminated sites. They are retained for consideration in the development of remedial alternatives.

3.8.1.2 Reuse and Recycling

Recycling alternatives consist of raw material and fuel uses. Raw material reuse pertains to recycling soils by incorporating the media of concern into the production of asphalt, bricks, and cement (ABC). Fuel use recycling consists of using high British Thermal Unit (BTU) content NAPL material and soil containing NAPL as a supplemental fuel in cement kilns and utility or industrial boilers.

Asphalt Batching

Asphalt batching is a widely demonstrated technology for the reuse of petroleum contaminated soils. During asphalt batching, contaminated soils are essentially mixed with asphalt, aggregate, and other emulsions to create a product for use in paving and backfilling. Asphalt batching can occur both as cold-mix and hot-mix processes, both of which are described below.

Cold-Mix Asphalt Batching

Cold-mix asphalt batching has been used successfully to immobilize and reuse MGP-contaminated soils and residues. Asphalt batching is essentially an ex-situ stabilization process that binds up contaminated soil and tarry residues into the matrix of an asphalt product by mixing them with wet aggregate and asphalt emulsion at ambient temperature. The product is then used in paving surfaces.

In the cold-mix asphalt batch process, wet aggregate material and an asphalt emulsion are mixed and placed at ambient temperature. The cold-mix batch product is then cured or allowed to set undisturbed for a mix-specific period. This curing process can begin either before or after the pavement has been placed and compacted.

The asphalt batching process is generally performed in several steps:

- Excavation and stockpiling of materials
- Material preprocessing (typically screening and crushing material to the desired size)
- Stabilization with asphalt emulsion reagent
- Curing in a stockpile

- Surface placement of material

The final product is a material that can be used as a sub-base for paving in areas of heavy vehicular traffic. Additional grading and paving or excavation is often required around the treated material to accommodate the extra height of the cured material.

Cold-mix asphalt batch products are typically produced either at a central plant location or are mixed in-place. The decision to produce a central plant pavement or a mixed-in-place pavement must consider the intended use, logistics and economics (EPRI, 1997).

Operational Considerations

This technology requires a treatability study to test leachability and engineering properties of the treated material. The mix design is dependent upon the performance requirements of the finished product. Clayey soils are generally not appropriate because a high clay content will reduce the strength of asphalt concrete. However, soils with high clay or loam content can be mixed with high grade aggregate to produce a material used in lower performance applications such as parking lots or driveways. Similarly, the percentage of fine grains in the contaminated soil should be less than 20 percent passing the Number 200 sieve since excessive fine-grained particles could lead to both an increase in the required asphalt content and performance problems such as cracking and instability.

Applications and Cost

Cold-mix asphalt batching is not applicable for RCRA-hazardous wastes. If the materials may be rendered non-RCRA either by consolidation or pretreatment (e.g., thermal desorption), then the technology may be applied. Before processing soil, an off-site asphalt batching facility typically examines the physical and chemical characteristics of the soil to determine if it can be incorporated into a usable quality of pavement. For off-site asphalt batching, the pre-acceptance criteria for using tar-containing soil in asphalt batching is plant-specific and designed to meet certain chemical and physical thresholds. None of the pre-acceptance criteria require that the chemistry of the MGP tar be examined to see how closely it resembles that of asphalt (EPRI, TR-108597, December 1997). The analytical requirements of the batch plant may include EPA-certified analyses for volatile and semi-volatile organic compounds, petroleum hydrocarbons, pesticides, herbicides, and metals. Typically, the criteria for acceptance for benzene, toluene, ethylbenzene, xylenes and metals will be low enough to ensure that the material will pass the TCLP test.

Since few full-scale applications of this technology have been implemented, cost information is limited. In California, vendor quotations have ranged from $40 to $50 per ton for on-site cold asphalt batching, and $60 to $70 per ton for off-site asphalt batching (transportation included).

Pros

- Material is reused rather than disposed off-site.
- Effective in immobilizing PAHs.
- For MGP tars, it is one of the few viable technologies available.

Cons

- Soil expansion is a concern in cold-mix asphalt batching.
- Curing times can be long, particularly in cold weather.
- Potential for leaching of contaminants from the asphalt, particularly cyanide (since the pH of the soil is raised).
- Treatment is primarily limited to gravelly soils and sands.
- There are few examples of the long-term durability of the product.

- There may be difficulty identifying an off-site local facility that is technically prepared and permitted to process MGP wastes.
- For on-site applications, there should be an identified need and compatible use for the end product.
- Depending on the material used, the physical properties of the final product do not always conform to the needs of vehicular traffic.

Hot-Mix Asphalt Batching

Hot-mix asphalt batching has been demonstrated at the pilot-scale level to immobilize and reuse MGP-contaminated soils and residues. Hot-mix asphalt batching is essentially an ex-situ stabilization process that blends contaminated soil and tarry residues with aggregate and asphalt emulsion to create a hot asphalt product. In addition, the high processing temperatures of hot asphalt batching volatilize the lighter-weight compounds found in MGP wastes (e.g., benzene) and promote formation of a homogenous blend of aggregate and asphalt cement. Materials treated via hot-mix asphalt batch are used in paving surfaces.

Most asphalt plants in the northern United States shut down in winter months, thus limiting the year-round implementability of hot-mix asphalt.

The hot-mix asphalt batching process is generally performed on-site or off-site in several steps:

- Excavation and stockpiling of materials
- Material pre-processing (typically screening and crushing material to the desired size)
- Heating and drying aggregate material prior to mixing
- Stabilization of dried material with asphalt emulsion reagents
- Compacting the finished product at temperatures well above ambient
- Surface placement of treated material

The final product is a material that can be used as a sub-base for paving in areas of heavy vehicular traffic. Additional grading and paving or excavation is often required around the treated material to accommodate the extra height of the cured material.

Operational Considerations

Hot-mix asphalt batching requires a treatability study to test leachability and engineering properties of the treated materials. The mix design is dependent upon Marshall and Hveem testing and the performance requirements of the finished product. Clayey soils are generally not appropriate because a high clay content will reduce the strength of asphalt concrete.

However, soils with high clay or loam content can be mixed with high-grade aggregate to produce a material used in lower performance applications such as parking lots or driveways. Similarly, the percentage of fine grains in the contaminated soils should be less than 20 percent passing the Number 200 sieve, since excessive fine-grained particles could lead to both an increase in the required asphalt content and performance problems such as cracking and instability.

Applications and Cost

Hot-mix asphalt batching is not applicable for RCRA-hazardous wastes. If the materials may be rendered RCRA non-hazardous either by consolidation or pretreatment (e.g., thermal desorption), then the technology may be applied. Prior to processing soil, an off-site asphalt batching facility typically examines the physical and chemical characteristics of the soil to determine if it can be incorporated into a usable quality of pavement. For off-site asphalt batching, the pre-acceptance criteria for using tar-containing soil in asphalt batching are plant-specific and designed to meet certain chemical and physical thresholds. None of the pre-acceptance criteria require that the chemistry of the MGP tar be examined to see how closely it resembled that of asphalt (EPRI, TR-108597, December 1997). The analytical requirements of the batch plant may include EPA-certified analyses for volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), petroleum hydrocarbons, pesticides, herbicides, and metals. Typically, the criteria for acceptance for benzene, toluene, ethylbenzene, xylenes, and metals will be low enough to ensure that the material will pass the TCLP test.

Since few full-scale applications of this technology have been implemented, cost information is limited. In California, vendor quotations have ranged from $60 to $70 per ton for off-site asphalt batching (transportation included).

Pros

- Material is reused rather than disposed of off-site.
- Effective in immobilizing PAHs and volatilizing VOCs.
- For MGP tars, it is one of the few viable technologies available.

Cons

- Potential for leaching of contaminant from the asphalt product.
- Treatment is primarily limited to gravelly soils and sands.
- For off-site asphalt batching, there may be difficulty identifying a local facility that is technically prepared and permitted to process MGP waste.
- There are few examples of the long-term durability of the product.
- For on-site application, there needs to be an identified need and use for the end product.

Brick Manufacturing

Contaminated soils from coal tar sites can be mixed with raw feed materials to produce bricks. The soil is incorporated into a crushed powdery shale and clay mixture which forms green brick after addition of water. Green bricks are air-dried at 100°F to 600°F until a moisture content of 1% is reached. Dried bricks are preheated at the front of a kiln at a temperature of 1000°F and then fired in the kiln at 1500°F for approximately 12 hours. Bricks are allowed to cool and then shipped for use.

Operational Considerations

Brick manufacturing processes prefer clayey and silty soils. Crushing, screening, and blending are required as pre-processing steps to achieve maximum particle sizes ranging between 2 inches and 6 inches in diameter. Construction debris such as concrete presents problems with brick manufacturing processes; this material must be screened and removed prior to transport to the manufacturing facility.

Applications and Cost

Demonstration tests have been conducted by Niagara Mohawk Power Company at two separate brick manufacturing plants. Volatile emissions were monitored and found to be within permitted limits. Final products met all ASTM brick standards for strength, absorption, suction rate, and efflorescence. Residual levels of BTEX, PAH compounds, and cyanide were not detected in bricks.

Costs from the demonstration test ranged from $55 per ton for recycling only to an estimated $102 per ton for preparation, transport, and processing.

Pros

- Recycles waste material and does not create a secondary waste legacy
- Competitive with regard to costs of treatment

Cons

- Limited number of permitted facilities available for recycling
- Not applicable to coal tar residuals

Cement Manufacturing

Contaminated soil and coal tar residuals can be introduced into a cement kiln as part of raw feedstock. Material can be fed into the kiln wet or dry where it enters the preheating zone at a temperature of 1500°F. After preheating, wastes and feedstock are transported into the calcining zone where CO_2 is driven off at a temperature of 2200°F. After calcining, material enters the sintering zone at a temperature of 3500°F where clinkers are formed, cooled, mixed with gypsum, and ground to from the cement product.

Operational Considerations

Cement kilns place stringent requirements on wastes they accept for recycling. Moisture content is generally limited to 15%. Rocks and debris greater than 2 inches in diameter must be removed and smaller rocks are generally limited as a small percentage of contaminated soil. Metals content is scrutinized to prevent off-spec finished product, damage to kiln walls, and exceedances of air permit requirements. Some facilities do not permit the disposal of RCRA hazardous waste; therefore blending or pre-treatment before transport is often required.

High BTU liquid and solid wastes may be used as alternative fuels. Wastes with lower heat content are combined with feedstocks and become bound in the finished product.

Applications and Cost

Cement kilns are used widely in Europe for disposal of contaminated media. USEPA has permitted facilities to accept hazardous and nonhazardous soils, sludges, and residuals. Recycling of coal tar residuals has been employed by Northern States Power Company, Iowa Gas & Electric Company, Niagara Mohawk Power Company, and IES Utilities. Cement manufacturers who accept coal tar residuals and contaminated soils include Giant Resource Recovery Co., Inc. in South Carolina, Heartland Cement Co, in Kansas, and Continental Cement in Missouri.

Costs for transport, treatment, and disposal range from $100 per ton to $175 per ton. Additional costs would be incurred for material handling, characterization, and blending, as needed.

Pros

- Cement kilns provide an effective set of conditions for residual destruction
- Additional treatment of materials is not necessary
- Flexible process facilitates wet and dry introduction of waste streams
- Virtually all metals are stabilized as part of clinker and kiln dust and do not leach
- Material is recycled and does not present any waste legacy issues

Cons

- Relatively expensive compared to other process options
- Few permitted vendors available for disposal
- MGP wastes compete with higher BTU-content waste streams for destruction in kilns

Coburning

One approach that has been used for the remediation of MGP source material is the coburning of MGP wastes. In this process wastes such as coal tar and tar-contaminated soils are combusted along with coal in utility boilers. Developed by the Edison Electric Institute's (EEI) subcommittee for MGP sites with technical support from Electric Power Research Institute (EPRI), this technology calls for remediation waste recovered during site excavation to be blended with coal so as to render it nonhazardous for coburning in utility boilers. EPRI also developed a sampling approach that is consistent with EPA test methods for characterizing the soils and wastes and for developing blending ratios for treating soils in a quicker, less expensive manner than the EPA leaching procedure. This strategy ensures that only nonhazardous MGP wastes are coburned in utility boilers, yet it avoids burdening utilities with the RCRA hazardous waste permit program and the high cost of commercial incineration (EPRI, 1995).

Operational Considerations

Utilities have coburned MGP site residuals in a variety of utility boilers, including stokers, cyclones, and pulverized coal-fired boilers. Residual preparation consists of screening to remove oversized material and rendering the material nonhazardous under RCRA, if necessary (GRI, 1996). MGP materials are typically blended with coal feedstock in the range of 5 to 10 percent. The BTU content of the residual is not critical because it is not intended to be a fuel supplement to the boiler. Coburning will significantly increase the amount of ash requiring management. For example, a 10-percent coburning mixture will double the amount of ash generated by the boiler (GRI, 1996).

Applications and Cost

This technology has been used as part of a full-scale remediation at several MGP sites. Media that have been treated include coal tars, purifier box wastes and contaminated soils. Coburning is currently offered as a commercial service by New York State Electric and Gas (NYSEG) at two of their facilities. The cost of coburning at a case study in Rochester, New York ranged from $44 to $142 per ton for soil and from $134 to $309 per ton for tars.

Pros

- Coburning constitutes a reuse or recycling of waste materials into a usable product.
- It has been demonstrated to be technically feasible to destroy organic contaminants.
- Allows utilities to expedite flexible, cost-effective remediation at MGP sites.

Cons

- Long term impact of coburning on boiler efficiency, maintenance and operation is unknown.

3.8.1.3 Thermal Desorption

Full-scale thermal desorption is a technology that has been successfully applied to the remediation of soils containing MGP wastes. Thermal desorption has been used since the early 1980s, achieving reductions of more than 98% in total petroleum hydrocarbons, BTEX compounds, PAHs, and cyanide. Thermal desorption has been used mainly in non-MGP applications, although it is increasingly gaining wider acceptance as a MGP remediation technology. The technology can be applied on-site with a mobile unit or at an off-site facility.

Thermal desorption is a treatment technology that uses heat ranging between 400°F and 1200°F to desorb chemicals from the soil. Soil is fed into a material dryer where heated air causes chemicals to volatilize. In general, temperatures between 200°F and 900°F are required to desorb VOCs and many of the PAH compounds. Higher-temperature units (up to 1,200°F) are required to desorb the additional high molecular weight PAHs. The offgas is then directed to an abatement (e.g., carbon adsorption) unit. After chemicals in the offgas are treated, the cleansed air is vented into the atmosphere. The dry, hot soil is then discharged to a pug mixer where water is introduced to reduce dust and lower the temperature. The quenched soil is discharged and transported to a stockpile. Each day's production volume of soil is held separately while the residual concentrations are determined. The treated soil is then returned to the excavation or transported to an off-site facility for disposal or recycling. A typical thermal desorption unit can treat approximately 8 to 45 tons per hour, depending on soil conditions (e.g., water content, waste concentrations, etc.) and the size of the unit used.

Operational Considerations

Operational considerations include soil type and characteristics, contaminant type and concentrations, moisture content, organic material content, pH, compound volatility, temperature and residence time during drying. This technology requires a pilot test demonstration. Consolidation and blending are recommended to reduce variations in organic concentrations. If these techniques can be used successfully to render RCRA hazardous materials into RCRA nonhazardous materials, they can be treated at off-site fixed thermal desorption facilities.

Application and Cost

Full-scale systems have achieved a destruction removal efficiency (DRE) of 99% treating contaminated soils from MGP sites at temperatures of 750°F to 850°F and residence times of approximately 10 minutes (GRI, 1996). On-site treatment costs range from approximately $110 to $130 per ton of soil and off-site treatment costs range from approximately $100 to $200 per ton of soil. Estimates include costs for general contracting, confirmation sampling, construction management, permitting and transportation for off-site treatment (GRI, 1996).

Pros

- Demonstrated effective in reducing PAHs to less than 1 mg/kg under correct conditions
- 80% to 99% removal of carcinogenic PAHs
- 90 to 99.7% removal of total PAHs (EPRI, 1996)
- Production rates of 8 to 15 tons per hour for small units and 25-45 tons per hour for large units.

Cons

- Hazardous levels of contaminants possibly limit technology at off-site, fixed facilities
- Very wet and saturated media must be dewatered prior to treatment
- Soil with high organic content (peat) may cause material handling problems and may have diminished DRE
- Air emissions of compounds such as chlorinated compounds, sulfur, and nitrogen oxides may need to be abated.

3.8.2 NAPL Treatment

NAPL treatment is typically accomplished via chemical, physical, or biological technology, either singularly or in combination. Multiple water treatment processes are generally needed for aqueous streams that contain a complex mixture of compounds to meet specified discharge requirements. The NAPL and groundwater aqueous mixture at the former Brooklyn Borough Gas Works site contains PAHs, VOCs, SVOCs, pesticides, inorganics, cyanide, TPH, and NAPL. The waste stream is characterized by both dissolved and non-dissolved constituents. The non-dissolved contaminants, such as TPH, NAPLs, and metals, are removed first via phase separation to prevent downstream fouling of the treatment equipment. As the free-phase LNAPLs separate via gravity, the metals and DNAPLs can settle and separate from the wastewater. The wastewater is then filtered to increase the percent removal of trace metals and solids prior to downstream treatment. The presence of free-phase NAPLs can potentially interfere with the removal of VOCs, SVOCs, and pesticides treated in downstream units if phase separation is not employed as a preliminary treatment step.

Due to the high vapor pressure of the volatile compounds, dissolved VOCs are efficiently removed through the transfer of the contaminants from the liquid phase to the vapor phase, after the non-dissolved contaminants are removed. However, the volatile emissions, in addition to the SVOCs and pesticides, must be treated further through polishing, in order to achieve the desired effluent quality.

Innovative treatment technologies are not being investigated at this time due to the wide array of conventional treatment processes for the contaminants of concern. Consistent with the focused nature of this report, only proven technologies are being considered to treat the array of contaminants.

The first step of treatment is the removal of insoluble material such as suspended solids and free-phase hydrocarbons, including NAPL. These materials have the ability to disrupt downstream unit operations by plugging lines and clogging equipment, clogging carbon, and raising effluent discharge limits. A phase separator is implemented to separate the NAPL and other insoluble material from the water. This method can be employed because the specific gravity of NAPL differs greatly from that of water. The phase separator may be oversized in order to increase the detention time and aid the separation process of NAPLs and inorganics from the groundwater. A corrugated plate interceptor (CPI) oil/water separator will remove 100% of all 58 micron and larger dispersed oil and free oil droplets having a 0.10 specific gravity differential with the carrier fluid (water). Another process option for the initial stage of the treatment system is dissolved air flotation. This unit operation employs pressurized air released into a tank to enhance the removal of NAPL and solids.

The second step of treatment commonly involves a chemical treatment step for the removal of inorganics, such as metals. This is accomplished through chemical precipitation. A base is added to the wastewater to form metal hydroxides, which will settle to the bottom of a given process unit. Caustic (NaOH) is often used as the base. Although it is more expensive than lime, it is available in liquid or solid form, in-line addition is feasible, minimum retention time is required, and there is less sludge generation. The phase separation and chemical precipitation steps can be carried out using the same piece of equipment, the CPI.

With chemical precipitation, dissolved metals such as iron and manganese are precipitated under oxidizing conditions to prevent the fouling of downstream equipment and a reduction in the treatment removal efficiency. Typically, sand filtration is employed as a polishing step to remove particulates not removed by settling following the chemical precipitation step.

The next unit operation that is needed is for the removal of VOCs. Air stripping is typically used for VOC removal, such as BTEX compounds, and is usually followed by activated carbon for polishing and removal of SVOCs and other organic compounds. Air strippers can be used alone if only treatment of VOCs is needed to meet effluent discharge limits; however, removal of grease, suspended solids, and dissolved inorganics such as iron and manganese would be required prior to air stripping to prevent fouling of the unit. An air treatment train for offgases is often required, typically with carbon adsorption units. This could add additional costs to the treatment for the management of the spent activated carbon. Air strippers can achieve removal rates greater than 99%.

Activated carbon is employed as a polishing step for both the offgas treatment in the vapor phase and for the stripped liquid in the liquid phase. Drawbacks to this treatment involve the need to regenerate the carbon or to backwash the column to maintain desired treatment levels. Typically, manganese and iron in the waste stream need to be reduced to less than 1 mg/L to prevent precipitation in the carbon column. These factors can add significant cost to treatment using activated carbon.

Biological treatment may be used as a treatment step in lieu of the air stripper and/or carbon adsorption system. This technology uses the biological and biochemical mechanisms of microorganisms for the decomposition of organic material. A priority to consider for biological treatment is the balance between contaminant load and micro-colonies. In general, aerobic degradation processes are more often used for biodegradation because the degradation process is rapid, reactions reach completion, and problematic end products (methane, hydrogen sulfide) are not produced as with anaerobic systems. Technologies such as activated sludge and fluidized bed reactors are used for biological treatment.

Activated sludge processes use a slurry containing an active mass of bacteria to achieve microbial oxidation and treatment of organic and inorganic compounds in waste streams. The main criteria in evaluating the use of activated sludge as part of an aqueous treatment train is the concentration of organic contaminants present in the influent water. Typically, a five-day biological oxygen demand (BOD) of 40 mg/L is required to sustain a viable bacterial mass in the system. Sometimes activated sludge cannot be used for groundwater treatment because the aqueous influent is too dilute.

Treatment via fluidized bed biological reactors is gaining popularity at MGP sites as an effective way to reduce organic MGP constituents. Generally, the removal efficiencies for BTEX, naphthtalene, and iron are greater than 97%.

The final step of the treatment process is polishing, or neutralization. It is often necessary to adjust pH to the acceptable discharge range of 6-9, accomplished by the addition of an acid or alkali, or by another process stream. The process should be performed in a well-mixed system to ensure completeness. It is also necessary to ensure compatibility of the waste and treatment chemicals to prevent the formation of more toxic or more hazardous compounds than were originally present.

3.9 Discharge of Treated Effluent

The treated effluent can be discharged to the local Public Owned Treatment Works (POTW) or the Coney Island Creek. Permitted discharge to the POTW would entail connection of the treatment system to a nearby sanitary trunkline via a subsurface sewer line. Treated effluent would flow to the sanitary trunkline by gravity flow. A manhole connection would be situated at the juncture of the effluent pipe and the sanitary trunkline. Monitoring of treated effluent would be performed in compliance with the given permit conditions. The treated effluent would be metered to determine volumetric flow and associated cost of treatment.

For discharge to the Coney Island Creek, a discharge sewer and outfall would be designed and installed in accordance with State Pollution Discharge Elimination System (SPDES) requirements. Considerations for discharge in the creek include reverse flow resulting from tidal variations and preventing the growth of aquatic organisms which could potentially clog the system. As with discharge to the POTW, the discharge into the Coney Island Creek would be monitored and metered to meet compliance standards set forth by the SPDES permit.

3.10 Summary of Technology Identification and Screening

Table 3-4 provides a summary of the technology identification and screening process. The technologies are assessed according to their effectiveness, implementability, and relative cost. Groundwater treatment technologies are not included in this table as each evaluated process is retained for alternative development. Table 3-5 summarizes the applications, advantages, disadvantages, and commercial status of the proven NAPL and aqueous waste treatment technologies discussed herein.

Table 3-6 lists the potentially applicable technologies and process options retained for alternative development and consideration in Section 4.0.

4.0 DEVELOPMENT, EVALUATION, AND COMPARISON OF REMEDIAL ALTERNATIVES

4.1 Introduction

This section presents the development, evaluation, and comparison of remedial alternatives. Remedial alternatives are developed by combining technologies screened in Section 3.0. Seven criteria identified by NYSDEC in TAGM HWR-90-4030 are used to evaluate each alternative qualitatively and quantitatively. The relative merits and disadvantages of each alternative are assessed in a comparison that examines each evaluation factor for clear differences which will be considered when recommendations for a preferred remedial alternative are made in Section 5.0.

4.2 Development of Remedial Alternatives

Remedial alternatives are developed by combining technologies screened in Section 3.0. The No Action alternative is included as a baseline for comparing other alternatives. In general, alternatives are assembled to achieve RAOs and address technical issues identified in Section 3.1. Assembling alternatives requires an assessment and understanding of significant differences between technologies screened in Section 3.0. By evaluating the differences between technologies and their relative contribution to risk-based brownfield development, a holistic solution for the site can be defined and the study can focus on determining the best remedial alternative according to NYSDEC guidelines.

The technologies retained in Section 3.0 for alternative development can be grouped according to significant differences as shown in Table 4-1. By evaluating the differences between these technologies, it is possible to select the best candidates for alternative evaluation, comparison, and cost estimating. The effect of differences can be assessed through sensitivity analyses or addressed during detailed remedial design, as appropriate.

The summary of significant differences in Table 4-1 leads to the following conclusions related to alternative development:

- Excavation of site soils to RBC levels versus excavation of coal tar source areas should be evaluated in separate alternatives because significant differences exist between these two excavation options as detailed in Table 4-1.
- NAPL/groundwater treatment system effluent discharge to the POTW versus discharge to the Coney Island Creek should be evaluated in separate alternatives because significant differences exist between these two discharge options as detailed in Table 4-1.
- Evaluation of the No Action alternative is a statutory requirement; therefore, a separate alternative for No Action needs to be developed.
- All other recommended technologies in the table represent elements common to all alternatives, except No Action.

In addition to the No Action alternative, a maximum of four additional alternatives can be assembled by various combinations of the options being considered:

Alternative #	Excavation	Discharge	Remaining Technology Elements
1	No Action is a statutory requirement.		
2	RBCs	Coney Island Creek	✓
3	RBCs	POTW	✓
4	Coal Tar Source Areas	Coney Island Creek	✓
5	Coal Tar Source Areas	POTW	✓

Alternative 1 is the statutory No Action alternative, providing a basis of comparison for all other alternatives. Alternative 2 includes excavation of site soils with contaminant levels in excess of RBC concentrations, installation of a vertical barrier wall around the site, construction of a low permeability cover system across the site, placement of a clean fill work zone on top of the cover system, stabilization and restoration of the Coney Island Creek bank, collection and treatment of NAPL, institutional controls, and discharge of treatment system effluent to the Coney Island Creek. Alternative 3 is the same as Alternative 2 except treatment system effluent is discharged to the POTW. Alternative 4 is the same as Alternative 2 except excavation is limited to coal tar source areas identified during the RI. Alternative 5 is the same as Alternative 4 except treatment system effluent is discharged to the POTW.

The following sections summarize the alternatives and present general concepts and assumptions used throughout alternative evaluation and comparison.

4.2.1 Alternative 1: No Action

The No Action alternative assumes no additional activity occurs at the site and current conditions are maintained. The perimeter fence and site security would remain in place to prevent trespassing and potential exposure to site contaminants. Periodic maintenance of the hard boom and skimmer installed as part of the IRM would occur. Contaminated liquids that accumulate in the IRM storage tank would be pumped periodically and disposed of in accordance with applicable regulations. Collection and analysis of groundwater samples would be performed on an assumed semi-annual basis to assess subsurface conditions and track the movement of contaminants.

4.2.2 General Approach to Site Remediation

This section presents the general approach to site remediation. Alternatives 2 through 5 have several common elements that are described herein. Other measures may be as effective for implementing these alternatives; these may be identified during detailed design optimization activities. In the context of this discussion, there is no differentiation between excavation methodologies for soils and coal tar sources. Furthermore, discharge refers to either the Coney Island Creek or the POTW. Section 4.2.3 addresses the variability introduced into the alternatives when considering different excavation and discharge options.

4.2.2.1 Integrated Solution

The common elements of the alternatives represent an integrated solution, addressing RAOs and technical issues raised in previous sections to provide a long-term remedial solution amenable to redevelopment. At the core of the integrated solution is the use of containment to mitigate inhalation, construction worker exposure, and creek seepage risks. The containment methodologies employ a multi-layer cover system placed over the entire site connected to a vertical barrier surrounding the site. Figure 4-1 depicts the site, the extent of the cover system, an assumed footprint for a future commercial development, and other pertinent site features. Figure 4-2 depicts a cross-section of the site, including layers of a typical cover system, elements of the vertical barrier, and a concrete relieving platform constructed on piles to support overlying structures.

After excavation is performed in accordance with the selected alternative, remaining site soils will be graded to an assumed base elevation. The cover system will be placed on top of this elevation to effectively isolate contaminated residuals from overlying clean zones. These clean zones will provide a future developer with unhindered access to the site for construction of buildings, subsurface utilities, and other improvements. The cover system will be integrated into the concrete relieving platform using conventional techniques. It is important to note that the concrete piles underlying the relieving platform will be installed using boring techniques to minimize the formation of preferential contaminant migration pathways that may be associated with typical pile driving methods.

The cover system will be connected to a steel sheet pile barrier wall. A shallow trench will be excavated around the perimeter to remove near-surface debris and obstructions prior to installation of sheet piles. The depth of installation will vary around the site; in general, sheet piles will be keyed into the discontinuous low permeability layer. Where discontinuities occur in the low permeability layer, the steel sheets will be installed to a depth that sufficiently contains floating and dissolved contaminants and minimizes the likelihood of seepage into the creek. Hydrogeologic modeling utilizing data from a site-wide geotechnical sampling and analysis program would be performed as part of design optimization to generate the best depth profile of the barrier wall.

Figure 4-1 also presents a conceptual plan view of the NAPL management system elements. This system is comprised of a downgradient collection trench along the Coney Island Creek boundary, an upgradient groundwater diversion trench along the MTA and Shore Parkway boundaries, and a treatment plant. Figures 4-3 and 4-4 depict conceptual cross-sections of the perimeter barrier wall looking into the NAPL collection trench alignment and looking along the Coney Island Creek boundary, respectively. Recovery and collection of NAPL is facilitated by:

- Movement of fluid through a permeable geotextile along the trench wall, which minimizes plugging of the trench with particles from the adjacent soil matrix
- Flow of fluid through highly permeable gravel backfill into a slotted pipe
- Flow of fluid along the slotted pipe to sumps situated at low points along the trench alignment
- Automated pumping of separate LNAPL and groundwater phases from the sump to the treatment building
- As-needed pumping of DNAPL and sludge from the sump using a dedicated drop tube from the surface
- Passive venting and treatment of volatile gases along the trench through vents equipped with carbon filters
- Active venting of volatile gases from sump manholes on an as-needed basis along a pipe embedded in the trench to the treatment building
- Periodic use of a dedicated lateral hot water line to heat the trench and loosen DNAPL.

Figure 4-5 depicts a conceptual cross-section of the perimeter barrier wall and the integration of an upgradient groundwater diversion trench. The upgradient diversion trench prevents build-up of hydrostatic pressure on the sheet pile barrier wall and routes groundwater around the encapsulated site into its normal, ultimate destination, the Coney Island Creek. Groundwater flows through a permeable geotextile into the recovery trench and proceeds along a slotted piped embedded in the trench alignment. The upgradient diversion pipes on the MTA and Shore Parkway boundaries are assumed to terminate at the Coney Island Creek as point source discharges. These discharges may improve surface water quality.

4.2.2.2 Coney Island Creek Bank Stabilization and Restoration

As a common element of each remedial alternative, the Coney Island Creek bank will be stabilized and restored. Stabilization is essential to the construction of the perimeter barrier wall and NAPL recovery trench, long-term performance and stability of the cover system, and preservation of an ecological habitat along the Coney Island Creek. The restoration of the bank to act as a 50-foot ecological buffer zone is critical to the success of conceptual remedies.

The current condition of the creek bank presents challenges to the implementation of remedial actions. A hard boom and skimmer were installed as part of the IRM to mitigate the NAPL seep from subsurface groundwater. Coal tar source areas depicted in Figure 3-4 extend to the bank in two locations. Disturbance of these source areas and other areas with elevated levels of contaminants can generate volatile emissions and odors. The deteriorating wooden bulkhead along some of the property line extends into the creek bank but is also supported by buried tie-backs that connect to anchors located several feet from the shoreline within the property boundary. Creek sediments have accumulated over time, leaving little free surface in the creek for movement of floating devices. While restoration of the creek (below the mean high water line) is not within the scope of this FFS and is being addressed as a second Operable Unit under the existing Consent Order with NYSDEC, it is important to conduct remedial actions such that future creek restoration activities are not prohibited or further complicated.

The inability to conduct remedial activities from floating devices limits the options available to implement creek bank stabilization and restoration activities. To prevent disturbance of creek sediments while working with the wooden bulkhead requires a means of isolating the bulkhead and preventing both disturbance of the sediments and release of NAPL seepage. While creek bank soils and the bulkhead are disturbed, measures to control the generation and release of volatile emissions and odors must be implemented.

Figures 4-6 and 4-7 depict plan and cross-sectional views, respectively, of conceptual approach to creek bank remedial activities. Isolation of the bulkhead and bank materials to be disturbed from the creek is accomplished by installing a coffer dam within the creek immediately adjacent to the bulkhead and property line. Sheet piles driven perpendicular to the coffer dam would create "work cells", discrete work zones for all critical stabilization activities. By creating isolated work zones, NAPL seepage, odor generation, and dewatering will be minimized and better managed.

A temporary construction enclosure such as a Sprung structure would be erected to cover the width and length of a typical "work cell." Activities within the work cell would be performed in a negative pressure environment, with extraction and treatment of volatile emissions and odors facilitated by a platform-mounted air pump and carbon treatment system. The Sprung structure would be mounted on wheels attached to steel rails. The rails would be extended along the boundary of the creek on both the bank and the coffer dam. Soldier piles installed along the coffer dam could be used to support the rails and temporary enclosure. After completion of volatile emission or odor producing activities, the temporary enclosure would be moved to the next work cell and restoration would proceed.

The general order of activities for a work cell depends on a number of factors, including potential for volatile emissions and odors, presence of coal tar sources, condition of bulkhead and tie-backs, presence of debris and obstructions, and potential for seepage. The following represents a typical work sequence for the conceptual bank stabilization and restoration:

1. ***Install coffer dam, lateral work cell enclosures, and rail systems.*** This first step establishes the infrastructure necessary to conduct construction activities in a safe and controlled environment. Recognizing that there may be rip rap, metal, or debris along the coffer dam alignment, a starter trench will be used to remove shallow obstructions prior to installation of dam components.

2. ***Install starter trench for steel sheet pile barrier wall.*** There are many subsurface obstructions present in the subsurface that will hinder installation of a barrier wall. In areas where obstructions are anticipated or known, it will be necessary to install a starter trench to effectively clear the path for pile installation. If volatile emissions or odors are a concern along starter trench alignment, trench excavation can be performed under the enclosure. Prior to moving the enclosure, less contaminated site soils that do not generate odors can be placed as daily cover on the trench to suppress odors and vapors and prevent their off-site migration. If odors and volatile emissions are not anticipated, trench excavation can proceed with routine monitoring in accordance with a health and safety plan.

3. ***Install sheet pile barrier wall.*** With subsurface obstructions cleared, it is assumed that steel sheet piles can be driven to desired depths using vibratory methods.

4. ***Stabilize creek bank.*** This is a general term for different activities that may need to occur. The goals of creek bank stabilization are to remove contaminants from the zone between the sheet pile barrier wall and coffer dam and to construct a stable base capable of supporting the site cover system and shoreline protection measures. As with sheet pile installation, the enclosure may or may not be used depending on the anticipated or confirmed presence of contaminants that may generate volatile emissions or odors. Where groundwater and/or NAPL infiltration into the excavation area is a concern, temporary well-points can be installed to pump accumulating water for temporary storage and treatment on-site. Excavated materials would be loaded into dump trailers or other transfer vehicles and consolidated at a central on-site location. Clean structural fill would be placed in the excavation and other means of stabilization, including geotextile grids, bulkheads, tie-backs, and permanent piles, would be installed.

5. ***Install downgradient recovery trench.*** Concurrent with bank stabilization, the installation of the downgradient recovery trench can occur within or outside the construction enclosure. A trench would be excavated to desired depths and trench components would be installed as depicted previously in Figures 4-3 and 4-4.

6. ***Install monitoring wells.*** Long-term groundwater monitoring as an institutional control would be accomplished using wells installed upgradient and downgradient of the site. Downgradient wells would be installed immediately outside the barrier wall to assess long-term performance based upon detections of contaminants. Excavation of contaminated bank soils prior to installation of wells would eliminate the need for work in a construction enclosure.

7. ***Restore creek bank.*** Bank restoration involves necessary improvements to prevent erosion of soils and to maintain a proposed 50-foot ecological buffer between the site and the Coney Island Creek. Preventing erosion can be accomplished using a variety of techniques to dissipate the eroding forces induced by currents in the creek. Instead of concrete walls and gabion armor, several bioengineering methods may be used to place rocks, boulders, and soil in a structurally sound matrix along the creek. A bioengineered solution would use natural materials that are aesthetically pleasing and provide a smooth transition to the 50-foot ecological buffer zone. The 50-foot ecological buffer zone would also be bioengineered using natural materials to support plant life and promote habitats for selected bird species. Trees, low brush cover, and grasses could be planted to protect underlying bank soils while promoting beneficial use of the transition zone from the creek to the developed site. An additional benefit of the bioengineered solution would be the dissipation of eroding forces from on-site stormwater runoff.

8. ***Integration with cover system and site improvements.*** This last step in the bank stabilization and restoration work sequence involves connection of the cover system with the sheet pile barrier wall and construction of surface improvements related to the brownfield development. After the bank is stabilized, fill materials can be placed along the interior side of the barrier wall. Cover system

elements would then be placed and connected to the barrier wall as described previously. Additional fill and other surface improvements would then be placed and constructed, respectively, as part of the brownfield development process. Figure 4-8 depicts a conceptual cross-section of the site along the creek after bank stabilization and restoration are completed.

4.2.2.3 NAPL Treatment

This section discusses and describes the implementation of proven, technically feasible treatment technologies for NAPL and aqueous wastes. These technologies were identified and screened in Section 3.0 and assessed for alternative development in Table 4-1. An assumed treatment train and process option for volatile organic NAPL and treatment are presented herein.

Figures 4-9 and 4-10 depict conceptual process flow and equipment arrangement diagrams, respectively, for Process Option 1, which uses carbon adsorption and air stripping for treatment of VOCs. Figures 4-11 and 4-12 are the conceptual process flow and equipment arrangement diagrams, respectively, for Process Option 2, which substitutes a bioreactor for the treatment of VOCs. The treatment train encompasses proven technologies, including flow equalization, product/solids separation, product/dissolved organics separation, polishing, and discharge. Product/solids separation is used for the removal of NAPL, metals, and total suspended solids (TSS); product/dissolved organics separation is used to remove BTEX, VOCs and PAHs such as naphthalene.

Water/Product/Solids Separation

The unit operations used for product/solids separation are phase separation, chemical precipitation, and filtration. These operations are identical for all treatment alternatives and are independent of the process options for treatment of VOCs.

The conceptual groundwater treatment system has an assumed treatment capacity of approximately 50 gpm. Twelve submersible pumps, positioned at 200-ft. centers along the recovery trench, are set within each of 12 manholes to pump 10 gpm of groundwater to a 13,000 gallon collection/equalization tank located inside the facility. The water is pumped into the treatment system from the equalization tank at 50 gpm via a centrifugal disc pump prior to the CPI phase separator. Because of its low shear, the disc pump is used to minimize hydrocarbon-water emulsification.

Liquid caustic solution (NaOH) is added in-line prior to the CPI separator, raising the pH and causing chemical precipitation of the metals present in the groundwater. It is assumed that precipitate settling will occur simultaneously during phase separation and a separate precipitation process unit is not needed. Although a flow rate of 50 gpm is assumed, the phase separator is sized for 100 gpm to increase detention time and enhance solids and DNAPL separation from the groundwater.

In the 1,900-gallon phase separator, TPH and other insoluble material separate from the water. Phase separation occurs because the specific gravity of petroleum hydrocarbons differs from that of water. The oil is removed via gravity flow and is stored in a 3,000 gallon carbon steel storage tank; the DNAPL and precipitated metal hydroxide sludge are removed through the sludge pump at the base of the unit and are stored in a 4,000 gallon carbon steel storage tank. After one month of storage, the oil and sludge are sent to permitted off-site treatment and disposal facilities. A dissolved air flotation unit is also very effective at removing product and solids. This is an issue for consideration during detailed design.

A sand filter follows caustic in-line addition and phase separation. The effluent from the CPI unit enters the filter via gravity flow. Continuous filtration polishes the waste stream by removing metal precipitates and other solids not removed by sedimentation following the precipitation step. With a sand filter, the discharge goal of TSS effluent quality (<5 mg/L) is attainable. The 710 gallon sand filter has a continuous backwash reject stream of 5-7% of the inlet flow that is recycled back into the CPI unit. A compressor is used to introduce air into the base of the filter to aid filter upflow. The effluent from the product/solids separation is amenable to dissolved organic separation.

Process Option 2 is identical to Process Option 1 for technologies involving separation of product and solids, including phase separation, chemical precipitation, and filtration.

Dissolved Organic Removal

The back end of the treatment train includes product/dissolved organic removal units for the removal of BTEX and PAH, carbon polishing units, and discharge. Process Option 1 uses physical treatment technologies to accomplish the separation; Process Option 2 uses biological treatment. Process Option 1 uses a plate air stripper in conjunction with both vapor and liquid phase carbon adsorption polishing units. Process Option 2 includes a biological reactor to break down dissolved VOCs, along with a liquid phase carbon adsorber. The decision to choose a particular option can be determined during detailed design optimization. Process Option 1 is used in FFS evaluations and cost estimates.

Process Option 1

In Process Option 1, sand filter effluent enters a low profile tray or plate air stripper, via gravity flow, for removal of VOCs. Air enters the base of the stripping unit through a blower at a volumetric flow rate of approximately 1200 cfm. As the waste stream flows through the air stripper, the VOCs leave the liquid phase and transfer to the gas phase. This phase transfer creates volatile emissions in the vapor phase that must be treated prior to discharge.

Off-gas treatment via a vapor phase carbon adsorber acts as a polishing unit for the vapor effluent from the stripper, allowing treated vapor to enter the atmosphere. The treated liquid contains low levels of contaminants that need further treatment prior to discharge. The liquid is pumped to a liquid phase carbon adsorption unit where it is "polished" prior to discharge in accordance with permit requirements.

Treated liquids are pumped to a 4,000 gallon treated groundwater tank and then discharged to either the Coney Island Creek or POTW, depending on the alternative.

Process Option 2

In Process Option 2, the sand filter effluent enters a biological reactor for dissolved organic treatment. Nutrients are added into the reactor to aid the microorganisms in the aerobic breakdown of the organic compounds. This treatment involves aerobic degradation of compounds; therefore air is supplied through a compressor to act as the oxygen source for the organisms. The gases resulting from this treatment are carbon dioxide, water vapor, and elemental nitrogen; therefore, off-gas treatment is unnecessary for this process option and these gases can enter the atmosphere through a vent at the top of the reactor.

The separated liquid coming out of the biological reactor is pumped to a carbon adsorption unit to polish low levels of residual contamination prior to permitted discharge. As with Process Option 1, the product is pumped to a 4,000 gallon treated groundwater tank and then discharged to either the Coney Island Creek or POTW, depending on the alternative.

4.2.2.4 Features and Benefits of Remedial Approach

As stated in Section 4.2, alternatives have been assembled to address RAOs and the technical issues identified in Section 3.1. The formal evaluation of alternatives in subsequent sections of this report addresses the ability to achieve RAOs. Table 4-2 assesses the ability of all alternatives, except No Action, to address the technical issues identified previously.

4.2.3 Alternative Technology Options

This section addresses the variability introduced into the alternatives when considering different excavation and discharge options. Table 4-1 summarized the significant differences between the options and provided the rationale for differentiating them in the four alternatives other than No Action. Additional consideration is provided herein to supplement the alternative descriptions presented in Section 4.2.2.

4.2.3.1 Excavation Alternatives

The differences cited in Table 4-1 recognized that excavation to RBCs removes soils and source materials to meet the RAO for an unprotected construction worker, while coal tar source area excavation removes a large percentage of on-site contaminants, but does not meet the unprotected worker RAO without installation of a cover system. Section 4.2.2 descriptions of common alternative elements include installation of a low permeability cover system. This cover system is necessary for both excavation options to minimize the likelihood of potential cross-contamination of clean overburden soils due to fluctuating groundwater conditions. This additional benefit, coupled with control of the unprotected worker exposure pathway, effectively eliminates the differences in meeting the unprotected construction worker RAO between the two excavation options. Remaining differences between the two excavation options are evaluated formally in subsequent sections of this report.

Excavation of soils to RBCs has been developed for a range of risks in accordance with EPA and NYSDEC guidance. To meet risk guidelines, the volume of soil to be removed from the assumed unsaturated zone in the upper six feet of soil ranges from approximately 73,000 cubic yards to 85,000 cubic yards. The difference between the lower and upper excavation volume estimates is relatively insignificant compared with the estimated coal tar source area excavation volume, which is approximately 22,000 cubic yards. To simplify the FFS, the upper excavation volume of 85,000 cubic yards is used for descriptive and cost estimating purposes. By removing the conservatively estimated 85,000 cubic yards of RBC soils, Brooklyn Union can meet the target risk goal of 1×10^{-6} for future unprotected construction workers who may contact unsaturated soil.

Excavation of coal tar source areas and contaminated soils will disturb significant portions of the site. The approximate 22,000 cubic yards of excavation assumed for the coal tar source area alternatives will disturb approximately 15% of the site surface. Excavation of 85,000 cubic yards to RBC levels will disturb approximately 60% of the site surface. Control of volatile emissions and odors will be of particular concern as site disturbance and excavation volumes increase. The use of temporary construction enclosures in areas suspected or known to pose emission and odor problems will create a controlled atmosphere for excavation and minimize releases of volatile emissions and odors into the environment. Construction enclosures would be positioned in a central location for materials consolidation, blending, and handling as well as over defined excavation areas, if necessary. After soil and coal tar are removed from defined areas, the enclosure will be either moved along rail tracks or dismantled and reassembled at a new location.

Figure 4-13 depicts a generalized schematic for the excavation of source areas and the consolidation within the area of contamination of site soils. The disposal of coal tar sources and the consolidation of site soils are consistent with EEI's Manufactured Gas Plant Site Remediation Strategy (April 1993). This strategy has been endorsed by EPA in 1993 and is further discussed and approved in an August 21, 1998 letter by USEPA Acting Director, Office of Solid Waste, Elizabeth A. Cotsworth, and an October 14, 1998 memo from the USEPA Assistant Administrator for Solid Waste and Energy Response, Timothy Fields, Jr.

This strategy provides a general approach to characterize, consolidate, store, and dispose of MGP wastes consistent with applicable regulations. Central to the success of the strategy is the consolidation of soils and collection of data to characterize potential waste streams prior to their generation according to RCRA hazardous waste definitions. With knowledge of potential hazardous waste, the EPA-approved strategy recommends designing a consolidation process to mix a "relatively dry, combustible medium such as coal, coal-fines, clean wood chips, corn cobs, less contaminated soil or other suitable material to ensure that the blended material does not exhibit a hazardous characteristic." Collection of appropriate data and design of a suitable consolidation process would be performed prior to consolidation and debris removal.

Debris will be separated from excavated materials and either staged for incorporation in the waste matrix under the cover system or disposed of at an off-site location. After debris is removed, the soil will undergo a separation process to remove oversize material. Remaining soil will be subjected to initial characterization testing for various disposal options. If the material appears to be hazardous, the material will be consolidated within the area of contamination with on-site nonhazardous soil and/or coal fines to achieve a nonhazardous waste designation. Consolidation will occur within the construction enclosure within 90 days of generation to satisfy RCRA requirements. Final disposition of RCRA nonhazardous waste will be dependent on the heating value of the material and availability of cost-competitive vendors at the time of disposal.

4.2.3.2 Discharge Alternatives

Different discharge methods are required to facilitate the discharge of treatment plant effluent to either the Coney Island Creek or the POTW. Discharge to the Coney Island Creek can be accomplished using a simple gravity discharge pipe from the treatment plant. The anticipated gain in elevation across the site from the cover system can accommodate gravity flow. The discharge pipe would terminate at the creek.

Discharge to the POTW would require a connection to an existing sanitary sewer trunkline. Conceptually, this connection can occur by routing a pipe along Leif Ericson Boulevard under the Shore Parkway and connection with a sewer main along Shell Road. Alternatively, a connection to a sanitary main along Neptune Avenue can occur if the site developer installs an access bridge across the Coney Island Creek. For the purposes of this FFS, it is assumed that the sanitary sewer connection runs along Leif Ericson Boulevard to Shell Road.

Significant differences exist between discharge of treated liquids to the POTW and discharge to the Coney Island Creek. These differences involve:

Coordination of different agencies: The discharges are governed by different agencies. The discharge to the Coney Island Creek is regulated by the NYSDEC through its SPDES permit program. The NYCDEP Bureau of Wastewater Pollution Control administers the water quality permit for the POTW. A separate permit from the NYCDEP bureau that handles sewer regulation and control would be required due to hydraulic consideration from the estimated plant flow of 72,000 gallons per day, which is above the 10,000 gallons per day threshold established for the permit. Both NYSDEC and NYCDEP require a review of the proposed effluent limits before issuing a permit. Detailed design optimization provides the information needed for permit applications.

Long-term costs: Discharge to the Coney Island Creek falls under a general permit with a fee structure independent of cumulative flow; therefore, there is no periodic cost associated with discharge other than those related to sampling and reporting requirements. The discharge to the POTW considers flow in the calculation of fee. The estimated cost to treat discharged effluent at the Coney Island POTW is approximately $3 per 1,000 gallons.

Degree of treatment for specific compounds: Table 4-3 summarizes the preliminary discharge criteria applicable for contaminants detected at the former Brooklyn Borough Gas Works Site. The table indicates that the conceptual NAPL treatment system can produce effluents within the preliminary limits identified for either discharge option. Detailed design optimization will confirm the ability of the treatment system to meet discharge requirements.

Long-term monitoring requirements: Under the SPDES discharge permit, periodic monitoring of effluent quality is required. Periodic monitoring may include the broad suite of chemicals present in groundwater with collection and analysis of samples quarterly. Periodic long-term monitoring is also a requirement under the NYCDEP discharge permit to the POTW. This monitoring also may include the broad suite of chemicals present in groundwater with collection and analysis of samples quarterly.

4.3 Evaluation Criteria

NYSDEC TAGM HWR-90-4030 identifies seven criteria to be used for the evaluation of remedial alternatives. These seven criteria are further divided into factors that should be considered for an accurate and complete qualitative and quantitative assessment of each alternative. Tables 5.2 through 5.7 of the TAGM present a methodology for the assignment of ranking scores to alternatives according to their ability to meet the performance metrics of each evaluation factor. The focused nature of this FFS, coupled with the development of remedial alternatives that equally meet the intended goals measured by these factors, results in evaluations that cannot be differentiated quantitatively using the ranking methodology. Therefore, this section presents evaluations for each criterion and its associated factors without use of the ranking methodology, relying on other issues, such as cost and constructability, to distinguish relative advantages and disadvantages between alternatives. Each of the seven criteria and their associated evaluation factors is discussed herein.

4.3.1 Compliance with New York SCGs

This evaluation criterion is used to determine how each remedial alternative complies with SCGs. Evaluation considers compliance with:

- Chemical-specific SCGs
- Action-specific SCGs
- Location-specific SCGs

4.3.2 Overall Protection of Human Health and the Environment

This evaluation criterion provides an overall assessment of the protection provided by the remediation combined with brownfield development. Evaluation of overall protection addresses:

- Use of the site after remediation
- The potential for exposure to contaminants after remediation
- Magnitude of residual risks to human health and the environment after remediation

4.3.3 Short-Term Effectiveness

This evaluation criterion addresses impacts of the remedial action during the construction and implementation phases preceding the attainment of the RAOs. Factors to be evaluated include:

- Protection of workers and the community during remedial actions
- Environmental impacts

- Time to implement the remedy

4.3.4 Long-Term Effectiveness and Permanence

This evaluation criterion addresses the results of the remedial action in terms of the risk remaining at the site after the RAOs are achieved. The components of this criterion include:

- The use of on-site versus off-site remedies
- The use of treatment versus land disposal
- Permanence of the remedial alternative
- Expected lifetime or duration of the remedial alternative
- Quantity and nature of waste or residual left on-site after remediation
- Adequacy and reliability of controls

4.3.5 Reduction of Toxicity, Mobility, and Volume

This evaluation criterion addresses the statutory preference that treatment results in the reduction of principal threats of the total mass of toxic contaminants, the irreversible reduction in contaminant mobility, or the reduction of the total volume of contaminated media. Factors to be evaluated include:

- Quantity of waste destroyed or treated
- Management of untreated wastes
- Reduction in contaminant mobility by treatment or containment
- Irreversibility of treatment
- Type and quantity of treatment residuals

4.3.6 Implementability

This criterion addresses the technical and administrative feasibility of implementing a remedial action and the availability of various services and material required during its implementation. Factors considered in the evaluation include:

- Technical Feasibility
  - Ability to construct technologies
  - Reliability of technologies
  - Potential delays resulting from technologies
  - Need to undertake additional remedial action
- Administrative Feasibility
  - Permit approvals
  - Coordination with other agencies
- Availability of Prospective Technologies
  - Availability of technologies
  - Availability of necessary equipment and specialists

4.3.7 Cost

Evaluation of cost includes an assessment of estimated capital, operation, and maintenance (O&M) costs. Capital costs consist of direct and indirect costs. Direct costs include expenditures for the equipment, labor, and materials necessary to implement remedial actions. Indirect costs include expenditures for engineering, financial, and other services required to complete the implementation of remedial actions. Annual O&M costs include auxiliary materials and energy, disposal of residues, purchased services, administrative costs, insurance, taxes, license costs, maintenance reserve and contingency funds, rehabilitation costs, and costs for NYSDEC oversite and periodic site review.

This assessment evaluates the costs of the remedial actions on the basis of present worth. Present worth analysis allows remedial alternatives to be compared on the basis of a single cost representing the amount which, if invested in the base year and disbursed as needed, would be sufficient to cover all costs associated v ·h the remedial alternative over its planned life. A required operating performance period is assumed for present worth, which is a function of the discount rate and time. A performance period of 30 years and a discount rate of 3.5 percent are assumed for a base calculation. The discount rate of 3.5 percent includes a 2 percent adjustment for inflation of an assumed 5.5 percent U.S. Treasury bond rate. The "study estimate" costs are intended to reflect actual costs with an accuracy of -30 to +50 percent.

The breakdown of major facilities and construction components, as well as the detailed breakdown of capital and annual O&M costs, are presented in Appendix A.

4.4 Evaluation of Alternatives

This section presents the evaluation of the four alternatives described previously, as well as the No Action alternative. Each alternative is evaluated for the seven criteria and their associated factors. Since many of the elements in the alternatives are identical, only differences introduced by excavation or discharge options will be addressed in Alternatives 3, 4, and 5 after the evaluation is presented in Alternative 2. Differences will be reflected within the text for individual evaluation factors to simplify the report.

The comparison of alternatives for each of the criteria appears in Section 4.5.

4.4.1 Alternative 1: No Action

4.4.1.1 Compliance with New York SCGs

The following factors address compliance with New York SCGs:

Chemical-specific SCGs. The No Action alternative does not address residual concentrations of contaminants in excess of RBCs. Contaminants in groundwater would persist; however, this is acceptable because the groundwater has the characteristics suitable for designation as GSB saline. Furthermore, contaminant concentrations in groundwater that seep into the Coney Island Creek could potentially exceed criteria established by NYSDEC for impacts to fish and wildlife. Therefore, this alternative does not comply with chemical-specific SCGs.

Action-specific SCGs. The only action-specific SCG associated with this alternative relates to issuance of a deed notice or deed restriction on the property. Amending the existing deed would require a minimal effort and could be completed over several months. There are no other action-specific requirements for the No Action alternative.

Location-specific SCGs. There are no location-specific SCGs triggered by the No Action alternative.

4.4.1.2 Overall Protection of Human Health and the Environment

The following factors address the overall protection of human health and the environment:

Use of the site after remediation. There would be no change to site use after this alternative is implemented. It will remain an abandoned, former manufacturing facility.

Potential for exposure to contaminants after remediation. There is some potential for exposure to contaminants after the No Action alternative is implemented. Windblown contaminants may reach off-site human receptors; however, this does not pose a significant human health risk (as demonstrated in the baseline RA [Atlantic/GEI, 1998]). Full-time security at the site can prevent trespassers from entering the site and encountering site contaminants. Ecological receptors, particularly birds, would have the potential to come in contact with site contaminants.

Magnitude oı residual risks to human health and the environment after remediation. Unacceptable risks to unprotected construction workers would persist at the site by implementing the No Action alternative. Residual contaminants would present nominal ecological risks. Any seepage of contaminated groundwater into Coney Island Creek would present some level of risk to inhabitants of the creek.

4.4.1.3 Short-Term Effectiveness

The following factors apply to short-term effectiveness:

Protection of workers and the community during remedial actions. Remedial actions are not planned; therefore, there is no protection afforded workers or the community during the short-term other than existing security measures. The existing hard boom and skimmer would continue to capture seeping contaminants and prevent their spread into the creek, and further downstream.

Environmental impacts. Environmental impacts during the short-term are considered negligible because significant activity is not planned for the site.

Time to implement the remedy. The No Action alternative can be implemented immediately.

4.4.1.4 Long-Term Effectiveness and Permanence

The following factors are evaluated for long-term effectiveness and permanence:

Use of on-site versus off-site remedies. There are no remedies with the No Action alternative.

Use of treatment versus land disposal. There is no treatment with No Action. Contaminants remain uncontrolled in site soils and groundwater.

Permanence of the remedial alternative. There is no permanent remedy with No Action.

Expected lifetime or duration of the remedial alternative. No Action can continue indefinitely.

Quantity and nature of waste or residual left on-site after remediation. There is no change in the quantity or nature of waste left on-site if No Action is taken.

Adequacy and reliability of controls. Fences and security guards provide adequate protection against trespassers. Routine maintenance of the hard boom, skimmer, and other IRM components can provide adequate and reliable collection of seeping contaminants.

4.4.1.5 Reduction of Toxicity, Mobility, and Volume

The following factors address the reduction of toxicity, mobility, and volume of contaminants:

Quantity of waste destroyed or treated. There is no waste destroyed or treated with No Action.

Management of untreated wastes. Untreated wastes remain uncontrolled in site soils and groundwater. Contaminants may impact Coney Island Creek in areas where the IRM systems are not operating.

Reduction in contaminant mobility by treatment or containment. There is no reduction in contaminant mobility with No Action.

Irreversibility of treatment. There is no treatment in this alternative.

Type and quantity of treatment residuals. There is no treatment, and therefore no residuals, with No Action. Residuals of IRM LNAPL collection are sent to an off-site disposal facility.

4.4.1.6 Implementability

The following factors address technical feasibility:

Ability to construct technologies. Maintaining fences and the IRM systems can be accomplished readily.

Reliability of technologies. Security guard and fencing are reliable deterrents to trespassers. The IRM system at the groundwater seep has been operating reliably and can continue to do so with simple, routine maintenance.

Potential delays resulting from technologies. There are no delays anticipated.

Need to undertake additional remedial action. No Action does not provide any risk reduction and does not meet RAOs. Therefore, some additional remedial action is required to facilitate brownfield development.

The following factors address administrative feasibility:

Permit approvals. There are no permits required as part of No Action.

Coordination with other agencies. Coordination with other agencies is needed to implement No Action. NYSDEC would remain involved with the long-term monitoring of site contaminant levels and movement. NYSDOH would review any changes in site contaminant exposure pathways to assess public health risks. Local city officials would be involved in execution of a deed notice or restriction on the site and notify the community of potential concerns. The U.S. Coast Guard may become involved in the planning or execution of IRM system maintenance or upgrade activities.

The following factors address availability of prospective technologies:

Availability of technologies. The activities included as part of No Action are readily available.

Availability of necessary equipment and specialists. The activities required for No Action do not require special equipment or technicians.

4.4.1.7 Cost

Table A-2 in Appendix A presents the assumptions and estimated annual costs for Alternative 1. There are no capital costs associated with Alternative 1. Annual O&M costs are estimated to be $253,000. The estimated present worth of Alternative 1, assuming a 30-year period and discount rate of 3.5 percent, is $4,667,000.

4.4.2 Alternative 2: Excavate to RBCs-->Perimeter Barrier Wall with NAPL Collection--> Fill on Cover System -->Off-Site Soil Recycling--> NAPL Treatment and Discharge to Coney Island Creek

4.4.2.1 Compliance with New York SCGs

Chemical-specific SCGs. This alternative can achieve compliance with applicable chemical-specific SCGs for soils. Contaminant concentrations in soils are reduced to below RBCs and meet the requirement for risk-based cleanup stipulated in the Order on Consent. Contaminants in groundwater would persist; however, this is acceptable because the groundwater has the characteristics suitable for designation as GSB saline and on the basis of a lack of human health risk. Discharge of treated groundwater meets preliminary discharge limits established by NYSDEC Division of Fish and Wildlife.

Action-specific SCGs. This alternative can achieve compliance with applicable action-specific SCGs. Activities related to the hazardous waste management, capping, discharge of treated waters, and air emissions are each addressed by the alternative satisfactorily.

Location-specific SCGs. This alternative can achieve compliance with applicable location-specific SCGs. Remedial measures consider the potential adverse effects to the 100-year floodplain, wetlands, existing ecological habitats, and the Coney Island Creek bank.

4.4.2.2 Overall Protection of Human Health and the Environment

The following factors address the overall protection of human health and the environment:

Use of the site after remediation. After remediation, the site will be used for commercial development.

Potential for exposure to contaminants after remediation. The use of a cover system, coupled with a perimeter barrier wall, and institutional controls minimizes exposure pathways to contaminants. Addition of fill across the site with overlying structures and asphalt pavement provides additional isolation of contaminants and minimizes exposure. Venting of vapors from the waste matrix through carbon treatment systems minimizes inhalation pathways concerns.

Magnitude of residual risks to human health and the environment after remediation. By controlling the exposure pathways to subsurface contaminants and controlling the release of volatile emissions through a passive venting system, residual risks to human health and the environment are minimized. This alternative meets all RAOs established in Section 2.0 of this report.

4.4.2.3 Short-Term Effectiveness

The following factors apply to short-term effectiveness:

Protection of workers and the community during remedial actions. On-site workers would be required to comply with the hazardous waste standard in OSHA 1910.120 and OSHA's general construction industry standards. Personal protective equipment would be used contingent on the level of protection required to perform activities based on hazard analyses. Real-time monitoring would be performed to assess worker exposures and determine necessary upgrades or downgrades of controls.

Site access would be controlled during the entire remedial action process with full-time security guards and use of fencing. Downwind and upwind perimeter air monitoring stations measuring levels of particulates and organics would be established to monitor levels of off-site emissions. By using temporary construction enclosures for activities with the highest potential to generate volatile emissions and odors, adequate protection of the community would be provided.

Truck traffic would be a concern during implementation of Alternative 2. In addition to the delivery of construction materials and fill to the site, significant traffic would be imposed by the off-site disposal of approximately 85,000 cubic yards of contaminated soil and coal tar source material. The largest waste transport vehicles used in similar applications typically accommodate approximately 20 cy of material. Therefore, more than 4,000 truck trips may be needed to transport RBC-excavated material from the site. Based on observations made during the lead excavation IRM in 1997, BU anticipates that an average of 30 trucks can be loaded and hauled from the site each day. More than 130 days would be needed to load and transport RBC-excavated soils and coal tar source materials if Alternative 2 is implemented. A traffic control plan would be implemented during remedial activities to minimize the adverse effects of truck traffic.

Environmental impacts. Existing vegetation across the site would be cleared to prepare the surface for excavation and installation of the cover system. Without vegetation, erosion from run-off becomes a concern. A soil erosion and sediment control plan would be prepared and implemented during remedial actions. Dust control, particularly during dry or windy periods, would minimize nuisances caused by airborne particles. Use of temporary construction enclosures with controlled atmospheres would minimize generation of dust by excavation activities.

Work within the coffer dam along the Coney Island Creek would effectively minimize short-term adverse effects to the creek. Dewatering and removal of seepage using wellpoints or similar techniques would prevent releases of contaminants and silt into the creek.

Time to implement the remedy. Twenty to 24 months are estimated for implementation of remedial measures.

4.4.2.4 Long-Term Effectiveness and Permanence

The following factors are evaluated for long-term effectiveness and permanence:

Use of on-site versus off-site remedies. Alternative 2 relies on on-site and off-site remedies. With much of the residual contaminant mass encapsulated within surface and perimeter barriers, this alternative relies on long-term on-site isolation of contaminants with natural attenuation in the saturated zone. Off-site remedies are proposed for approximately 85,000 cubic yards of RBC-excavated material from across the site. NAPL and groundwater treatment will occur onsite due to the expected quantities anticipated from the collection trench.

Use of treatment versus land disposal. Alternative 2 uses treatment and land disposal for contaminants. Land disposal applies to residual contaminants encapsulated within the surface and perimeter barrier systems. Treatment by off-site recycling or thermal desorption vendors would be used for approximately 85,000 cubic yards of RBC-excavated material from across the site.

Permanence of the remedial alternative. Alternative 2 provides a permanent remedy for the site. The bulk of contaminant mass in the unsaturated zone soils would be removed from the site and treated. Remaining contaminants in the unsaturated zone under the site would be encapsulated within a multi-layer cover system and a low permeability perimeter barrier. Natural attenuation of contaminants in the saturated zone would reduce concentrations over time. As contaminants migrate with groundwater to the perimeter collection trench, they would be removed and treated in the on-site treatment system. Volatile emissions would be diverted in the gas vent layer and treated in carbon canisters prior to discharge into the atmosphere. With routine monitoring and maintenance, on-site remedies can perform according to design requirements for many years.

Expected lifetime or duration of the remedial alternative. The remedial components would have an expected lifetime beyond the 30-year evaluation period used by EPA when remedial actions are evaluated.

Quantity and nature of waste or residual left on-site after remediation. RBC-excavation would effectively eliminate the bulk of waste in the unsaturated zone that poses a significant health risk to unprotected construction workers. Residual, low concentration of contaminants that would not pose a risk would be present in unsaturated zone soil. Isolated coal tar sources, NAPL, and dissolved contaminants would persist in site groundwater. Contaminant concentrations would decrease over time by natural attenuation and removing and treating NAPL. Since the site groundwater is restricted from use, residual levels do not pose a risk to human health. The perimeter barrier wall and extraction systems control the migration pathway from the site into the adjoining Coney Island Creek.

Adequacy and reliability of controls. The multi-layer cover system and perimeter barrier wall, combined with gas venting and NAPL management systems, provide adequate control of residual site contaminants. These technologies are proven and used routinely as reliable measures to control MGP-related wastes.

4.4.2.5 Reduction of Toxicity, Mobility, and Volume

The following factors address the reduction of toxicity, mobility, and volume of contaminants:

Quantity of waste destroyed or treated. Approximately 85,000 cubic yards of RBC-excavated soil and coal tar sources would be excavated from the site and transported for treatment. The recycling and desorption technologies considered for the waste either destroy the waste material or bind it in a new matrix suitable for commercial applications.

Approximately 72,000 gallons per day of contaminated groundwater/NAPL would be removed, treated, and discharged. It is expected that this quantity will decrease over time as the containment barriers exert influence over site-wide hydrogeologic conditions. The treatment plant provides reductions in contaminant concentrations to meet preliminary SPDES discharge requirements.

Management of untreated wastes. Untreated wastes would remain on-site. These wastes, primarily in the saturated zone soil and groundwater, would be encapsulated within a multi-layer cover system and a perimeter barrier wall. These encapsulation systems would be designed to prevent migration of contaminants from the site and flow of water into the site from upgradient groundwater flow, tidal movement of downgradient groundwater, and infiltration of water from the surface. Expected long-term contaminant treatment from natural attenuation processes would not be hindered by the cover system or perimeter barrier wall.

Reduction in contaminant mobility by treatment or containment. Recycling or desorption of RBC-excavated soils and coal tar sources would effectively immobilize or destroy contaminants. The multi-layer cover system and perimeter barrier wall would minimize the off-site migration of contaminants in the subsurface. Natural attenuation processes will act on contaminants in the saturated zone to slowly reduce concentrations. As contaminated groundwater/NAPL migrates to the collection trench, it will be pumped to a treatment system and treated to acceptable contaminant concentrations prior to discharge. Volatile emissions from subsurface wastes would be diverted through a gas management system to carbon canisters for treatment prior to release into the atmosphere.

Irreversibility of treatment. Recycling and desorption technologies considered herein provide essentially irreversible treatment of soil and coal tar wastes. *In situ* natural attenuation processes and *ex situ* groundwater treatment technologies are also irreversible. The use of low permeability geomembrane liner in the cover system minimizes the likelihood of cross-contamination of clean overburden soils from contaminated subsurface soils.

Type and quantity of treatment residuals. Treatment residuals from off-site recycling or desorption vendors are expected to be materials suitable for commercial application. Residuals from natural attenuation processes are generally less toxic compounds, carbon dioxide, methane, or water. The on-site treatment plant would generate secondary sludge and oil residuals, as well as solid wastes such as filters, seals, tubes, and other parts. Activated carbon from the treatment plant and the gas venting system would be regenerated for future use.

4.4.2.6 Implementability

The following factors address technical feasibility:

Ability to construct technologies. The technologies comprising Alternative 2 can be constructed at the site. The coordination of construction activities will be complex; however, there are experienced contractors available who can plan and install the technologies without sacrificing the quality of the final remedy or placing the public at risk. The most complex elements of remedial construction will occur along the Coney Island Creek bank. Section 4.2.2.2 presents a workable approach to bank stabilization and restoration. The other technical elements of the project can be installed and operated with relative ease.

Reliability of technologies. The cover system, perimeter barrier wall, gas venting system, and NAPL management systems are comprised of reliable and proven technologies that can be designed to perform for several years. Routine maintenance of systems is necessary to extend the life and the successful performance of the NAPL management system.

Potential delays resulting from technologies. There are no foreseeable delays associated with the technologies in Alternative 2. The equipment and vendors are available and can be procured competitively.

Need to undertake additional remedial action. The technologies in Alternative 2 represent a final, permanent remedy. There is not an anticipated need to perform additional remedial actions on-site.

The following factors address administrative feasibility:

Permit approvals. Pursuant to 6 NYCRR 375-1.7, all on-site remedial activities need only comply with substantive technical requirements of applicable state and local city permits; the permits themselves do not need to be obtained. At the federal level, work along the Coney Island Creek and disturbance of tidal wetlands will trigger U.S. Army Corps of Engineers (USACE) permit requirements as noted in Section 2.0.

Coordination with other agencies. Coordination with other agencies will be required as part of Alternative 2. As lead agency, NYSDEC will have oversight responsibility for the implementation of remedial actions. Risks to the public and the environment will be evaluated by the NYSDOH. As with the hard boom and skimmer IRM, activities that may impact the Coney Island Creek will be coordinated with the U.S. Coast Guard. USACE permit requirements will require their involvement.

The following factors address availability of prospective technologies:

Availability of technologies. The technologies included in Alternative 2 are readily available. Technologies that are not proven, or may not be commercially viable at the time of remediation, have not been considered. Furthermore, a variety of recycling technologies are considered viable for Alternative 2. Market conditions at the time of implementation will lead to the selection of an appropriate off-site recycling vendor.

Availability of necessary equipment and specialists. There are several qualified and experienced contractors and vendors who can supply the necessary equipment and expertise to complete remedial actions as part of Alternative 2. It is expected that these contractors and vendors will continue to be available at the time of implementation.

4.4.2.7 Cost

Table A-3 in Appendix A presents the assumptions for development of Alternative 2 costs. Table A-4 presents a summary of the capital cost estimate of remedial activities, including NAPL treatment costs. A breakdown of estimated capital costs appears in Table A-5. Estimated LNAPL treatment system costs are in Table A-9. Table A-10 lists the assumptions and costs for long-term O&M of remedial systems.

The estimated capital cost of this remedial alternative is $29,131,336. Annual long-term O&M costs are estimated to be $537,813. The present worth of this alternative, assuming a 30-year period and discount rate of 3.5 percent is $39,050,000.

4.4.3 Alternative 3: Excavate to RBCs--> Perimeter Barrier Wall with NAPL Collection --> Fill on Cover System -->Off-Site Soil Recycling--> NAPL Treatment and Discharge to POTW

4.4.3.1 Compliance with New York SCGs

The evaluation of compliance with New York SCGs for Alternative 3 is identical to the evaluation for Alternative 2 except for:

Chemical-specific SCGs. This alternative can achieve compliance with applicable chemical-specific SCGs for soils. Contaminant concentrations in soils are reduced to below RBCs and meet the requirement for risk-based cleanup stipulated in the Order on Consent. Contaminants in groundwater would persist; however, this is acceptable because the groundwater has the characteristics suitable for designation as GSB saline and on the basis of a lack of human health risk. Discharge of treated groundwater meets preliminary discharge limits established by NYCDEP Bureau of Wastewater Pollution Control.

Refer to Section 4.4.2.1 for details regarding the evaluation.

4.4.3.2 Overall Protection of Human Health and the Environment

The evaluation of overall protection of human health and the environment for Alternative 3 is identical to the evaluation for Alternative 2. Refer to Section 4.4.2.2 for details regarding the evaluation.

4.4.3.3 Short-Term Effectiveness

The evaluation of short-term effectiveness for Alternative 3 is identical to the evaluation for Alternative 2. Refer to Section 4.4.2.3 for details regarding the evaluation.

4.4.3.4 Long-Term Effectiveness and Permanence

The evaluation of long-term effectiveness for Alternative 3 is identical to the evaluation for Alternative 2. Refer to Section 4.4.2.4 for details regarding the evaluation.

4.4.3.5 Reduction of Toxicity, Mobility, and Volume

The evaluation of reduction of toxicity, mobility, and volume for Alternative 3 is identical to the evaluation for Alternative 2, except for:

Quantity of waste destroyed or treated. Approximately 72,000 gallons per day of contaminated groundwater/NAPL would be removed, treated, and discharged. The treatment plant provides reductions in contaminant concentrations to meet preliminary POTW discharge requirements.

Refer to Section 4.4.2.5 for details regarding the evaluation.

4.4.3.6 Implementability

The evaluation of implementability for Alternative 3 is identical to the evaluation for Alternative 2, except for:

Coordination with other agencies. Coordination with other agencies will be required as part of Alternative 3. As lead agency, NYSDEC will have oversight responsibility for the implementation of remedial actions. Risks to the public and the environment will be evaluated by the NYSDOH. As with the hard boom and skimmer IRM, activities that may impact the Coney Island Creek will be coordinated with the U.S. Coast Guard. USACE permit requirements will require their involvement. NYCDEP will be involved with approval of and long-term compliance with the discharge permit for treated effluent to the POTW.

Refer to Section 4.4.2.6 for details regarding the evaluation.

4.4.3.7 Cost

Table A-3 in Appendix A presents the assumptions for development of Alternative 3 costs. Table A-4 presents a summary of the capital cost estimate of remedial activities, including treatment costs. A breakdown of estimated capital costs appears in Table A-5. Estimated NAPL treatment system costs are in Table A-9. Table A-11 lists the assumptions and costs for long-term O&M of remedial systems.

The estimated capital cost of this remedial alternative is $27,508,000. Annual long-term O&M costs are estimated to be $631,000. The present worth of this alternative, assuming a 30-year period and discount rate of 3.5 percent is $39,147,000.

4.4.4 Alternative 4: Source Area Excavation-> Perimeter Barrier Wall with NAPL Collection Interception -->Fill on Cover System -->Off-Site Soil Recycling--> NAPL Treatment and Discharge to Coney Island Creek

4.4.4.1 Compliance with New York SCGs

The evaluation of compliance with New York SCGs for Alternative 4 is identical to the evaluation for Alternative 2, except for:

Chemical-specific SCGs. This alternative does not achieve compliance with all applicable chemical-specific SCGs. While the bulk of contaminant mass is removed by excavating coal tar source areas, residual soil contaminant concentrations above RBCs would remain on-site. Contaminants in groundwater would persist; however, this is acceptable because the groundwater has the characteristics suitable for designation as GSB saline and on the basis of a lack of human health risk. Discharge of treated groundwater meets preliminary discharge limits established by NYCDEP Bureau of Wastewater Pollution Control.

Refer to Section 4.4.2.1 for details regarding the evaluation.

4.4.4.2 Overall Protection of Human Health and the Environment

The evaluation of overall protection of human health and the environment for Alternative 4 is identical to the evaluation for Alternative 2. Refer to Section 4.4.2.2 for details regarding the evaluation.

4.4.4.3 Short-Term Effectiveness

The evaluation of short-term effectiveness for Alternative 4 is identical to the evaluation for Alternative 2, except for:

Protection of workers and the community during remedial actions. On-site workers would be required to comply with the hazardous waste standard in OSHA 1910.120 and OSHA's general construction industry standards. Personal protective equipment would be used contingent on the level of protection required to perform activities based on hazardous analysis. Real-time monitoring would be performed to assess worker exposures and determine necessary upgrades or downgrades of controls.

Site access would be controlled during the entire remedial action process with full-time security guards and use of fencing. Downwind and upwind perimeter air monitoring stations measuring levels of particulates and organics would be established to monitor levels of off-site emissions. By using temporary construction enclosures for activities with the highest potential to generate volatile emissions and odors, adequate protection of the community would be provided.

Truck traffic would be a concern during implementation of Alternative 4. In addition to the delivery of construction materials and fill to the site, traffic would be imposed by the off-site disposal of approximately 22,000 cubic yards of coal tar source material. The largest waste transport vehicles used in similar applications typically accommodate approximately 20 cubic yards of material. Therefore, more than 1,100 truck trips may be needed to transport coal tar source material from the site. Based on observations made during the lead excavation IRM in 1997, BU anticipates that an average of 30 trucks can be loaded and hauled from the site each day. Approximately 40 days would be needed to load and transport coal tar source materials if Alternative 4 is implemented. A traffic control plan would be implemented during remedial activities to minimize the adverse effects of truck traffic.

Time to implement the remedy. Sixteen to 20 months are estimated for implementation of remedial measures.

Refer to Section 4.4.2.3 for details regarding the evaluation.

4.4.4.4 Long-Term Effectiveness and Permanence

The evaluation of long-term effectiveness for Alternative 4 is identical to the evaluation for Alternative 2, except for:

Use of on-site versus off-site remedies. Alternative 4 relies on on-site and off-site remedies. With much of the residual contaminant mass encapsulated within surface and perimeter barriers, this alternative relies on long-term on-site isolation of contaminants with natural attenuation in the saturated zone. Off-site remedies are proposed for approximately 22,000 cubic yards of coal tar source material from discrete areas within the site.

Use of treatment versus land disposal. Alternative 4 uses treatment and land disposal for contaminants. Land disposal applies to residual contaminants encapsulated within the surface and perimeter barrier systems. Treatment by off-site recycling or thermal desorption vendors would be used for approximately 22,000 cubic yards of coal tar source material from discrete areas within the site.

Quantity and nature of waste or residual left on-site after remediation. Coal tar source area excavation would effectively eliminate the bulk of waste in the saturated zone; residual contaminant concentrations would pose a significant health risk to unprotected construction workers. Isolated coal tar sources, NAPL, and dissolved contaminants would persist in site groundwater. Contaminant concentrations would decrease over time by natural attenuation and removing and treating groundwater/NAPL. Since the site groundwater is restricted from use, residual levels do not pose a risk to human health. The perimeter barrier wall and collection systems control the migration pathway from the site into the adjoining Coney Island Creek.

Refer to Section 4.4.2.4 for details regarding the evaluation.

4.4.4.5 Reduction of Toxicity, Mobility, and Volume

The evaluation of reduction of toxicity, mobility, and volume for Alternative 4 is identical to the evaluation for Alternative 2, except for:

Quantity of waste destroyed or treated. Approximately 22,000 cubic yards of coal tar source area material would be excavated from the site and transported for treatment. The recycling and desorption technologies considered for the waste either destroy the waste material or bind it in a new matrix suitable for commercial applications.

Approximately 72,000 gallons per day of contaminated groundwater/NAPL would be removed, treated, and discharged. It is expected that this quantity will decrease over time as the containment barriers exert influence on site-wide hydrogeologic conditions. The treatment plant provides reductions in contaminant concentrations to meet preliminary SPDES discharge requirements.

Reduction in contaminant mobility by treatment or containment. Recycling or desorption of coal tar source area materials would effectively immobilize or destroy contaminants. The multi-layer cover system and perimeter barrier wall would control the off-site migration of contaminants in the subsurface. Natural attenuation processes will act on contaminants in the saturated zone to slowly reduce concentrations. As NAPL migrates to the collection trench, it will be pumped to a treatment system and treated to acceptable contaminant concentrations prior to discharge. Volatile emissions from subsurface wastes would be diverted through a gas management system to carbon canisters at the perimeter of the site for treatment prior to release into the atmosphere.

Refer to Section 4.4.2.5 for details regarding the evaluation.

4.4.4.6 Implementability

The evaluation of implementability for Alternative 4 is identical to the evaluation for Alternative 2. Refer to Section 4.4.2.6 for details regarding the evaluation.

4.4.4.7 Cost

Table A-6 in Appendix A presents the assumptions for development of Alternative 4 costs. Table A-7 presents a summary of the capital cost estimate of remedial activities, including NAPL treatment costs. A breakdown of estimated capital costs appears in Table A-8. Estimated NAPL treatment system costs are in Table A-9. Table A-10 lists the assumptions and costs for long-term O&M of remedial systems.

The estimated capital cost of this remedial alternative is $16,295,000. Annual long-term O&M costs are estimated to be $550,000. The present worth of this alternative, assuming a 30-year period and discount rate of 3.5 percent, is $26,440,000.

4.4.5 Alternative 5: Source Area Excavation-> Perimeter Barrier Wall with NAPL Collection -->Fill on Cover System -->Off-Site Soil Recycling-->NAPL Treatment and Discharge to POTW

4.4.5.1 Compliance with New York SCGs

The evaluation of compliance with New York SCGs for Alternative 5 is identical to the evaluation for Alternative 2, except for:

Chemical-specific SCGs. This alternative does not achieve compliance with all applicable chemical-specific SCGs. While the bulk of contaminant mass is removed by excavating coal tar source areas, residual soil contaminant concentrations above RBCs would remain on-site. Contaminants in groundwater would persist; however, this is acceptable because the groundwater has the characteristics suitable for designation as GSB saline and on the basis of a lack of human health risk. Discharge of treated groundwater meets preliminary discharge limits established by NYSDEC Division of Fish and Wildlife.

Refer to Section 4.4.2.1 for details regarding the evaluation.

4.4.5.2 Overall Protection of Human Health and the Environment

The evaluation of overall protection of human health and the environment for Alternative 5 is identical to the evaluation for Alternative 2. Refer to Section 4.4.2.2 for details regarding the evaluation.

4.4.5.3 Short-Term Effectiveness

The evaluation of short-term effectiveness for Alternative 5 is identical to the evaluation for Alternative 2, except for:

Protection of workers and the community during remedial actions. On-site workers would be required to comply with the hazardous waste standard in OSHA 1910.120 and OSHA's general construction industry standards. Personal protective equipment would be used contingent on the level of protection required to perform activities based on hazard analyses. Real-time monitoring would be performed to assess worker exposures and determine necessary upgrades or downgrades of controls.

Site access would be controlled during the entire remedial action process with full-time security guards and use of fencing. Down and upwind perimeter air monitoring stations measuring levels of particulates and organics would be established to monitor levels of off-site emissions. By using temporary construction enclosures for activities with the highest potential to generate volatile emissions and odors, adequate protection of the community would be provided.

Truck traffic would be a concern during implementation of Alternative 5. In addition to the delivery of construction materials and fill to the site, traffic would be imposed by the off-site disposal of approximately 22,000 cubic yards of coal tar source material. The largest waste transport vehicles used in similar applications typically accommodate approximately 20 cubic yards of material. Therefore, more than 1,100 truck trips may be needed to transport coal tar source material from the site. Based on observations made during the lead excavation IRM in 1997, BU anticipates that an average of 30 trucks can be loaded and hauled from the site each day. Approximately 40 days would be needed to load and transport coal tar source materials if Alternative 5 is implemented. A traffic control plan would be implemented during remedial activities to minimize the adverse effects of truck traffic.

Time to implement the remedy. Sixteen to 20 months are estimated for implementation of remedial measures.

Refer to Section 4.4.2.3 for details regarding the evaluation.

4.4.5.4 Long-Term Effectiveness and Permanence

The evaluation of long-term effectiveness for Alternative 5 is identical to the evaluation for Alternative 2, except for:

Use of on-site versus off-site remedies. Alternative 5 relies on on-site and off-site remedies. With much of the residual contaminant mass encapsulated within surface and perimeter barriers, this alternative relies on long-term on-site isolation of contaminants with natural attenuation in the saturated zone. Off-site remedies are proposed for approximately 22,000 cubic yards of coal tar source material from discrete areas within the site.

Use of treatment versus land disposal. Alternative 5 uses treatment and land disposal for contaminants. Land disposal applies to residual contaminants encapsulated within the surface and perimeter barrier systems. Treatment by off-site recycling or thermal desorption vendors would be used for approximately 22,000 cy of coal tar source material from discrete areas within the site.

Quantity and nature of waste or residual left on-site after remediation. Coal tar source area excavation would effectively eliminate the bulk of waste in the unsaturated zone; residual contaminant concentrations would pose a significant health risk to unprotected construction workers. Isolated coal tar sources, NAPL, and dissolved contaminants would persist in site groundwater. Contaminant concentrations would decrease over time by natural attenuation and removing and treating NAPL. Since the site groundwater is restricted from use, residual levels do not pose a risk to human health. The perimeter barrier wall and collection systems control the migration pathway from the site into the adjoining Coney Island Creek.

Refer to Section 4.4.2.4 for details regarding the evaluation.

4.4.5.5 Reduction of Toxicity, Mobility, and Volume

The evaluation of reduction of toxicity, mobility, and volume for Alternative 5 is identical to the evaluation for Alternative 2, except for:

Quantity of waste destroyed or treated. Approximately 22,000 cubic yards of coal tar source area material would be excavated from the site and transported for treatment. The recycling and thermal desorption technologies considered for the waste either destroy the waste material or bind it in a new matrix suitable for commercial applications.

Approximately 72,000 gallons per day of contaminated groundwater/NAPL would be removed, treated, and discharged. It is expected that this quantity would decrease over time as the containment barriers exert influence on hydrogeologic conditions. The treatment plant provides reductions in contaminant concentrations to meet preliminary POTW discharge requirements.

Reduction in contaminant mobility by treatment or containment. Recycling or desorption of coal tar source area materials would effectively immobilize or destroy contaminants. The multi-layer cover system and perimeter barrier wall would control the off-site migration of contaminants in the subsurface. Natural attenuation processes will act on contaminants in the saturated zone to slowly reduce concentrations. As NAPL migrates to the extraction trench, it will be pumped to a treatment system and treated to acceptable contaminant concentrations prior to discharge. Volatile emissions from subsurface wastes would be diverted through a gas management system to carbon canisters for treatment prior to release into the atmosphere.

Refer to Section 4.4.2.5 for details regarding the evaluation.

4.4.5.6 Implementability

The evaluation of implementability for Alternative 5 is identical to the evaluation for Alternative 2, except for:

Coordination with other agencies. Coordination with other agencies will be required as part of Alternative 5. As lead agency, NYSDEC will have oversight responsibility for the implementation of remedial actions. Risks to the public and the environment will be evaluated by the NYSDOH. As with the hard boom and skimmer IRM, activities that may impact the Coney Island Creek will be coordinated with the U.S. Coast Guard. USACE permit requirements will require their involvement. NYCDEP will be involved with approval of and long-term compliance with the discharge permit for treated effluent to the POTW.

Refer to Section 4.4.2.6 for details regarding the evaluation.

4.4.5.7 Cost

Table A-6 in Appendix A presents the assumptions for development of Alternative 5 costs. Table A-7 presents a summary of the capital cost estimate of remedial activities, including NAPL treatment costs. A breakdown of estimated capital costs appears in Table A-8. Estimated NAPL treatment system costs are in Table A-9. Table A-11 lists the assumptions and costs for long-term O&M of remedial systems.

The estimated capital cost of this remedial alternative is $16,295,000. Annual long-term O&M costs are estimated to be $631,000. The present worth of this alternative, assuming a 30-year period and discount rate of 3.5 percent is $27,934,000.

4.5 Comparison of Alternatives

This section presents a brief comparison of the five alternatives. Since many of the elements within Alternatives 2 through 5 are similar, comparisons focus on the significant differences resulting from the two excavation and the two discharge options.

4.5.1 Compliance with New York SCGs

Chemical-specific SCGs. The No Action alternative does not comply with chemical-specific SCGs.

Alternatives 2 and 3 can achieve compliance with applicable chemical-specific SCGs for soils by removal of contaminated materials with concentrations in excess of RBCs. Alternatives 4 and 5 do not achieve compliance with applicable chemical-specific SCGs for soils because concentrations of contaminants in excess of RBCs would remain on-site after excavation of coal tar source areas.

For Alternatives 2, 3, 4, and 5, contaminants in groundwater would remain at elevated concentrations; however, this is acceptable because the groundwater has the characteristics suitable for designation as GSB saline.

Action-specific SCGs. The only action-specific SCG associated with Alternative 1 relates to issuance of a deed notice or deed restriction on the property. Alternatives 2, 3, 4, and 5 can achieve compliance with applicable action-specific SCGs equally.

Location-specific SCGs. There are no location-specific SCGs triggered by the No Action Alternative. Alternatives 2, 3, 4, and 5 can achieve compliance with applicable location-specific SCGs equally.

4.5.2 Overall Protection of Human Health and the Environment

Use of the site after remediation. There would be no changes to the current idle use of the site under the No Action alternative. After remediation under Alternatives 2, 3, 4, and 5, the site will be used for commercial development.

Potential for exposure to contaminants after remediation. There is some potential for exposure to contaminants under the No Action alternative. Alternatives 2, 3, 4, and 5 control exposure to contaminants equally by use of a cover system, installation of a perimeter barrier wall, addition of fill across the site with overlying structures and asphalt pavement, and venting of vapors from the waste matrix through carbon treatment systems.

Magnitude of residual risks to human health and the environment after remediation. Unacceptable risks to unprotected construction workers would persist at the site by implementing the No Action alternative. Residual contaminants would present nominal ecological risks. Any seepage of contaminated groundwater into the Coney Island would present some level of risk to inhabitants of the creek.

By controlling the exposure pathways to subsurface contaminants and controlling the release of volatile emissions through passive venting systems, residual risks to human health and the environment after implementation of Alternatives 2, 3, 4, and 5 are reduced equally. The four alternatives meet all RAOs equally.

4.5.3 Short-Term Effectiveness

Protection of workers and the community during remedial actions. Remedial actions are not planned for Alternative 1; therefore, there is no protection afforded workers or the community during the short-term other than existing security measures. The existing hard boom and skimmer would continue to capture seeping contaminants and minimize their release into the creek.

Truck traffic poses greater concern for Alternatives 2 and 3 relative to Alternatives 4 and 5 due to the additional 63,000 cubic yards of excavated material to be transported for off-site disposal. While the traffic would not vary significantly on a daily basis, it would persist for approximately four additional months under Alternatives 2 and 3. A traffic control plan would be implemented as part of any selected remedial alternative.

Environmental impacts. Environmental impacts during the short-term are considered negligible for Alternative 1. Alternatives 2, 3, 4, and 5 address erosion, dust control, and short-term adverse effects to the Coney Island Creek; due to the significant additional excavation associated with Alternatives 2 and 3, there is an increased likelihood of environmental impacts as compared with Alternatives 4 and 5.

Time to implement the remedy. The No Action alternative can be implemented immediately. For Alternatives 2 and 3, 20 to 24 months are estimated for implementation of remedial measures. The duration of Alternatives 4 and 5 is approximately four months shorter due to the decreased quantity of material subject to excavation, materials handling, off-site transport, and disposal.

4.5.4 Long-Term Effectiveness and Permanence

Use of on-site versus off-site remedies. There are no remedies with the No Action alternative. Alternatives 2, 3, 4, and 5 rely on on-site and off-site remedies, with long-term protection provided by surface and perimeter barriers. Alternatives 2 and 3 result in off-site transport of approximately 85,000 cubic yards of contaminated material for recycling or treatment. Approximately 22,000 cubic yards of contaminated material would be shipped to off-site facilities under Alternatives 4 and 5.

Use of treatment versus land disposal. There is no treatment with No Action and contaminants remain uncontrolled in site soils and groundwater. Alternatives 2, 3, 4, and 5 use treatment and land disposal for contaminants. Alternatives 4 and 5 would result in on-site land disposal of more residual contaminants than Alternatives 2 and 3. The residual mass of contaminants left under Alternatives 4 and 5, which would pose risks to unprotected construction workers, would be a relatively small fraction of the most concentrated contaminant mass currently in the upper six feet of site soils.

Permanence of the remedial alternative. There is no permanent remedy with No Action. Alternatives 2, 3, 4, and 5 provide permanent remedies for the site equally.

Expected lifetime or duration of the remedial alternative. No Action can continue indefinitely. The remedial components in Alternatives 2, 3, 4, and 5 would have an expected lifetime beyond the 30-year evaluation period used by EPA when remedial actions are evaluated.

Quantity and nature of waste or residual left on-site after remediation. There is no change in the quantity or nature of waste left on-site if No Action is taken. RBC-excavation under Alternatives 2 and 3 would remove the bulk of waste in the unsaturated zone and reduce significant health risks to unprotected construction workers. While a large percentage of contaminant mass would be removed from the site under Alternatives 4 and 5, residual concentrations of contaminants would pose risks to unprotected construction workers if they penetrate the cover system and conduct work without proper oversight or adherence to a site health and safety plan.

Residual contaminants, along with isolated occurrences of coal tar, would be present in site groundwater after implementation of Alternatives 2, 3, 4, or 5. Concentrations of contaminants would be expected to decline over time due to natural attenuation and the collection and treatment of NAPL.

Adequacy and reliability of controls. For Alternative 1, fences and security guards provide adequate protection against trespassers. Routine maintenance of the hard boom, skimmer, and other IRM components can provide adequate and reliable collection of seeping contaminants. The technologies proposed for Alternatives 2, 3, 4, and 5 are proven and used routinely as reliable measures to control MGP-related wastes.

4.5.5 Reduction of Toxicity, Mobility, and Volume

Quantity of waste destroyed or treated. There is no waste destroyed or treated with No Action. Approximately 85,000 cubic yards of RBC-excavated soil and coal tar sources would be excavated from the site and transported for treatment under Alternatives 2 and 3. This quantity would be reduced to approximately 22,000 cubic yards for coal tar source area removal only under Alternatives 4 and 5. The recycling and thermal desorption technologies considered for the waste in all four alternatives either destroy the waste material or bind it in a new matrix suitable for commercial applications.

Approximately 72,000 gallons per day of contaminated groundwater/NAPL would be removed, treated, and discharged under Alternatives 2, 3, 4, and 5. The treatment plant provides reductions in contaminant concentrations to meet preliminary SPDES discharge criteria under Alternatives 2 and 4 and preliminary POTW discharge requirements under Alternatives 3 and 5.

Management of untreated wastes. Untreated wastes remain uncontrolled in site soils and groundwater under the No Action alternative. Contaminants may impact into the Coney Island Creek in areas where the IRM systems are not operating if No Action is implemented.

For Alternatives 2, 3, 4, and 5, untreated wastes would remain on-site, encapsulated within a multi-layer cover system and a perimeter barrier wall. The same management approach for untreated waste is used for the four alternatives.

Reduction in contaminant mobility by treatment or containment. There is no reduction in contaminant mobility with No Action. The recycling, treatment, and containment technologies described for Alternatives 2, 3, 4, and 5 either treat contaminants, convert them into products with commercial application, or prevent their movement beyond defined barriers. The same technologies to reduce contaminant mobility are used in the four alternatives.

Irreversibility of treatment. There is no treatment in Alternative 1. Recycling and thermal desorption technologies considered for Alternatives 2, 3, 4, and 5 provide essentially irreversible treatment of soil and coal tar wastes. Groundwater and NAPL treatment technologies in the four alternatives are also irreversible. The use of a low permeability geomembrane liner in the cover system common to the four alternatives minimizes the likelihood of cross-contamination of clean overburden soils from contaminated subsurface soils.

Type and quantity of treatment residuals. There is no treatment, and therefore no residuals, with No Action. Treatment residuals from off-site recycling or thermal desorption vendors used as part of Alternatives 2, 3, 4, and 5 are expected to be materials suitable for commercial application. Residuals from natural attenuation processes are generally less toxic compounds, carbon dioxide, methane, or water. The on-site treatment plant considered in the four alternatives would generate secondary sludge and oil residuals, as well as solid wastes such as filters, seals, tubes, and other parts. Activated carbon from the treatment plant and the gas venting system would be regenerated off-site for future use.

4.5.6 Implementability

Ability to construct technologies. Maintaining fences and the IRM systems under Alternative 1 can be accomplished readily. For Alternatives 2, 3, 4, and 5, work along the Coney Island Creek presents the greatest construction challenge. Constructable solutions have been described for the remedial components of the four alternatives.

Reliability of technologies. For Alternative 1, security and fences are reliable deterrents to trespassers. The IRM system at the groundwater seep has been operating reliably and can continue to do so with simple, routine maintenance.

For Alternatives 2, 3, 4, and 5, the remedial systems are comprised of reliable and proven technologies which can be designed to perform for several years as long as routine maintenance is performed.

Potential delays resulting from technologies. Delays are not anticipated for any of the activities or technologies considered for the five alternatives.

Need to undertake additional remedial action. No Action does not provide any risk reduction and does not meet RAOs. Therefore, some additional remedial action is required. Additional on-site remedial action would not be required after implementation of Alternatives 2, 3, 4, and 5.

Permit approvals. There are no permits required as part of No Action. Pursuant to 6 NYCRR 375-1.7, all on-site remedial activities for Alternatives 2, 3, 4, and 5 need only comply with substantive technical requirements of applicable state and local city permits; the permits themselves would not have to be obtained. At the federal level, work along the Coney Island Creek and disturbance of tidal wetlands as part of the four alternatives would trigger USACE permit requirements.

Coordination with other agencies. Coordination with NYSDEC, NYSDOH, NYCDEP, local city officials, and the U.S. Coast Guard would be necessary for all five alternatives. USACE involvement must be considered for tidal wetland and creek construction issues under Alternatives 2, 3, 4, and 5. Alternative 1 would require the least level of coordination under the No Action approach. More coordination with NYCDEP would be required for Alternatives 3 and 5 to permit, operate, and monitor the sewer connection to the POTW. Additional coordination with NYSDEC would be necessary with Alternatives 2 and 4 to permit and monitor discharge to the Coney Island Creek. The differences between permitting among Alternatives 2, 3, 4, and 5 are considered negligible.

Availability of technologies. The activities included as part of No Action are readily available. The technologies considered in Alternatives 2, 3, 4, and 5 are available and can be procured competitively.

Availability of necessary equipment and specialists. The activities and technologies required for all of the alternatives are not limited by the availability of special equipment or technicians.

4.5.7 Cost

Table 4-4 presents a summary of the estimated present worth costs for each of the five alternatives.

The No Action alternative has the lowest estimated present worth, based on continuation of site security measures and O&M of IRM systems. The other four alternatives vary in estimated present worth from $26,440,000 for Alternative 4 to $39,147 for Alternative 3. The differences in cost are attributable to capital and O&M costs:

- The incremental cost to excavate soils with contaminant concentrations in excess of RBC concentrations relative to excavation of coal tar sources is approximately $11.2 million
- The difference between discharge to the POTW and discharge to the Coney Island Creek is approximately $81,000 annually, representing a difference in estimated present worth of approximately $1.5 million over 30 years

5.0 RECOMMENDED REMEDIAL ACTION ALTERNATIVE

This section presents the recommended remedial action alternative. A summary of the comparative analysis of remedial alternatives and the key factors contributing to the recommendation are presented. Additional considerations for remedial action, including IRMs, constructability issues, additional data collection, and the schedule for project development, are also discussed herein.

5.1 Selection of Recommended Remedial Action Alternative

The comparative analysis of remedial alternatives in Section 4.5 focuses on significant differences between the four alternatives other than No Action. Alternative 1, No Action, fails to meet RAOs and does not permit brownfield development of the site. Therefore, Alternative 1 is eliminated from further consideration as a viable remedial action alternative.

Alternatives 2, 3, 4, and 5 each meet RAOs; however, significant differences exist between the alternatives. These differences, which are identified in Section 4.5, stem from material excavation and effluent discharge options. The key differences between the excavation methodologies for the four alternatives focused on:

Residual contaminant concentrations in excess of RBCs in unsaturated zone soils. Based on a cursory evaluation, Alternatives 2 and 3 would be preferred relative to Alternatives 4 and 5 because soils with contaminant concentrations in excess of RBCs are removed from the unsaturated zone. This removal to RBCs effectively meets SCGs for site soils; SCGs for groundwater in all four alternatives are not applicable because groundwater has the characteristics suitable for designation as GSB saline. Since there is no expected beneficial use of the groundwater and it presents an acceptable human health risk, the GSB saline designation is appropriate. Alternatives 4 and 5 strive to remove the most significant sources of unsaturated zone contaminants and most of the contaminant mass; however, the residual concentrations remaining in the soil, which are a fraction of contaminant mass, present risks to unprotected construction workers. The installation of a multi-layer cover system across the site minimizes concerns relative to worker exposure, effectively negating the differences between the two excavation options as they relate to the risk-based approach for site remediation. Therefore, there is no clear advantage to implementing any of the four alternatives relative to the residual risks posed by buried and contained waste materials.

Short-term impacts. Alternatives 4 and 5 are preferred relative to Alternatives 2 and 3 due to less disturbance of the site, fewer trucks and related traffic, a shorter overall duration to complete remedial actions, and faster redevelopment of the site with associated economic benefits.

Cost-effectiveness. Alternatives 4 and 5 are preferred relative to Alternatives 2 and 3 due to the significant cost savings achieved by excavating coal tar source areas and not excavating the site to RBCs. The average estimated savings of $11.2 million between the different excavation options can be justified based on the ability of the four remedial alternatives to achieve RAOs. In effect, there is no benefit obtained by the unprotected construction worker if $11.2 million is expended to remove RBC soils other than coal tar sources from the site. With institutional controls in place and use of a clean fill zone above the cover system, future workers will either conduct their activities in clean soil or wear appropriate protection in accordance with a health and safety plan when breaches of the cover system into the site soils are required.

After considering the key issues of the excavation option, Alternatives 2 and 3 can be eliminated from further consideration. As such, Alternatives 4 and 5 remain viable for further evaluation. To select a preferred alternative between the two, consideration of the discharge option factors includes:

Coordination with agencies. The NYSDEC and USACE would have some level of involvement in the discharge of treated effluent into the Coney Island Creek. NYSDEC would have primary jurisdiction over the matter since they would be responsible for issuance of a SPDES permit. Discharge to the POTW requires approvals and coordination with the NYCDEP. Preliminary assessments of the options indicate that both discharge permits can be obtained with a similar level of effort. There is some question as to the ability of the Coney Island POTW to accept wastewater with a high chloride content, which could result in the need for additional treatment units to reduce levels suitable for facility acceptance. In addition to regular reporting required by NYSDEC and NYCDEP, the POTW option will also require regular service meter readings and payment of service fees. The level of coordination required for either discharge option does not present a clear advantage to either Alternative 4 or 5.

Cost-effectiveness. Discharge to the Coney Island Creek is preferred relative to the POTW discharge on the basis of cost-effectiveness. An estimated $81,000 each year, which represents a present worth of approximately $1.5 million over 30 years, can be saved by a direct discharge from the treatment plant to the creek.

On the basis of these evaluations, Alternative 4 is the recommended remedial action alternative. The alternative includes:

- Excavation of coal tar source areas depicted in Figure 5-1 down to the groundwater table. The technical difficulties of excavating coal tar sources and residual contaminants below the groundwater table makes such a cleanup effort impractical.
- Performing coal tar source area excavation, consolidation, and blending activities under temporary enclosures, as appropriate, to control the releases of volatile emissions and odors.
- Off-site transport and recycling of blended source area materials at a permitted facility, such as a cement kiln, thermal desorber, asphalt plant, utility boiler, or brick manufacturer.
- Installation of a protective coffer dam along the Coney Island Creek perimeter to minimize potential releases from the site during creek bank excavation and restoration efforts.
- Use of a temporary construction enclosure along the creek bank when trenching or excavation activities may release significant volatile emissions or odors into the atmosphere.
- Installation of a perimeter barrier around the site to minimize the migration of NAPL from the site into the Coney Island Creek while diverting upgradient groundwater around this site to the Coney Island Creek.
- Removal of the existing wooden bulkhead and contaminated materials between the barrier wall and the coffer dam with subsequent construction of a stabilized creek bank.
- Installation of a NAPL collection trench along the interior the creek barrier wall section to capture migrating NAPL and reduce hydrostatic pressure exerted on the wall by tidally influenced fluctuating groundwater levels.
- Treatment of captured aqueous waste in a system designed to reduce contaminant concentrations such that treated effluent may be discharged to the Coney Island Creek.
- Use of a subsurface relieving platform constructed on piles to provide structural bearing capacity for a planned commercial development.
- Installation of a multi-component cover system to act as a low permeability barrier to minimize both infiltration and the potential for direct contact of workers with concentrations of residual contaminants in excess of RBCs.
- Passive venting of vapors, which may form under the cover system, using risers equipped with carbon adsorption canisters.

- Restoration of the Coney Island Creek bank to provide a 50-foot ecological buffer zone. Monitoring wells would be installed immediately outside of the barrier within the buffer zone to assess the long-term performance of the barrier wall.
- Use of institutional controls, such as notifications, deed restrictions, fencing, a health and safety plan, a contingency plan, and long-term monitoring, after implementation of remedial actions.

Alternative 4 meets RAOs at the lowest estimated present worth cost of the four alternatives, approximately $26.4 million. It includes institutional controls, containment, source area removal, and off-site treatment to effectively mitigate the principal risks posed by the site. Identified remedial actions are consistent with Brooklyn Union's plans for brownfield development and do not preclude the performance of future remedial actions in the Coney Island Creek.

Alternative 4 is protective of human health and the environment. The proposed actions achieve most SCGs and reduce risk as required by CERCLA and the NCP. Identified risk pathways of concern, including direct contact by unprotected construction workers and inhalation of indoor air in a planned commercial development, are addressed adequately by source removal, containment, and engineering controls. Additional source removal and engineering controls protect the Coney Island Creek from residual contaminants contained within the site.

Alternative 4 is effective, implementable, and reduces the toxicity, mobility, and volume of contaminants. Short-term control measures can be instituted to minimize adverse impacts to the community, workers, and the environment during remedial construction. Remedies provide long-term protection as demonstrated by use of the identified technologies at other similar sites. These technologies and remedies can be monitored and assessed over time to measure their integrity. Vendors, equipment, and materials are available for installation of identified controls and performance of off-site treatment efforts. The expertise needed to install and maintain remedial systems on-site is expected to be available for many years.

5.2 Additional Considerations

This section presents additional considerations for the recommended remedial alternative. The role of IRMs in the execution of recommended project activities is addressed. Constructability issues, particularly those related to creek bank excavation activities, are discussed. Consideration is given to additional data collection activities that can be performed during detailed design or construction to optimize the remedial action and mitigate short-term risks to workers and the community. The acquisition of neighboring land parcels to enhance the effectiveness of the recommended remedy is addressed. A conceptual development schedule is presented for design and construction activities associated with the recommended remedial alternative.

5.2.1 Interim Remedial Measures

After completion of the FFS, the NYSDEC Order on Consent anticipates performance of an approved IRM program by Brooklyn Union at the former Brooklyn Borough Gas Works site. The IRM terminology used in the Order on Consent differs from the remedial action nomenclature used herein; however, the intent of an IRM and a remedial action is the same. Both seek to mitigate risks from site contaminants in a timely manner. Generally, an IRM is intended to provide short-term abatement of the most critical risks at a particular site as part of an overall remedy, or prior to development of a site-wide remedial alternative as with the existing on-site LNAPL IRM. In this context, an IRM is a discrete remedial action designed and implemented to reduce imminent short-term risks to human health and the environment. The remedial actions and remedial alternatives presented herein may be construed as a succession of IRMs over an expanded schedule of approximately 20 months to mitigate short- and long-term risks and provide a permanent remedy for on-site contaminants, in conjunction with final reuse.

When Brooklyn Union and NYSDEC entered into the Order on Consent, it was recognized that site-related contaminants were found on-site and off-site in the Coney Island Creek. To expedite the mitigation of risks from on-site sources, Brooklyn Union and NYSDEC agreed to separate on-site and off-site remedial activities and the schedule to address them. Since an overall remedy for both on- and off-site contaminants is not anticipated at this time, Brooklyn Union and NYSDEC agreed that separate IRMs for on-site and off-site contaminants would be appropriate. These separate IRMs would lead ultimately to the implementation of final remedies, which may be staggered in time, to reduce the risks from both on-site and off-site contaminants to the satisfaction of NYSDEC. To this end, implementation of the recommended remedial action alternative meets the requirements of an IRM program as defined in the Order on Consent.

5.2.2 Constructability Issues

The description and evaluation of remedial alternatives addressed the availability, performance, and installation of recommended technologies. Conceptual design schematics in Section 4.0 depict typical plan and cross-sectional views of identified remedial systems and the text provides descriptions of how these systems may be installed. With Brooklyn Union's intent to develop the site into a commercial establishment, additional consideration is appropriate for construction of remedial technologies and their integration with buildings, parking areas, and access improvements. The following constructability issues should be considered during the design and construction of the selected remedy:

Coordination with the developer. The developer's layout of the site, including the location of structures, utilities, parking areas, and access improvements, must be considered in the design of the final remedy. While certain remedies such as the barrier wall and creek bank stabilization can proceed independent of the developer, it is important to recognize that a fairly comprehensive preliminary design of the development is required to design and construct a concrete relieving platform, multi-layer cover system, 50-foot ecological buffer zone, treatment plant building, and discharge outfall. Since a developer is motivated to accelerate the design and construction of site improvements to start commercial operations and generate revenue, the early scheduling of remedy/development integration should not be of concern. During the time when both the remedial designer and the developer are preparing their respective drawings and designs, it is essential that they meet regularly and frequently to exchange ideas, concepts, and concerns. With good communications and a high level of coordination, remedial systems will be installed correctly and the developer will be able to work in clean construction zones with minimal concern for the risks associated with site contaminants.

Agency coordination. There are separate permit and approval processes for the site remedy and the site development. Different agencies may impose restrictions or request changes to preliminary designs in exchange for their approval. These restrictions and changes may conflict with planned or executed construction, depending on the timing of agency approval. This applies equally to remedial designs and the proposed commercial development. To minimize the potential adverse effects of agency-mandated changes during construction, which may be imposed after several months based on standard review times, it is recommended that a stakeholder group of all interested parties, including Brooklyn Union, the developer, NYSDEC, and other federal, state, and local agencies, meet for a partnering session. During the partnering session, project goals, key milestones, and the responsibilities of stakeholders can be discussed and commitments can be obtained to participate proactively in brownfield development. If the meeting is held early enough, potential conflicts between agency requirements may be identified and agreement may be reached on the best approach to resolve potential conflicts.

5.2.3 Recommendations for Additional Data Collection and Evaluation

The Final RI contains data of sufficient quantity and quality to complete remedial designs for most of the recommended remedial measures. As conceptual designs and process flows were developed during the

FFS, the need to collect additional data was identified. Additional data collection efforts that are recommended for early stages of remedial design include:

Geotechnical studies. The Final RI provided several cross-sections of the site subsurface stratigraphy. Preliminary engineering parameters for the different subsurface strata were inferred from the standard classifications documented in boring logs coupled with actual geotechnical data collected from field samples. Detailed design of the perimeter barrier wall, subsurface relieving platform and piles, and multi-layer cover system will require expanded coverage and more detailed analysis of subsurface stratigraphy. Additional geotechnical studies should determine the depths and physical characteristics of near-surface low-permeability layers around the site perimeter; depths and physical parameters, particularly compressibility, of soil strata beneath a planned subsurface relieving platform; depths and physical parameters, particularly compressibility, of soil strata beneath planned bridge foundations; stability of the creek bed along the site boundary to support a coffer dam; depth and extent of obstructions along a proposed barrier wall alignment; expected water generating rates along the creek boundary to design an adequate dewatering system during trenching and bank stabilization activities and the actual limits of coal tar source area excavation activities.

Chemical compatibility. As remedial systems are optimized during detailed design, it is recommended that chemical compatibility analyses and tests be performed. While the concentrations of contaminants are expected to diminish over time by natural attenuation and operation of the treatment plant, newly installed remedial systems will be subjected to the highest levels of contaminants and should be expected to perform without upset. Remedial systems and components which may be adversely affected by site contaminants include concrete, geomembrane liners, geotextiles, steel, slurry admixtures, pumps, and pipes. If a slurry wall is used as a vertical barrier, it is recommended that chemical compatibility tests be performed along with mix optimization tests to ensure long-term durability and low permeability in the saturated conditions present at the site. Special coatings may need to be specified for concrete and steel if chemical or electrochemical degradation of material is anticipated.

5.2.4 Incorporation of Adjacent Land Parcels

There are two small land parcels adjacent to the former Brooklyn Borough Gas Works Site not owned by Brooklyn Union. One parcel is located to the north of the central portion of the site. This parcel, bordered by Leif Ericson Drive, is owned by New York City and leased to the MTA under a long-term agreement. When the baseball fields were in use, this parcel was used for parking. The other parcel, also owned by New York City, is located adjacent to the northeastern portion of the site, bordered by Leif Ericson Drive and Coney Island Creek.

Both parcels are essentially vacant and their relative small size and location make them unattractive to future development on their own. However, their strategic location adjacent to the site makes them very attractive for inclusion in the final remedy. By incorporating these parcels into the site remedy, the final border of the site can be defined readily by Coney Island Creek, Leif Ericson Drive, and the MTA ROW. Inclusion of the properties will simplify the design and construction of perimeter barrier walls, provide additional land for brownfield development, and improve secondary access to future commercial establishments. The developer and Brooklyn Union may need to consider New York City, the MTA, and provisions for additional institutional controls to incorporate the adjacent land parcels in the final remedy and commercial development.

5.2.5 Conceptual Development Schedule

Figure 5-1 depicts the conceptual development schedule for the site. The schedule includes tasks associated with detailed design, permitting, construction, O&M, and commercial development. Assumed durations reflect recent experience performing these tasks at similar sites. The overall duration of conceptual development is estimated to be 22 months.

The schedule reflects a design-build philosophy and assumes that engineering and construction activities can be performed simultaneously to shorten the overall duration of remedial construction. As NYSDEC prepares the Record of Decision (ROD) for the recommended remedial alternative, preliminary engineering activities, such as design studies and site planning, can occur. By performing these tasks concurrent with ROD preparation, Brooklyn Union would be poised to mobilize construction forces to the site immediately upon issuance of the ROD.

Construction tasks are scheduled to occur as early as possible. The general sequence of construction activities follows the narratives provided in Section 4.0. Effective scheduling results in the completion of the most critical risk reduction activities in approximately 16 months. At this milestone, a 1-foot barrier layer of clean structural fill is installed across the site, allowing access to the developer's contractors to place additional clean fill, install subsurface utilities, and construct foundations. A secure treatment plant construction area on sufficient clean fill would be secured for remaining construction, start-up, and plant operation activities.

6.0 REFERENCES

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Table ES-1
Potentially Applicable Technologies Retained For Remediating Soils and NAPL

INSTITUTIONAL CONTROLS	CONTAINMENT	SOURCE REMOVAL	PREPARATION/ TREATMENT	DISPOSAL
Access Controls Deed restrictions Health & Safety Plan • Digging Permit Long-term monitoring Notifications	Soil • Cover System on Fill Groundwater/NAPL • Vertical Barrier ➢ Conventional Slurry Wall ➢ Vibrating Beam Slurry Wall ➢ Interlocking Steel Sheet Piles Air and Emissions • Temporary Enclosures	Soil • Excavation of Soils in Excess of Risk-Based Concentrations • Coal Tar Source Area Excavation Groundwater/NAPL • Recovery Trench	Soil Preparation • Consolidation • Screening • Blending Off - Site Recycling/ Treatment of Soil • Cold-Mix Asphalt • Hot-Mix Asphalt • Brick Manufacture • Cement Manufacture • Coburning in a utility boiler • Thermal Desorption NAPL • Phase Separation • Metals Precipitation • Filtration • Air Stripping • Carbon Adsorption • Neutralization • Aerobic Biological Treatment	Treated Effluent • Discharge to POTW • Discharge to Coney Island Creek

Table ES-2
Summary of Estimated Present Worth Costs
for Remedial Action Alternatives

Alternative	Description	Capital Cost ($)	Annual O&M ($)	Present Worth
1	No Action	$0	$253,000	$4,667,000
2	RBC excavation with discharge to Creek	$27,508,000	$550,000	$37,653,000
3	RBC excavation with discharge to POTW	$27,508,000	$631,000	$39,147,000
4	Source Area excavation with discharge to Creek	$16,295,000	$550,000	$26,440,000
5	Source Area excavation with discharge to POTW	$16,295,000	$631,000	$27,934,000

Table 1-1 (Sheet 1 of 2)
History of Investigations and Other Activities at the Former Brooklyn Borough Gas Works Site

Investigation Name	Date of Occurrence	Performed by	Performed for	Required by	Investigation or Activity Type	Purpose	Important Findings and Conclusions
Preliminary Subsurface Investigation	1984	Roux Associates	Brooklyn Union	Brooklyn Union	Preliminary Site Investigation	Initial assessment of potential for significant tar deposits.	Brown, oily free product observed in soils as were blackened soils having a coal-tar odor.
Contaminant Investigation and Transport Modeling	1988-1989	A.D. Little	Brooklyn Union	Brooklyn Union	Preliminary Site Investigation	Identify other contaminant sources and evaluate contaminant migration rates on to and off of the property.	While no other major sources were discovered, the previous observations were confirmed. Migration was found to be below reportable quantities.
Hazardous Materials Survey	1989	R.F. Weston	New York City Department of Sanitation	NYCDOS	Preliminary Site Investigation	Evaluate the conditions of the property.	Observed free product and oil on groundwater and in soil borings and high lead levels in the western portions of the site.
Health Risk Assessment of the Former Gil Hodges Baseball Fields	1990-1992	A.D. Little	Brooklyn Union	Brooklyn Union	Preliminary Site Investigation and Risk Assessment	Perform additional soil samples and soil gas analysis in the area of the former ball fields, compile all relevant data and evaluate potential health risks from playing on the field at that time.	None of the observed levels were found to potentially result in an unacceptable health hazard.
Phase II Geotechnical Investigation	1993	E&E	Brooklyn Union	Brooklyn Union	Site Investigation	Extensive investigation of the environmental conditions of the site.	Provided a detailed analysis of the chemical contamination of soil and water at the site.
Phase III Geotechnical Investigation	1993	E&E	Brooklyn Union	Brooklyn Union	Site Investigation	Additional subsurface investigation and groundwater sampling.	Observed several underground structures and groundwater seep entering Coney Island Creek and carrying free product.
Phase IV Geotechnical and Hydrogeological Investigation	1993	E&E	Brooklyn Union	Brooklyn Union	Site Investigation	Evaluate the seep.	Obtained an improved understanding of the behavior of the seep.
Phase V Geotechnical and Hydrogeological Investigation	1993-1994	E&E	Brooklyn Union	Brooklyn Union	Site Investigation	Performed additional subsurface and groundwater monitoring and evaluations to provide engineering data.	Clarified groundwater behavior and conditions along the perimeter of the site.

Table 1-1 (Sheet 2 of 2)

History of Investigations and Other Activities at the Former Brooklyn Borough Gas Works site

Investigation Name	Date of Occurrence	Performed by	Performed for	Required by	Investigation or Activity Type	Purpose	Important Findings and Conclusions
Interim Response Measure for Seep	1993-1995	E&E	Brooklyn Union	U.S. Coast Guard	Interim Response Measure (IRM)	Place a temporary control measure to prevent further contamination of the creek.	A hard boom and skimmer system were placed and shown to contain product release into the creek. Action was observed and verbally accepted by the Coast Guard in May 1995.
Phase VI Supplemental Remedial Investigation	1996-1997	E&E	Brooklyn Union	Brooklyn Union Under an Consent Order with NYSDEC	Remedial Investigation (RI)	In support of the preparation of the RI additional soil and groundwater sampling were performed.	Additional information about contamination in the eastern portion of the site was obtained and all information evaluated and combined into the RI Report.
Interim Response Measure to Remove High Levels of Lead in Surface Soil	1997	Fanning, Philips & Molnar	Brooklyn Union	Brooklyn Union	IRM	Reduce significant lead levels in surface soil in the western portion of the site around the former large gas holder foundation.	The top foot of soil was removed from approximately 4 acres.
Baseline Risk Assessment	1997-1998	GEI/Atlantic	Brooklyn Union	Brooklyn Union Under an Consent Order with NYSDEC	Risk Assessment	As part of the requirements under the Consent Order a risk assessment was performed, based on future reuse.	See Section 1.2.4 of this FFS report.
Focused Feasibility Study	1998	Foster Wheeler	Brooklyn Union	Brooklyn Union Under an Consent Order with NYSDEC	Focused Feasibility Study	As part of the requirements under the Consent Order a study was performed to evaluate response options to reduce health and environmental hazards to support redevelopment of the site.	See the report

Table 1-2 (Sheet 1 of 2)
Summary of Chemicals Detected in Surface Soil at the Former Brooklyn Borough Gas Works Site

CAS No.	Name	Number of Detections	Number of Samples	Frequency of Detection	Units	Background Concentrations(1)	NYSDEC Recommended Soil Cleanup Objectives(2)	Minimum Detected Concentration	Maximum Detected Concentration	Minimum Quantitation Limit	Maximum Quantitation Limit	Selected COPC
Organic Chemicals												
Volatile Organic Chemicals												
67-64-1	Acetone	26	77	0.338	mg/kg	NA	0.2	0.0029	4.2	0.0109	17	Yes
71-43-2	Benzene	8	77	0.1039	mg/kg	NA	0.06	0.0015	8.3	0.0004	8.7	Yes
117-81-7	bis(2-Ethylhexyl)phthalate	1	1	1	mg/kg	NA	50	0.25	0.25	4.3	4.3	No
78-93-3	2-Butanone (methyl ethyl ketone)	1	77	0.013	mg/kg	NA	0.3	21	21	0.0039	17	
75-15-0	Carbon Disulfide	1	77	0.013	mg/kg	NA	2.7	0.0047	0.0047	0.0009	8.7	No
100-41-4	Ethylbenzene	12	77	0.156	mg/kg	NA	5.5	0.002	190	0.0003	8.7	Yes
75-09-2	Methylene Chloride	63	77	0.818	mg/kg	NA	0.1	0.0016	16	0.0003	8.7	Yes
100-42-5	Styrene	5	77	0.0649	mg/kg	NA		0.0012	0.74	0.0003	8.7	Yes
127-18-4	Tetrachloroethene	7	77	0.091	mg/kg	NA	1.4	0.0022	0.014	0.0004	8.7	No
108-88-3	Toluene	19	77	0.247	mg/kg	NA	1.5	0.0011	10	0.0003	8.7	Yes
71-55-6	1,1,1-Trichloroethane	2	77	0.026	mg/kg	NA	0.8	0.004	0.0049	0.0003	8.7	No
79-01-6	Trichloroethene	1	77	0.013	mg/kg	NA	0.7	0.0096	0.0096	0.0006	8.7	No
1330-20-7	Xylenes, total	16	77	0.208	mg/kg	NA	1.2	0.0015	290	0.0009	8.7	Yes
Semivolatile Organic Chemicals												
132-64-9	Dibenzofuran	1	1	1	mg/kg	NA	6.2	0.16	0.16	4.3	4.3	No
Semivolatile Organic Chemicals - Polycyclic Aromatic Hydrocarbons (PAHs)												
83-32-9	Acenaphthene	59	81	0.728	mg/kg	NA	50	0.088	1300	0.0326	240	Yes
208-96-8	Acenaphthylene	50	80	0.625	mg/kg	NA	41	0.41	650	0.0282	240	Yes
120-12-7	Anthracene	78	81	0.963	mg/kg	NA	50	0.0068	120	0.0048	24	Yes
56-55-3	Benz(a)anthracene	79	80	0.988	mg/kg	NA	0.224	0.063	450	0.0069	24	Yes
50-32-8	Benzo(a)pyrene	79	80	0.988	mg/kg	NA	0.061	0.049	230	0.003	24	Yes
205-99-2	Benzo(b)fluoranthene	79	81	0.975	mg/kg	NA	1.1	0.045	100	0.0038	24	Yes
191-24-2	Benzo(g,h,i)perylene	75	79	0.949	mg/kg	NA	50	0.1	91	0.0038	60	Yes
207-08-9	Benzo(k)fluoranthene	77	80	0.963	mg/kg	NA	1.1	0.0026	66	0.0023	24	Yes
218-01-9	Chrysene	80	81	0.988	mg/kg	NA	0.4	0.068	430	0.0039	24	Yes
53-70-3	Dibenz(a,h)anthracene	9	81	0.111	mg/kg	NA	0.014	0.0413	6.1	0.0063	60	Yes
206-44-0	Fluoranthene	80	81	0.988	mg/kg	NA	50	0.11	1100	0.0091	60	Yes
86-73-7	Fluorene	75	80	0.938	mg/kg	NA	50	0.0214	330	0.0035	24	Yes
193-39-5	Indeno(1,2,3-cd)pyrene	75	79	0.949	mg/kg	NA	3.2	0.036	78	0.0026	24	Yes
91-57-6	2-Methylnaphthalene	47	81	0.58	mg/kg	NA		0.24	1100	0.0324	240	Yes

Table 1-2 (Sheet 2 of 2)
Summary of Chemicals Detected in Surface Soil at the Former Brooklyn Borough Gas Works Site

CAS No.	Name	Number of Detections	Number of Samples	Frequency of Detection	Units	Background Concentrations	NYSDEC Recommended Soil Cleanup Objectives	Minimum Detected Concentration	Maximum Detected Concentration	Minimum Quantitation Limit	Maximum Quantitation Limit	Selected COPC
91-20-3	Naphthalene	69	80	0.863	mg/kg	NA	13	0.43	1700	0.0329	240	Yes
85-01-8	Phenanthrene	81	81	1	mg/kg	NA	50	0.038	750	0.0023	24	Yes
129-00-0	Pyrene	79	80	0.988	mg/kg	NA	50	0.094	660	0.0136	60	Yes
	Organic Chemicals - Pesticides and Polychlorinated Biphenyls											
309-00-2	Aldrin	1	17	0.0588	mg/kg	NA	0.041	0.09	0.09	0.0002	0.11	Yes
57-74-9	Chlordane	12	17	0.7059	mg/kg	NA	0.54	0.002	36.1	0.0001	0.92	Yes
50-29-3	4,4'-DDT	8	17	0.4706	mg/kg	NA	2.1	0.0021	0.071	0.0003	0.57	No
72-54-8	4,4'-DDD	8	17	0.4706	mg/kg	NA	2.9	0.0059	0.254	0.0004	0.23	No
72-55-9	4,4'-DDE	11	17	0.6471	mg/kg	NA	2.1	0.0017	0.166	0.0002	0.23	No
60-57-1	Dieldrin	5	17	0.2941	mg/kg	NA	0.044	0.0101	0.0252	0.0002	0.23	No
1024-57-3	Heptachlor epoxide	4	17	0.2353	mg/kg	NA	0.02	0.0044	0.0581	0.0001	0.11	Yes
11097-69-1	PCB-1254	2	17	0.1176	mg/kg	NA	1	7.5	9.9	0.0006	2.3	Yes
	Inorganic Chemicals											
7440-36-0	Antimony	1	86	0.0116	mg/kg	0.67		30	30	0.559	11	Yes
7440-38-2	Arsenic	86	86	1	mg/kg	7.2	7.5	2	60	0.331	3.2	Yes
7440-41-7	Beryllium	18	86	0.209	mg/kg	0.92	0.16	0.7	3.8	0.54	0.89	Yes
7440-43-9	Cadmium	1	1	1	mg/kg	0.06	1	2.6	2.6	0.66	0.66	No
7440-47-3	Chromium	14	14	1	mg/kg	54	10	6.91	54	0.0331	1.1	Yes
7440-48-4	Cobalt	1	1	1	mg/kg	10	30	10	10	2.6	2.6	No
7440-50-8	Copper	85	86	0.988	mg/kg	25	25	15	920	2.2	3.6	Yes
57-12-5	Cyanide	1	21	0.0476	mg/kg	NA		1.6	1.6	0.0808	0.0974	Yes
7439-92-1	Lead	86	86	1	mg/kg	19		0.91	5900	0.221	13	Yes
7439-96-5	Manganese	86	86	1	mg/kg	560		10	460	0.133	1.8	Yes
7439-97-6	Mercury	69	86	0.802	mg/kg	0.089	0.1	0.111	2.6	0.0552	0.18	Yes
7440-02-0	Nickel	84	84	1	mg/kg	19	13	5	270	0.221	3.6	Yes
7782-49-2	Selenium	26	86	0.302	mg/kg	0.39	2	0.569	4.3	0.54	3.4	Yes
7440-62-2	Vanadium	1	1	1	mg/kg	76	150	25	25	2.6	2.6	No
7440-66-6	Zinc	86	86	1	mg/kg	60	20	5.6	2400	1.1	1.8	Yes

Notes:

(1) Shacklette, H.T., andJ. G., Boerngen, 1984, Elemental Concentrations in Soils and Other Surficial Materials of the Conterminous United States, U.S. Geological Survey Professional Paper 1270, USGPO, Washington, DC.
(2) NYSDEC TAGM HWR-94-4046

Table 1-3 (Sheet 1 of 2)
Summary of Chemicals Found in Subsurface Soils at the Former Brooklyn Borough Gas Works Site

CAS No.	NAME	Number of Detections	Number of Samples	Frequency of Detection	Units	Background Concentration(1)	NYSDEC Recommended Soil Cleanup Objectives(2)	Minimum Detected Concentration	Maximum Detected Concentration	Minimum Quantitation Level	Maximum Quantitation Level	Selected as COPC
	Organic Chemicals											
	Volatile Organic Chemicals											
67-64-1	Acetone	185	277	0.673	mg/kg	NA	0.2	0.0022	71	0.0099	510	Yes
71-43-2	Benzene	95	277	0.346	mg/kg	NA	0.06	0.0014	101	0.0003	23	Yes
75-27-4	Bromodichloromethane	1	277	0.0036	mg/kg	NA		0.002	0.002	0.0005	130	No
78-93-3	2-Butanone	19	277	0.0686	mg/kg	NA	0.3	0.0044	20	0.0036	12	Yes
75-15-0	Carbon Disulfide	44	277	0.16	mg/kg	NA	2.7	0.0017	35	0.0008	51	Yes
108-90-7	Chlorobenzene	1	277	0.0036	mg/kg	NA	1.7	0.23	0.23	0.0005	12	No
67-66-3	Chloroform	1	277	0.0036	mg/kg	NA	0.3	0.0025	0.0025	0.0004	12	No
75-34-3	1,1-Dichloroethane	1	277	0.0036	mg/kg	NA	0.2	0.024	0.024	0.0006	51	No
75-35-4	1,1-Dichloroethene	1	277	0.0036	mg/kg	NA	0.4	1	1	0.0005	130	No
100-41-4	Ethylbenzene	149	277	0.542	mg/kg	NA	5.5	0.0013	640	0.0003	12	Yes
75-09-2	Methylene Chloride	178	277	0.643	mg/kg	NA	0.1	0.0012	66	0.0003	12	Yes
108-10-1	4-Methyl-2-Pentanone	2	277	0.0072	mg/kg	NA	1	0.0238	0.0335	0.0014	23	No
100-42-5	Styrene	30	277	0.109	mg/kg	NA		0.0012	410	0.0002	12	Yes
127-18-4	Tetrachloroethene	16	277	0.058	mg/kg	NA	1.4	0.0015	0.011	0.0004	12	No
108-88-3	Toluene	98	277	0.356	mg/kg	NA	1.5	0.0016	450	0.0003	12	Yes
71-55-6	1,1,1-Trichloroethane	3	277	0.0108	mg/kg	NA	0.8	0.0049	0.048	0.0003	12	No
79-00-5	1,1,2-Trichloroethane	1	277	0.0036	mg/kg	NA		0.0486	0.0486	0.0007	12	No
79-01-6	Trichloroethene	7	277	0.0253	mg/kg	NA	0.7	0.0034	0.013	0.0005	12	No
1330-20-7	Xylenes, total	152	277	0.553	mg/kg	NA	1.2	0.0016	1600	0.0008	12	Yes
	Semivolatile Organic Chemicals - Polycyclic Aromatic Hydrocarbons (PAHs)											
83-32-9	Acenaphthene	139	270	0.515	mg/kg	NA	50	0.075	2800	0.0272	460	Yes
208-96-8	Acenaphthylene	140	269	0.52	mg/kg	NA	41	0.11	3400	0.0235	23	Yes
120-12-7	Anthracene	246	269	0.915	mg/kg	NA	50	0.0059	1900	0.004	510	Yes
56-55-3	Benz(a)anthracene	241	269	0.896	mg/kg	NA	0.224	0.0084	1100	0.0057	51	Yes
50-32-8	Benzo(a)pyrene	249	270	0.922	mg/kg	NA	0.061	0.0084	450	0.0025	12	Yes
205-99-2	Benzo(b)fluoranthene	243	269	0.903	mg/kg	NA	1.1	0.0044	280	0.0031	51	Yes
191-24-2	Benzo(g,h,i)perylene	193	270	0.715	mg/kg	NA	50	0.011	170	0.0031	51	Yes
207-08-9	Benzo(k)fluoranthene	235	269	0.874	mg/kg	NA	1.1	0.0065	170	0.0019	51	Yes
218-01-9	Chrysene	250	269	0.929	mg/kg	NA	0.4	0.012	1000	0.0032	12	Yes

Table 1-3 (Sheet 2 of 2)
Summary of Chemicals Found in Subsurface Soils at the Former Brooklyn Borough Gas Works Site

CAS No.	NAME	Number of Detections	Number of Samples	Frequency of Detection	Units	Background Concentration(1)	NYSDEC Recommended Soil Cleanup Objectives(2)	Minimum Detected Concentration	Maximum Detected Concentration	Minimum Quantitation Level	Maximum Quantitation Level	Selected as COPC
53-70-3	Dibenz(a,h)anthracene	40	270	0.148	mg/kg	NA	0.014	0.047	33	0.0053	12	Yes
206-44-0	Fluoranthene	254	269	0.944	mg/kg	NA	50	0.03	4400	0.0076	130	Yes
86-73-7	Fluorene	246	269	0.915	mg/kg	NA	50	0.013	2200	0.0029	51	Yes
193-39-5	Indeno(1,2,3-cd)pyrene	218	270	0.807	mg/kg	NA	3.2	0.0043	190	0.0022	51	Yes
91-57-6	2-Methylnaphthalene	170	269	0.632	mg/kg	NA		0.045	10000	0.027	12	Yes
91-20-3	Naphthalene	204	269	0.758	mg/kg	NA	13	0.0445	3800	0.0274	510	Yes
85-01-8	Phenanthrene	258	269	0.959	mg/kg	NA	50	0.018	5000	0.0019	51	Yes
129-00-0	Pyrene	243	269	0.903	mg/kg	NA	50	0.021	3070	0.0113	110	Yes
	Organic Chemicals - Pesticides and Polychlorinated Biphenyls (PCBs)											
309-00-2	Aldrin	3	83	0.0361	mg/kg	NA	0.041	0.0215	0.816	0.0002	1.8	Yes
57-74-9	Chlordane	16	83	0.1928	mg/kg	NA	0.54	0.0091	8.51	0.0002	14	Yes
50-29-3	4,4'-DDT	9	83	0.1084	mg/kg	NA	2.1	0.0128	0.36	0.0003	9.1	No
72-54-8	4,4'-DDD	9	83	0.1084	mg/kg	NA	2.9	0.0036	0.78	0.0004	3.6	No
72-55-9	4,4'-DDE	7	83	0.0843	mg/kg	NA	2.1	0.0144	0.119	0.0002	3.6	No
60-57-1	Dieldrin	2	83	0.0241	mg/kg	NA	0.044	0.0258	0.0533	0.0002	3.6	Yes
76-44-8	Heptachlor	1	83	0.012	mg/kg	NA	0.1	0.237	0.237	0.0001	1.8	Yes
1024-57-3	Heptachlor epoxide	4	83	0.0482	mg/kg	NA	0.02	0.017	1.75	0.0001	1.8	Yes
53469-21-9	PCB-1242	1	83	0.012	mg/kg	NA	10	0.909	0.909	0.0006	36	Yes
12672-29-6	PCB-1248	3	83	0.0361	mg/kg	NA	10	17.5	28.7	0.0006	36	Yes
11097-69-1	PCB-1254	4	83	0.0482	mg/kg	NA	10	5.83	37.3	0.0006	36	Yes
11096-82-5	PCB-1260	5	83	0.0602	mg/kg	NA	10	0.0021	10.2	0.012	36.5	Yes
	Inorganic Chemicals											
7440-36-0	Antimony	3	262	0.0115	mg/kg	0.67		7.1	10.8	0.538	21	Yes
7440-38-2	Arsenic	257	270	0.952	mg/kg	7.2	7.5	0.56	135	0.316	3.8	Yes
7440-41-7	Beryllium	11	270	0.0407	mg/kg	0.92	0.16	0.526	2.4	0.526	1.8	Yes
7440-47-3	Chromium	71	71	1	mg/kg	54	10	2.7	46.3	0.0316	1.8	Yes
7440-50-8	Copper	247	270	0.915	mg/kg	25	25	2	2700	2.2	7.1	Yes
57-12-5	Cyanide	50	107	0.4673	mg/kg	NA		0.696	446	0.0129	6.99	Yes
7439-92-1	Lead	267	270	0.989	mg/kg	19		0.74	3000	0.211	21	Yes
7439-96-5	Manganese	269	270	0.996	mg/kg	560		6.6	2910	0.126	3.6	Yes
7439-97-6	Mercury	90	270	0.333	mg/kg	0.089	0.1	0.11	4.7	0.0526	0.36	Yes
7440-02-0	Nickel	244	251	0.972	mg/kg	19	13	2.8	170	0.211	7.1	Yes
7782-49-2	Selenium	103	269	0.393	mg/kg	0.39	2	0	15.9	0.526	1.8	Yes
7440-66-6	Zinc	171	270	0.6333	mg/kg	60	20	4.3	8500	1.05	3.6	Yes

Notes: (1) *Shacklette, H.T., andJ. G., Boerngen, 1984, Elemental Concentrations in Soils and Other Surficial Materials of the Conterminous United States, U.S. Geological Survey Professional Paper 1270, USGPO, Washington, DC.*
(2) NYSDEC TAGM HWR-94-4046

Table 1-4 (Sheet 1 of 2)
Selection of Chemicals of Concern for the Former Brooklyn Borough Gas Works Site

CAS No.	Analyte	COPC	COCs			
			Surface Soil	Subsurface Soil	Groundwater & Surface Water	Indoor Air
	Organic Chemicals					
	Volatile Organic Chemicals					
67-64-1	Acetone	Yes	No	No	No	No
71-43-2	Benzene	Yes	No	No	Yes	Yes
117-81-7	bis(2-Ethylhexyl)phthalate	No	No	No	Yes	No
75-27-4	Bromodichloromethane	No	No	No	No	No
78-93-3	2-Butanone (methyl ethyl ketone)	Yes	No	No	No	No
75-15-0	Carbon Disulfide	Yes	No	No	No	No
108-90-7	Chlorobenzene	No	No	No	No	No
67-66-3	Chloroform	No	No	No	No	No
75-34-3	1,1-Dichloroethane	No	No	No	No	No
75-35-4	1,1-Dichloroethene	No	No	No	No	No
100-41-4	Ethylbenzene	Yes	No	No	Yes	No
75-09-2	Methylene Chloride	Yes	No	No	No	No
108-10-1	4-Methyl-2-Pentanone	No	No	No	No	No
100-42-5	Styrene	Yes	No	No	No	No
127-18-4	Tetrachloroethene	No	No	No	No	No
108-88-3	Toluene	Yes	No	No	Yes	No
71-55-6	1,1,1-Trichloroethane	No	No	No	No	No
79-00-5	1,1,2-Trichloroethane	No	No	No	Yes	No
79-01-6	Trichloroethene	No	No	No	Yes	No
1330-20-7	Xylenes, total	Yes	No	No	Yes	No
	Semivolatile Organic Chemicals					
132-64-9	Dibenzofuran	No	No	No	No	No
	Semivolatile Organic Chemicals - Polycyclic Aromatic Hydrocarbons (PAHs)					
83-32-9	Acenaphthene	Yes	Yes	Yes	Yes	No
208-96-8	Acenaphthylene	Yes	Yes	Yes	Yes	No
120-12-7	Anthracene	Yes	Yes	Yes	Yes	No
56-55-3	Benz(a)anthracene	Yes	Yes	Yes	Yes	No
50-32-8	Benzo(a)pyrene	Yes	Yes	Yes	Yes	No
205-99-2	Benzo(b)fluoranthene	Yes	Yes	Yes	Yes	No
191-24-2	Benzo(ghi)perylene	Yes	Yes	Yes	Yes	No
207-08-9	Benzo(k)fluoranthene	Yes	Yes	Yes	Yes	No
218-01-9	Chrysene	Yes	Yes	Yes	Yes	No
53-70-3	Dibenz(a,h)anthracene	Yes	Yes	Yes	Yes	No
206-44-0	Fluoranthene	Yes	Yes	Yes	Yes	No
86-73-7	Fluorene	Yes	Yes	Yes	Yes	No
193-39-5	Indeno(1,2,3-cd)pyrene	Yes	Yes	Yes	Yes	No
91-57-6	2-Methylnaphthalene	Yes	Yes	Yes	Yes	No
91-20-3	Naphthalene	Yes	Yes	Yes	Yes	No
85-01-8	Phenanthrene	Yes	Yes	Yes	Yes	No

Table 1-4 (Sheet 2 of 2)

Selection of Chemicals of Concern for the Former Brooklyn Borough Gas Works Site

CAS No.	Analyte	COPC	COCs			
			Surface Soil	Subsurface Soil	Groundwater & Surface Water	Indoor Air
129-00-0	Pyrene	Yes	Yes	Yes	Yes	No
			Organic Chemicals - Pesticides and Polychlorinated Biphenyls			
309-00-2	Aldrin	Yes	Yes	Yes	No	No
57-74-9	Chlordane	Yes	Yes	Yes	No	No
50-29-3	4,4'-DDT	No	No	No	No	No
72-54-8	4,4'-DDD	No	No	No	No	No
72-55-9	4,4'-DDE	No	No	No	No	No
60-57-1	Dieldrin	Yes	No	Yes	No	No
76-44-8	Heptachlor	Yes	No	No	No	No
1024-57-3	Heptachlor epoxide	Yes	Yes	Yes	No	No
53469-21-9	PCB-1242	Yes	Yes	Yes	No	No
12672-29-6	PCB-1248	Yes	Yes	Yes	No	No
11097-69-1	PCB-1254	Yes	Yes	Yes	No	No
11096-82-5	PCB-1260	Yes	Yes	Yes	No	No
			Inorganic Chemicals			
7440-36-0	Antimony	Yes	No	No	No	No
7440-38-2	Arsenic	Yes	Yes	Yes	No	No
7440-41-7	Beryllium	Yes	No	No	No	No
7440-43-9	Cadmium	No	No	No	No	No
7440-47-3	Chromium	Yes	No	No	No	No
7440-48-4	Cobalt	No	No	No	No	No
7440-50-8	Copper	Yes	No	No	No	No
---	Cyanide, Total	Yes	Yes	Yes	No	No
7439-92-1	Lead	Yes	Yes	Yes	No	No
7439-96-5	Manganese	Yes	No	No	No	No
7439-97-6	Mercury	Yes	No	No	No	No
7440-02-0	Nickel	Yes	No	No	No	No
7782-49-2	Selenium	Yes	No	No	No	No
7440-62-2	Vanadium	No	No	No	No	No
7440-66-6	Zinc	Yes	No	No	No	No

Notes:
COPC = Contaminant of Potential Concern
COC = Contaminant of Concern

Table 2-1

Typical New York City Department Approvals

Approval/Authorization	Agency	Requirement
Uniform Land Use Review Procedure (ULURP)	Department of City Planning	Land use approval for zoning map changes/re-zoning applications.
City Environmental Quality Review Act (CEQR)[1]	Department of City Planning[2]	Determination of environmental significance of the development/ redevelopment.
Waterfront Development Review and Approval	Department of Business Services	Project site is within Waterfront zone. Development activities, including building of structures, must comply with coastal policies and obtain approval.
New Building Permit/Plan Approval	Buildings Department, Brooklyn Borough Office	Construction of new structures in compliance with Building Code and Zoning Resolution.
Equipment Work Permits	Buildings Department, Brooklyn Borough Office	Approval for the installation of service equipment (i.e., HVAC systems).
Certificate of Operation	Department of Environmental Protection, Bureau of Air Resources	Fuel combustion equipment (oil, gas or coal) having a capacity rating of 350,000 BTU/hr. or greater.
Sewer Connection Approval	Department of Environmental Protection, Bureau of Wastewater Pollution Control	Authorization to connect or re-connect to public sewers.
Street Opening/Closing Permit	Department of Transportation	Water sewer service openings; restoration of pavement; other street openings.

Notes:

[1] Assumes a New York City lead review agency. If a state agency is assigned lead agency status, then the State Environmental Quality Review Act (SEQRA) will apply.

[2] Lead agency will be dependent on the type and extent of the development/re-development action.

Table 2-2

Statutes, Regulations, And Guidelines Used In The Identification Of Chemical-Specific SCGs

REQUIREMENTS	CITATION	DESCRIPTION	SCG or TBC	COMMENT
STATE				
New York State Environmental Conservation Law				
Inactive Hazardous Waste Disposal Sites	Article 27, Title 13	Establishes general cleanup goals for environmental media to levels that will eliminate a significant threat to the environment. This allows NYSDEC to designate inactive hazardous waste disposal sites.	SCG	Sites are listed based on evidence of a significant threat posed by hazardous waste disposed of at the site. A significant adverse impact on the environment and/or a significantly increased risk to human health would constitute a significant threat. The Former Brooklyn Borough Gas Works site is currently listed on the registry of Inactive Hazardous Waste Disposal Sites.
NYSDEC Soil Cleanup Objectives	Division of Hazardous Waste Remediation, TAGM HW94-4046, 1994	Establishes soil cleanup objectives based on residential land use and protection of groundwater quality.	TBC	Risk-based action levels for the site have been calculated pursuant to the mandates of the Consent Order. These levels are presented herein.
Interim Procedures for Inactivation of Petroleum Contaminated Sites	January 2, 1997 Draft	Guidance for risk-based clean-up of petroleum impacted sites	TBC	Risk-based action levels for the site are presented herein.
NYSDEC Fish and Wildlife Impact Analysis for Inactive Hazardous Waste Sites (FWIA)	Division of Fish and Wildlife, October 1994	Provides guidance for evaluating ecological impacts on fish and wildlife in areas contaminated with hazardous waste. Includes contaminant-specific impact assessment consisting of a Pathway analysis, Criteria-Specific Analyses, and Toxic Effects Analysis. Criteria-Specific Analysis uses numerical criteria, including SCGs and TBCs, for contaminants of concern that have been established for specific media or biota.	SCG	

Table 2-3 (Sheet 1 of 6)
Statutes, Regulations, And Guidelines Used In The Identification Of Action-Specific SCGs

ACTION	REQUIREMENTS	CITATION	DESCRIPTION	SCG or TBC	COMMENT
Management of Hazardous Waste Generated On-site	Resource Conservation and Recovery Act (RCRA)	42 U S C Section 6901 et seq			
	Standards for Hazardous Waste Generators, Manifesting, Pre-transportation, Reporting Requirements	40 CFR Part 262 Subparts B, C, D	Regulations governing packaging, labeling, reporting and manifesting of hazardous waste	SCG	These generator requirements are potentially applicable to remedial activities involving the offsite transport of hazardous waste generated onsite
Institutional Controls	Resource Conservation and Recovery Act (RCRA)	40 U S C Section 6901 et seq			
	Land Disposal Facility Notice in Deed	40 CFR 264/265 116-119(b)(1)	Establishes provisions for a deed notation for closed hazardous waste disposal units, to prevent land disturbance by future owners	SCG	These regulations are potentially applicable because closed areas may be similar to closed RCRA units
Generation, Management, and Treatment of Hazardous Waste	Resource Conservation and Recovery Act (RCRA) Subtitle C - Hazardous Waste Management	40 U S C Section 6901 et seq			
	Identification and Listing of Hazardous Wastes	40 CFR Part 261	Outlines criteria for determining if a solid waste is a hazardous waste and is subject to regulation under 40 CFR Parts 260-266	SCG	MGP residuals are not a listed hazardous waste. Neither coal nor petroleum-based residuals are listed hazardous wastes. For residuals determined to be characteristically hazardous based on the TCLP, the requirements are applicable. The TCLP limit for benzene is 0.5 mg/L. These regulations do not set clean-up standards, but would apply during various remedial actions.
	Standards for Hazardous Waste Generators	40 CFR Part 262			
	Hazardous Waste Determinations	40 CFR Part 262.11	Generators must characterize their wastes to determine if the waste is hazardous by listing (40 CFR 261, Subpart D) by characteristic (40 CFR 261, Subpart C) or excluded from regulation (40 CFR 261.4)	SCG	These regulations would be applicable to wastes generated during remedial activities at the site. Neither coal nor petroleum-based residuals are listed hazardous wastes but may be hazardous by characteristic (particularly for benzene toxicity).

Table 2-3 (Sheet 2 of 6)
Statutes, Regulations, And Guidelines Used In The Identification Of Action-Specific SCGs

ACTION	REQUIREMENTS	CITATION	DESCRIPTION	SCG or TBC	COMMENT
Generation, Management, and Treatment of Hazardous Waste (cont)	Accumulation Limitations	40 CFR Part 262.34	Allows generators of hazardous waste to store and treat hazardous waste at the generation site for up to 90 days in tanks, containers, and containment buildings without having to obtain a RCRA hazardous waste permit.	SCG	Hazardous MGP soils may be stored for up to 90 days on-site without the need for a storage permit unless NYSDEC waives the 90-day limit as an administrative requirement.
	Standards for Owners/Operators of Hazardous Waste Treatment, Storage, Disposal (TSD) Facilities	40 CFR Part 264/265			
	General Facility Standards	Subpart B	General requirements for owners/operators of TSD facilities including general waste analysis and compatibility, notices and inspection requirements, location and construction standards, and security	SCG	These subpart standards would be applicable for the construction, operation or closure of a new or currently permitted TSD facility used for management of remediation waste classified as a hazardous waste or for the closure of existing interim-status and new land disposal facilities where hazardous waste will remain in place after completion of closure.
	Closure and Post-Closure	Subpart G	Established closure and post-closure requirements for TSD facilities, including post-closure property uses	SCG	
	Container Management	Subpart I	Hazardous waste stored in containers must comply with management requirements, including types of containers used, waste compatibility and inspection requirements.	SCG	Applicable to storage of hazardous wastes in containers on-site.
	Tank Systems	Subpart J	Tank systems for the treatment or storage of hazardous wastes are to be designed and operated in a manner to prevent releases to the environment	SCG	Applicable for the tank treatment and/or storage of all remediation waste that is classified as a hazardous waste.
	Miscellaneous Units	Subpart X	New miscellaneous units must be designed, constructed, and operated to meet regulatory performance standards	SCG	Standards applicable to the construction and operation of new miscellaneous units used to treat remediation waste that is classified, or is sufficiently similar to a hazardous waste. These regulations apply to thermal desorption units that are not classified as incinerators or industrial furnaces.

Table 2-3 (Sheet 3 of 6)
Statutes, Regulations, And Guidelines Used In The Identification Of Action-Specific SCGs

ACTION	REQUIREMENTS	CITATION	DESCRIPTION	SCG or TBC	COMMENT
Capping of Hazardous Waste	RCRA Subtitle C	40 U S C Section 6901 et seq			
	Standards for Capping Surface Impoundments Waste Piles Landfills	40 CFR Part 264/265 Subpart K Subpart L Subpart N	Regulations governing placement of cap. Requirements for installation, permeability, maintenance of cover, elimination of free liquids or solidification, run-on/run-off damage control, and post-closure use of property	TBC	RCRA hazardous waste placed at the site after the effective date of the requirements, or placement of hazardous waste into another unit will make requirements applicable when the waste is being covered with a cap for the purpose of leaving it behind after the remedy is completed. These requirements are not applicable to the former Brooklyn Borough Gas Works site since operations ceased prior to 1980 (effective date of requirements).
Capping of Non-Hazardous Waste	RCRA Subtitle D	42 U S C Section 6901 et seq			
	Criteria for Classification of Solid Waste Disposal Facilities	40 CFR Part 257	Minimum criteria for siting, construction, operation, and closure of solid waste disposal facilities. Each State is to develop, permit, and enforce a solid waste management program based on USEPA requirements	SCG	These regulations are applicable to remedial activities which would leave wastes and residues in place or to construction of remediation waste management facilities. Coal- and petroleum-based site residuals must be identified as solid and/or hazardous waste in order to determine applicability of waste management consideration. These requirements are not applicable unless documented placement occurs or has occurred.
Water Treatment Discharges	Clean Water Act	33 U S C Section 1251-1376			
	Ambient Water Quality Criteria Guidelines	40 CFR Part 131	Establishes toxicity-based surface water quality criteria for protection of aquatic organisms and human health.	SCG	Ambient water quality criteria would be potentially applicable in establishing discharge limitations for surface water.
	Wastewater Discharge Permits, Effluent Guidelines, Best Available Technology (BAT) and BMPPT	40 CFR Parts 122, 125, 401	Permit requirements for point source discharges to waters of the United States, establishes effluent standards and requirements for preventing toxic releases	SCG	Would be applicable for remedial actions involving a direct wastewater discharge to surface waters.
	Discharge to publicly-owned treatment works (POTW)	40 CFR Part 403 5	Discharge must comply with local POTW pretreatment program	SCG	Requirements would be applicable to remedial actions involving a discharge to a POTW.
	Underground Injection Control Program	40 CFR Parts 144-147	Provisions for protection of groundwater drinking water resources	SCG	Would be applicable to remedial actions involving reinjection to groundwater of treated water.
Air Emissions from a Point Source	Clean Air Act (CAA)	40 U S C Section 7401-7642			
	National Ambient Air Quality Standards (NAAQS)	40 CFR Part 50	Establishes ambient air quality standards for protection of public health	SCG	NAAQS may be applicable in evaluating whether there are air impacts at the site during remedial activities.

Table 2-3 (Sheet 4 of 6)
Statutes, Regulations, And Guidelines Used In The Identification Of Action-Specific SCGs

ACTION	REQUIREMENTS	CITATION	DESCRIPTION	SCG or TBC	COMMENT
	New Source Review (NSR) and Prevention of Significant Deterioration (PSD) Requirements	40 CFR Part 52	New Sources of modifications which emit greater than the defined threshold for listed pollutants must perform ambient impact analysis and install controls which meet best available control technology (BACT)	SCG	These regulations are potentially applicable and would require a comparison of potential emissions from the remedial activity to the emission thresholds for NSR
	National Emission Standards for Hazardous Air Pollutants (NESHAPs)	40 CFR Part 61 40 CFR Part 63	Source-specific regulations which established emissions standards for hazardous air pollutants (HAPs)	SCG	NESHAPs may be applicable if emissions from remedial activities exceed the thresholds for compliance
	New Source Performance Standards (NSPS)	40 CFR Part 6	Source-specific regulations with establish testing, control monitoring and reporting requirements for new emission sources	SCG	NSPS could be relevant and appropriate if steam-generating equipment, thermal desorption units, or other regulated new sources were to be used onsite
Land Disposal of Hazardous Waste	RCRA Subtitle C	40 U S C Section 6901 et seq		SCG	
	Land Disposal Restrictions (LDRs)	40 CFR Part 268	Restricts land disposal of hazardous wastes that exceed specific criteria. Establishes Universal Treatment Standards (UTSs) to which hazardous wastes must be treated to prior to land disposal.		Petroleum-based residuals are subject to LDRs, including UTSs. MGP residuals exhibiting a hazardous characteristic would need to be treated to meet UTS for all hazardous constituents present in the residuals.
Characteristic Hazardous Waste Treatment	MGP Site Remediation Strategy	MGP Site Remediation Strategy MGP Subcommitted, Edison Electric Institute (EEI, 1993)	Strategy document intended to facilitate responsible parties undertaking the source removal of heavily contaminated organic residues and contaminated soils at MGP sites in a manner that is consistent with the RCRA hazardous waste program. The remediation strategy is based on the fact that RCRA hazardous materials may be blended on-site and decharacterized prior to off-site transport and disposed of at a permitted facility. It covers relevant onsite activities including characterization, excavation, accumulation and treatment in 90-day units, and offsite transportation.	TBC	The remediation strategy applies only to the management of excavated solid materials that are hazardous by characteristic. The strategy does not supersede existing regulations, it is not intended to be the presumptive remedy under CERCLA, nor can it serve as a shield against enforcement under RCRA or any other statute. The strategy should be implemented taking into account site-specific circumstances it would not necessarily be appropriate or practical at all sites.
Treatment of Groundwater	Technical impracticality (TI) Waiver for Groundwater Restoration	Guidance for Evaluating the Technical Impracticability of Groundwater Restoration (USEPA, 1993a)	Provides guidance on addressing sites where restoration of groundwater to background conditions is not feasible or practicable. Sources of groundwater impacts should be removed where practicable and where significant reduction of current and future risk can be realized. Guidance also addresses DNAPL and impracticability of its removal	TBC	This guidance was prepared primarily for Superfund site cleanups, but can be considered for the former Brooklyn Borough Gas Works site as needed.
STATE					
Generation, Management, and Treatment of Hazardous Waste	NYSDEC Division of Regulatory Affairs				
	Siting of Industrial Hazardous Waste Facilities	6 NYCRR Part 361	Establishes procedures for selecting appropriate sites for hazardous waste facilities	SCG	These regulations are potentially applicable for remedial activities which would involve the construction of remediation hazardous waste management facilities

Table 2-3 (Sheet 5 of 6)
Statutes, Regulations, And Guidelines Used In The Identification Of Action-Specific SCGs

ACTION	REQUIREMENTS	CITATION	DESCRIPTION	SCG or TBC	COMMENT
	NYSDEC Division of Hazardous Substances Regulation				
	Identification and Listing of Hazardous Wastes	6 NYCRR Part 371	Outlines criteria for determining if a solid waste is a hazardous waste and is subject to regulation under 6 NYCRR Parts 372-376	SCG	MGP residuals are not a listed hazardous waste. Neither coal nor petroleum-based residuals are listed hazardous wastes. For Brooklyn Borough Gas Works residuals determined to be characteristically hazardous based on the TCLP, the requirements are applicable. The TCLP limit for benzene is 0.5 mg/L. These regulations do not set clean-up standards, but would apply during various remedial actions.
	New York State Hazardous Waste Management Facility Regulations	6 NYCRR Part 370.373.372	Establishes New York State's USEPA equivalent hazardous waste management program. Includes regulations for hazardous waste facility construction, operation, and closure, and standards for hazardous waste generation, manifesting, and transport	SCG	[See RCRA Hazardous Waste Management Regulations. 40 CFR Parts 263 and 264/265 under Federal SCGs listed in this table]
Capping of Non-Hazardous Waste	New York State Solid Waste Management Facility Regulations	6 NYCRR Part 360, 364	Establishes New York State's USEPA equivalent solid waste management program. Includes regulations governing construction, operation, and closure of solid waste disposal facilities	SCG	These regulations are applicable to remedial activities which would leave wastes and spill residues in place or to construction of remediation waste management facilities. Coal and petroleum-based site residuals must be identified as solid and/or hazardous waste in order to determine applicability of waste management consideration. These requirements are not applicable unless documented placement occurs or has occurred.
Water Treatment Discharge	New York State Regulations on the State Pollution Discharge Elimination System (SPDES)	6 NYCRR Parts 750-758	Defines permitting requirements for water treatment discharges including	SCG	The regulations would be applicable for alternatives that include a discharge to surface water or a POTW.
	New York State Water Classifications and Quality Standards	6 NYCRR Parts 701, 702, 704	Defines surface water classifications and ambient water quality standards that are the basis for establishing effluent limitations under the SPDES program.	SCG	The Coney Island Creek is classified as Class I waters.
	NYSDEC Ambient Water Quality Standards and Guidance Values	Division of Water Technical and Operational Guidance Series (TOGS) 1.1.1	Provides a compilation of ambient water quality standards and guidance values for toxic and non-conventional pollutants for use in NYSDEC programs, including the SPDES permit program.	SCG	These standards and guidance values are applicable in establishing discharge limitations to surface waters.

Table 2-3 (Sheet 6 of 6)
Statutes, Regulations, And Guidelines Used In The Identification Of Action-Specific SCGs

ACTION	REQUIREMENTS	CITATION	DESCRIPTION	SCG or TBC	COMMENT
Air Emissions from a Point Source	New York State Air Pollution Control Regulations	6 NYCRR Parts 120, 200-203, 207, 211, 211, 212, 219 Air Guide-1	Establishes emissions standards for new sources of air pollutants, incinerators, and specific contaminants.	SCG	Requirements would be applicable to alternatives that result in air emissions of regulated substances or equipment.
	New York State Ambient Air Quality Standards	6 NYCRR Part 257	Establishes state ambient air quality standards and guidelines for protection of public health.	SCG	May be applicable in evaluating air impacts during remedial activities. Establishes short-term action limits for occupational exposure.
LOCAL					
Water Treatment Discharge	Local County or Municipality Pretreatment Requirements	Local regulations	Establishes pretreatment requirements for water prior to discharge to the local sanitary sewer system.	SCG	These requirements are established separately for each water discharge that is routed to an off-site municipal wastewater treatment plant prior to discharge.

Table 2-4

Summary Of Air Quality Guidelines (TBCs) For Typical Site Residual Constituents

Parameter	NYS Air Guidelines[1] AGC[2] (ug/m^3)	SGC[3] (ug/m^3)
BTEX		
Benzene	0.12	30
Ethylbenzene	1,000	100,000
Toluene	2,000	89,000
Xylenes	300	100,000
Probable Carcinogenic PAHs		
Benzo(a)anthracene	-	-
Benzo(a)pyrene	0.002	-
Benzo(b)fluoranthene	-	-
Benzo(k)fluoranthene	-	-
Chrysene	-	-
Dibenzo(a,H)anthracene	-	-
Indeno(1,2,3-cd)pyrene	-	-
Other PAHs		
Acenaphthene	-	-
Acenaphthylene	-	-
Anthracene	-	-
Benzo(g,h,I)perylene	-	-
Fluoranthene	-	-
Fluorene	-	-
Naphthalene	120	12,000
Phenanthrene	-	-
Pyrene	-	-
2-methylnaphthalene	-	-
Phenol	9.6	4,500
PCBs*	0.00045	0.1
Metals		
Antimony	1.2	120
Arsenic	0.00023	0.2
Beryllium	0.004	0.05
Lead	1.5	--
Manganese	0.3	240
Mercury	0.3	12
Zinc	50	150
Cyanide	12	150

1 Acceptable ambient level guidelines from New York State Air Guide-1 (NYSDEC Division of Air Resources, 1991).
2 Annual guidance Concentration
3 Short-Term (≤ 1 hour) Guideline Concentration
(-) No guideline
* PCBs = Polychlorinated Biphenyls

Table 2-5 (Sheet 1 of 2)
Statutes, Regulations, And Guidelines Used In The Identification Of Location-Specific SCGs

ACTION	REQUIREMENTS	CITATION	DESCRIPTION	SCG or TBC	COMMENT
FEDERAL					
Floodplain	Hazardous Waste Facility Location Standards - 100-yr Floodplain	40 CFR 264.18(b)	A Treatment, Storage, and Disposal (TSD) Facility must be designed and operated to avoid washout.	SCG	Requirements are applicable because the site is located within the 100-year floodplain (based on review of FEMA map).
	Executive Order 11988 - Floodplain Management	40 CFR 6, Subpart A; 40 CFR 6.302	Activities taking place within floodplains must be done to avoid adverse impacts and preserve beneficial values in floodplains.	SCG	Requirements are applicable because the site is located within the 100-year floodplain (based on review of FEMA map).
Wetlands/Waters of the U.S.	Clean Water Act (CWA) Section 404 / Rivers and Harbors Act, Section 10	33 U.S.C. 1344 / 33 USC 403			
	Dredge and Fill in Wetlands	33 CFR Parts 320-330/40 CFR Part 230	Discharge of dredge or fill material into wetlands are regulated by a permit.	SCG	Would be applicable to remedial activities resulting a discharge of dredge or fill material into the jurisdictional wetlands that have been identified on the site.
	Executive Order 11990 - Protection of Wetlands	40 CFR Part 6 Subpart A	Activities taking place within wetlands must be done to avoid adverse impacts.	SCG	Would be applicable to remedial activities conducted in the jurisdictional wetlands that have been identified on the site.
	National Historic Preservation act	16 USC 470	Establishes requirements for the identification and preservation of historic and cultural resources	SCG	Would be applicable to the management of historic or archeological artifacts identified on the site.
Critical Habitat	Endangered Species Act and Fish and Wildlife Coordination Act	16 USC 661 and 16 U.S.C. 1531	Actions must be taken to conserve critical habitat in areas where there are endangered or threatened species.	SCG	Requirements would be applicable if endangered or threatened species are identified or adjacent to the site.
Considering Wetlands at CERCLA Sites	Wetlands Protection at CERCLA sites	OSWER 9280.0-03	Guidance document to be used to evaluate impacts to wetlands at Superfund sites	TBC	Requirements should be considered when evaluating impacts to on-site wetlands.
STATE					
Floodplain	TSD Facility Permitting Requirements	6 NYCRR Subpart 373-1	Facility must be designed and operated to avoid washout.	SCG	Requirements are applicable because the site is located within the 100-year floodplain (based on review of FEMA map).
Wetlands	New York State Freshwater Wetlands Act	ECL Article 24 and 71			
	New York Freshwater Wetlands Program	6 NYCRR Parts 662-665	Activities in wetlands areas must be conducted to preserve and protect wetlands.	SCG	Would be applicable to remedial activities conducted in the jurisdictional wetlands occurring on the site.

Table 2-5 (Sheet 2 of 2)
Statutes, Regulations, And Guidelines Used In The Identification Of Location-Specific SCGs

ACTION	REQUIREMENTS	CITATION	DESCRIPTION	SCG or TBC	COMMENT
Wetlands (Cont'd)	Tidal Wetlands Act New York Tidal Wetlands Regulations	ECL Article 25 6 NYCRR Part 661	Activities in tidal wetland areas must be conducted to preserve and protect wetlands	SCG	Would be applicable to remedial activities conducted in jurisdictional wetlands and their associated buffers.
	Protection of Waters	6 NYCRR 608	Regulates the placement of fill material in the state's navigable waters	SCG	Placement of sheet piling below the mean high water mark of Coney Island Creek.
Floodplain	Floodplain Management Regulations	6 NYCRR Part 500	Establishes floodplain management requirements including limitations on projects, including placement of fill, which may result in an increase in flood levels or water surface elevations during a base flood discharge.	SCG	Requirements would be applicable because the site is located within the 100-year floodplain (based on review of FEMA maps).

Table 2-6
Calculation of Soil Saturation Limits

Csat = (S / rho.b) x (kd x rho.b + H' x theta.a)

Where:		
	Csurf	Surface Soil Concentration
	Csub	Subsurface Soil Concentration
	Csat	Soil Saturation Concentration (mg/kg)
	S	Water Solubility (mg/L, from Table C-11)
	rho.b	Dry Soil Bulk Density (1.5 kg/L, EPA, 1996)
	Kd	Soil-water partition Coefficient [Koc x foc (for organics)]
	n	Total Soil Porosity (0.43 (Lpore/Lsoil, 1-rho.b/rho.s, EPA, 1996)
	theta.w	Volumetric Water Content (0.15 Lwater/Lsoil, from EPA, 1997)
	theta.a	Volumetric Air Content (0.28 Lair/Lsoil, n-theta.w)
	H'	Unitless Henry's Constant (H * 41)
	Koc	Soil Organic Carbon/Water Partition coefficient (L/kg, from Table C-11)
	foc	Fraction of Organic Carbon in Soil (0.006, EPA, 1996)
	rho.s	Soil Particle Density (2.65 kg/L, from EPA, 1996)

Type	CAS No.	COPC	S	H'	KOC (KD)	Csat	Csurf	surf>Csat?	Csub	Csub>Csat?
PAH	91-57-6	2-Methylnaphthalene	2.56E+01	1.80E-02	2.51E+03	3.88E+02	85.17	No	223.12	No
	83-32-9	Acenaphthene	4.24E+00	6.36E-03	7.08E+03	1.81E+02	92.72	No	77.7	No
	208-96-8	Acenaphtylene	3.93E+00	4.74E-03	1.00E+04	2.36E+02	62.22	No	116.72	No
	120-12-7	Anthracene	4.34E-02	2.76E-03	2.95E+04	7.69+00	14.5	Yes	40.19	Yes
	56-55-3	Benz(a)anthracene	9.40E-03	1.37E-04	3.98E+05	2.24E+01	57.83	Yes	41.87	Yes
	50-32-8	Benzo(a)pyrene	1.62E-03	4.63E-05	1.02E+06	9.91E+00	33.09	Yes	20.84	Yes
	205-99-2	Benzo(b)fluoranthene	1.50E-03	4.55E-03	1.23E+06	1.11E+01	20.1	Yes	14.8	Yes
	191-24-2	Benzo(g,h,i)perylene	5.70E-03	5.74E-07	1.38E+06	4.72E+01	16.57	No	8.75	No
	207-08-9	Benzo(k)fluoranthene	8.00E-04	3.40E-05	1.23E+06	5.90E+00	11.33	Yes	8.64	Yes
	218-01-9	Chrysene	1.60E-03	3.88-03	3.98E+05	3.82E+00	46.59	Yes	39.51	Yes
	53-70-3	Dibenz(a,h)anthracene	2.49E-03	6.03E-07	3.80E+06	5.68E+01	4.76	No	4.69	No
	206-44-0	Fluoranthene	2.06E-01	6.60E-04	1.07E+05	1.32E+02	102.25	No	139.75	Yes
	86-73-7	Fluorene	1.98E+00	2.61E-03	1.38E+04	1.64E+02	27.16	No	60.3	No
	193-39-5	Indeno(1,2,3-cd)pyrene	2.20E-05	6.56E-05	3.47E+06	4.58E-01	12.54	Yes	7.36	Yes
	91-20-3	Naphthalene	3.10E+01	1.98E-02	2.00E+03	3.75E+02	143.49	No	204.41	No
	85-01-8	Phenanthrene	1.60E+00	2.52E-01	1.41E+04	1.36E+02	66.52	No	124.85	No
	129-00-0	Pyrene	1.35E-01	4.51E-04	1.05E+05	8.51E+01	74.96	No	127.24	Yes

Notes:
ND-Not Detected
NA-Not Applicable

Table 2-7
Soil Cleanup Goals Based on Construction Worker Scenario
(Assuming HI=1.0; Risk = 10^-4)

Class	CAS #	COPC	Baseline Risk		Individual Goals		Concentration		Units	Percent
			HI	Risk	Hi	Risk	EPC	Goal		Reduction
Semi-voa	83-32-9	Acenaphthene	0.01	0	<1	<0.0001	77.7	64.9	mg/kg	16
Semi-voa	208-96-8	Acenaphthylene	0.02	0	<1	<0.0001	116.7	97.5	mg/kg	16
Semi-voa	120-12-7	Anthracene	0.001	0	<1	<0.0001	40.2		mg/kg	0
Semi-voa	56-55-3	Benz(a)anthracene	0	4.6E-06	<1	<0.0001	41.9		mg/kg	0
Semi-voa	50-32-8	Benzo(a)pyrene	0	2.3E-05	<1	<0.0001	20.8		mg/kg	0
Semi-voa	205-99-2	Benzo(b)fluoranthene	0	1.6E-06	<1	<0.0001	14.8		mg/kg	0
Semi-voa	191-24-2	Benzo(g,h,i)perylene	0.002	0	<1	<0.0001	8.8		mg/kg	0
Semi-voa	207-08-9	Benzo(k)fluoranthene	0	9.5E-08	<1	<0.0001	8.6		mg/kg	0
Semi-voa	218-01-9	Chrysene	0	4.4E-08	<1	<0.0001	39.5		mg/kg	0
Semi-voa	53-70-3	Dibenz(a,h)anthracene	0	5.2E-06	<1	<0.0001	4.7		mg/kg	0
Semi-voa	206-44-0	Fluoranthene	0.04	0	<1	<0.0001	139.8	116.8	mg/kg	16
Semi-voa	86-73-7	Fluorene	0.02	0	<1	<0.0001	60.3	50.4	mg/kg	16
Semi-voa	193-39-5	Indeno(1,2,3-cd)pyrene	0	8.1E-07	<1	<0.0001	7.4		mg/kg	0
Semi-voa	91-57-6	Methyl Naphthalene, 2-	0.06	0	<1	<0.0001	223.1	186.4	mg/kg	16
Semi-voa	91-20-3	Naphthalene	0.05	0	<1	<0.0001	204.4	170.8	mg/kg	16
Semi-voa	85-01-8	Phenanthrene	0.03	0	<1	<0.0001	124.9	104.3	mg/kg	16
Semi-voa	129-00-0	Pyrene	0.04	0	<1	<0.0001	127.2	106.3	mg/kg	16
Pest/PCB	309-00-2	Aldrin	0.02	1.8E-07	<1	<0.0001	0.07	0.06	mg/kg	14
Pest/PCB	57-74-9	Chlordane	0.1	1.4E-07	<1	<0.0001	0.7	0.4	mg/kg	42
Pest/PCB	60-57-1	Dieldrin	0.02	2.7E-07	<1	<0.0001	0.11	0.09	mg/kg	14
Pest/PCB	1024-57-3	Heptachlor Epoxide	0.07	1.2E-07	<1	<0.0001	0.09	0.08	mg/kg	14
Pest/PCB	1336-36-3	PCBs	3	1.8E-06	<1	<0.0001	7.5	0.7	mg/kg	90
Inorganic	7440-38-2	Arsenic (inorganic)	0.2	1.4E-06	<1	<0.0001	9.8	5.7	mg/kg	42
Inorganic	57-12-5	Cyanide(free)	0.1	0	<1	<0.0001	43.7	28.8	mg/kg	34
		Sum=	4.0	3.9E-05						
			Cumulative Goals =		1.0	1.0E-04				

Notes:
Media: Soil; Case: Reasonable Maximum Exposure to a Construction worker
Calculation Method: Reduction of COC concentrations to achieve both cumulative and individual HI goals. In addition, because both cumulative and individual cancer risks were all below 10^-4, COC concentration goals did not have to be optimized to ensure against cancer risk.

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Table 2-8
Soil Cleanup Goals Based on Construction Worker Scenario
(Assuming HI = 1.0; Risk=10^-5)

Class	CAS#	COPC	Baseline Risk Hi	Baseline Risk Risk	Individual Goals Hi	Individual Goals Risk	Concentration EPC	Concentration Goal	Units	Percent Reduction
Semi-Voa	83-32-9	Acenaphthene	0.01	0	<1	<0.00001	77.7	68.5	mg/kg	12
Semi-Voa	208-96-8	Acenaphthylene	0.02	0	<1	<0.00001	116.7	1030	mg/kg	12
Semi-Voa	120-12-7	Anthracene	0.001	0	<1	<0.00001	40.2		mg/kg	0
Semi-Voa	56-55-3	Benz(a)anthracene	0	4.6E-06	<1	<0.00001	41.9	20.8	mg/kg	50
Semi-Voa	50-32-8	Benzo(a)pyrene	0	2.3E-05	<1	<0.00001	20.8	1.7	mg/kg	92
Semi-Voa	205-99-2	Benzo(b)fluoranthene	0	1.6E-06	<1	<0.00001	14.8	7.4	mg/kg	50
Semi-Voa	191-24-2	Benzo(g,h,i)perylene	0.002	0	<1	<0.00001	8.8		mg/kg	0
Semi-Voa	207-08-9	Benzo(k)fluoranthene	0	9.5E-08	<1	<0.00001	8.6		mg/kg	0
Semi-Voa	218-01-9	Chrysene	0	4.4E-08	<1	<0.00001	39.5		mg/kg	0
Semi-Voa	53-70-3	Dibenz(a,h)anthracene	0	5.2E-06	<1	<0.00001	4.7	2.3	mg/kg	50
Semi-Voa	206-44-0	Fluoranthene	0.04	0	<1	<0.00001	139.8	123.3	mg/kg	12
Semi-Voa	86-73-7	Fluorene	0.02	0	<1	<0.00001	60.3	53.2	mg/kg	12
Semi-Voa	193-39-5	Indeno(1,2,3-cd)pyrene	0	8.1E-07	<1	<0.00001	7.4	7	mg/kg	5
Semi-Voa	91-57-6	Methyl Napthalene, 2-	0.06	0	<1	<0.00001	223.1	196.8	mg/kg	12
Semi-Voa	91-20-3	Napthalene	0.05	0	<1	<0.00001	204.4	180.3	mg/kg	12
Semi-Voa	85-01-8	Phenanthrene	0.03	0	<1	<0.00001	124.9	110.1	mg/kg	12
Semi-Voa	129-00-0	Pyrene	0.04	0	<1	<0.00001	127.2	112.2	mg/kg	12
Pest/PCB	309-00-2	Aldrin	0.02	1.8E-07	<1	<0.00001	0.07	0.1	mg/kg	14
Pest/PCB	57-74-9	Chlordane	0.1	1.4E-07	<1	<0.00001	0.7	0.4	mg/kg	42
Pest/PCB	60-57-1	Dieldrin	0.02	2.7E-07	<1	<0.00001	0.1	0.1	mg/kg	14
Pest/PCB	1024-57-3	Heptachlor Epoxide	0.07	1.2E-07	<1	<0.00001	0.1	0.1	mg/kg	14
Pest/PCB	1336-36-3	PCBs	3	1.8E-06	<1	<0.00001	7.5	0.7	mg/kg	90
Inorganic	7440-38-2	Arsenic (inorganic)	0.2	1.4E-06	<1	<0.00001	9.8	4.4	mg/kg	55
Inorganic	57-12-5	Cyanide (free)	0.13	0	<1	<0.00001	43.7	32.6	mg/kg	25
		Sum =	4.0	3.9E-05						
			Cumulative Goals =		1.0	1.0E-05				

Notes:

Media: Soil; Case: Reasonable Maximum Exposure to a Construction Worker

Calculation Method: Reduction of COC concentrations to achieve both cumulative and individual HI goals. In addition, because both cumulative and individual cancer risks were all below 10^ - 5, COC concentration goals did not have to be optimized to ensure against cancer risk.

Table 2-9
Soil Cleanup Goals Based on Construction Worker Scenario
(Assuming HI = 1.0; Risk = 10^-6)

Class	CAS #	COPC	Baseline Risk HI	Baseline Risk Risk	Individual Goals HI	Individual Goals Risk	EPC	Concentration Goal	Units	Percent Reduction
Semi-Voa	83-32-9	Acenaphthene	0.01	0	<1	<0.000001	77.7		mg/kg	0
Semi-Voa	208-96-8	Acenaphthylene	0.02	0	<1	<0.000001	116.7		mg/kg	0
Semi-Voa	120-12-7	Anthracene	0.001	0	<1	<0.000001	40.2		mg/kg	0
Semi-Voa	56-55-3	Benz(a)anthracene	0	4.6E-06	<1	<0.000001	41.9	0.38	mg/kg	99
Semi-Voa	50-32-8	Benzo(a)pyrene	0	2.3E-05	<1	<0.000001	20.8	0.04	mg/kg	100
Semi-Voa	205-99-2	Benzo(b)fluoranthene	0	1.6E-06	<1	<0.000001	14.8	0.38	mg/kg	97
Semi-Voa	191-24-2	Benzo(g,h,i)perylene	0.002	0	<1	<0.000001	8.8		mg/kg	0
Semi-Voa	207-08-9	Benzo(k)fluoranthene	0	9.5E-08	<1	<0.000001	8.6	7.55	mg/kg	13
Semi-Voa	218-01-9	Chrysene	0	4.4E-08	<1	<0.000001	39.5	34.53	mg/kg	13
Semi-Voa	53-70-3	Dibenz(a,h)anthracene	0	5.2E-06	<1	<0.000001	4.7	0.04	mg/kg	99
Semi-Voa	206-44-0	Fluoranthene	0.04	0	<1	<0.000001	139.8		mg/kg	0
Semi-Voa	86-73-7	Fluorene	0.02	0	<1	<0.000001	60.3		mg/kg	0
Semi-Voa	193-39-5	Indeno(1,2,3-cd)pyrene	0	8.1E-07	<1	<0.000001	7.4	2.64	mg/kg	64
Semi-Voa	91-57-6	Methyl Napthalene-,2-	0.06	0	<1	<0.000001	223.1		mg/kg	0
Semi-Voa	91-20-3	Nepthalene	0.05	0	<1	<0.000001	204.4		mg/kg	0
Semi-Voa	85-01-8	Phennthrene	0.03	0	<1	<0.000001	124.9		mg/kg	0
Semi-Voa	129-00-0	Pyrene	0.04	0	<1	<0.000001	127.2		mg/kg	0
Pest/PCB	309-00-2	Aldrin	0.02	1.8E-07	<1	<0.000001	0.1	0.02	mg/kg	65
Pest/PCB	57-74-9	Chlordane	0.1	1.4E-07	<1	<0.000001	0.7	0.24	mg/kg	65
Pest/PCB	60-57-1	Dieldrin	0.02	2.7E-07	<1	<0.000001	0.1	0.04	mg/kg	65
Pest/PCB	1024-57-3	Heptachlor Epoxide	0.07	1.2E-07	<1	<0.000001	0.1	0.03	mg/kg	65
Pest/PCB	1336-36-3	PCBs	3	1.8E-06	<1	<0.000001	7.5	0.19	mg/kg	98
Inorganic	7440-38-2	Arsenic(inorganic)	0.2	1.4E-06	<1	<0.000001	9.8	0.31	mg/kg	97
Inorganic	57-12-5	Cyanide (free)	0.1	0	<1	<0.000001	43.7		mg/kg	0
		Sum =	4.0	3.9E-05						
			Cumulative Goals = 1.0	1.0E-06						

Notes:

Media: Soil; Case: Reasonable Maximum Exposure to a Construction Worker

Calculation Method: Reduction of COC concentration to achieve both cumulative and individual HI goals. In addition, because the cumulative and some individual cancer risks were all above 10 ^ -6, COC concentration goals to be optimized to ensure against cancer risk.

Table 3-1 (Sheet 1 of 2)
Summary of Technical Issues

TOPIC	ISSUE	CONCERN	RELATIVE IMPORTANCE
Site Development	100-Year Floodplain	The former operations area lies in the 100-year floodplain. Restoration and/or redevelopment will require importation of fill to raise the elevation of this area as a protective measure. Additional new fill across the site cannot be contaminated by existing materials. The weight of new fill will exert forces on subsurface soils and may cause settlement or alter groundwater migration pathways. Elevation changes may affect Coney Island Creek flow patterns and alter historic flood elevations.	• Very important. • Common to risk reduction and brownfield development.
	Preference for "clean" construction zone and unhindered future access	Prospective developers prefer to work in uncontaminated surroundings. This preference affords increased productivity, safe work conditions, and lowers costs. OSHA standards are less rigorous when working in clean areas compared with contaminated areas.	Important for brownfield development and risk reduction
	Integration of remedy with final development	Risk reduction measures must consider construction and operation aspects of commercial development. Remedies which preclude site redevelopment will be considered less favorable than remedies which can achieve equal risk reduction and facilitate brownfield development.	Important for brownfield development.
	Establishment of green space	The site currently attracts a variety of birds due to the vegetative cover across the site. BU intends to provide enhancements around the site to increase aesthetic and ecological value. Proposed developers consider green space an important attraction to commercial establishments.	• Not important for risk reduction. • Moderately Important for brownfield development.
	Low-profile remedial systems and components	Remedial systems and their components may be present on-site for many years. These systems need to be isolated from commercial establishments and pedestrian traffic. Where physical signs of systems are apparent, efforts must be made to minimize the visual impact of their presence.	• Not important to risk reduction. • Moderately important to brownfield development.
Boundary Issues	Proximity to railyard, elevated highway, and high-rise residences	The site has high visibility from passing commuter trains, automobiles, and neighboring dwellings. Variable wind directions can transport volatile emissions and odors outside site boundaries. There is potential for inhalation receptors in all directions.	Important during remediation
	Stability of creek bank	Addition of fill across the site must be supported along the creek. Subsurface remedies to prevent transport of contaminants from the site to the creek require a stable bank for construction and long-term performance. Redevelopment may require a bridge across the creek; a bridge will require a stable and reliable foundation along the embankment.	• Very important. • Common to risk reduction and brownfield development.
	Tidal influence of creek on groundwater	Tides result in fluctuating groundwater table conditions. Reverse hydraulic gradients in the subsurface have been observed, further complicating the prediction of contaminant fate and transport.	Very important to risk reduction.

Table 3-1 (Sheet 2 of 2)
Summary of Technical Issues

TOPIC	ISSUE	CONCERN	RELATIVE IMPORTANCE
Boundary Issues (continued)	Integrity of low permeability subsurface layers	Low permeability subsurface strata have helped minimize the downward migration of contaminants. These strata may become integrated into an overall remedy to minimize migration of contaminants from the site. Any development will require some subsurface structural support. Historic use of pilings may have created preferential pathways for movement of contaminants. Any future structural improvement or subsurface barrier must minimize creation of preferential pathways.	• Very important. • Common to risk reduction and brownfield development.
Materials Handling	Volume and quality of fill	Large quantities of fill in former manufacturing area and in ballfield area may require cleanup. Materials handling of fill and rubble must be performed prior to implementation of a remedy. Remaining fill has poor structural properties, which could affect future grading and fill plans for redevelopment.	• Important. • Common to risk reduction and brownfield development.
	Air emissions and odor control	Disturbance of coal tar impacted soils generates nuisance odors. Volatile organic compounds may also be emitted during remedy implementation. Control measures will be required.	Very important to risk reduction.
	Truck traffic	The import of construction materials, particularly large quantities of fill, and off-site transport of contaminated materials will increase local truck traffic. Previous IRMs have shown this is manageable; however, large-scale remedial actions may require more traffic at a higher frequency than experienced previously.	Moderately important to risk reduction.
	Dewatering	Saturated materials may be generated from creek bank stabilization and on-site excavation activities. Dewatering of saturated materials presents a materials handling challenge for most technologies. With shallow groundwater, it may be necessary to maintain active dewatering of excavations to install remedial systems. Storage, treatment, and disposal of dewatered fluids is an additional materials handling concern.	Very important to risk reduction.
General	Technical impracticability of groundwater remediation	From an engineering perspective, there are several hindrances to complete remediation of the subsurface aquifer. Application of EPA's guidance for Evaluating the Technical Impracticability of Groundwater Restoration has widespread acceptance at coal tar sites due to similar conditions.	Very important to risk reduction.
	Monitored natural attenuation	In conjunction with source control and containment, monitored natural attenuation of groundwater contaminants represents a remedial strategy accepted by EPA and NYSDEC. The scope and implementation of other remedial activities need to be considered since contaminant mass, as well as transport and degradation rates, may be effected. Long-term performance monitoring should assess the magnitude of contaminant reduction while measuring potential impacts to downgradient receptors.	Very important to risk reduction.
	Security and access	Remedial systems will need to be present on-site for several years. Measures must be instituted to ensure the security of these systems. Access needs to be available to monitor the performance of remedies. Access and security must be integrated with redevelopment options.	Moderately important to risk reduction and brownfield development.
	Contingency planning	Remedial measures will be performed using incomplete information. Unknowns will be assessed and considered when remedies are designed, executed, operated, and maintained. Where uncertainties remain after completion of remedial actions, contingency plans will be developed to minimize the adverse effect of an undesirable event.	• Very important to risk reduction. • Moderately important to brownfield development
	Institutional Controls will remain with owner of property	MGP issues, including administration of institutional controls, will remain with the property owner.	Very important to brownfield development.

Table 3-2
Typical Unit Costs Associated with Construction of Cover Systems

WORK ITEM	UNIT OF MEASUREMENT	MATERIAL UNIT COST	INSTALLATION UNIT COST	TOTAL UNIT COST
MOBILIZATION				Allow 5% to 10% of total cost
SITE PREPARATION				Allow 5% to 10% of total cost
CLEARING AND GRUBBING	ACRE	$0	$2,700	$2,700
6" TOPSOIL COVER	CY	$15	$3	$18
18" PROTECTION LAYER (COMMON SOIL)	CY	$10	$3	$13
12"SAND/CRUSHED GRAVEL DRAIN LAYER	CY	$15	$2	$17
24" COMPACTED CLAY	CY	$22	$3	$25
12" GRAVEL/ STONE GAS VENT LAYER	CY	$14	$2	$16
SEEDING AND MULCHING	ACRE	$2,200	$1,500	$3,700
GRADING: CUT/FILL BALANCE	CY	$0	$2	$2
GEOTEXTILE FILTER FABRIC	SY	$2	$1	$3
HDPE DRAINAGE NET	SY	$4	$1	$5
GEOMEMBRANE LINER				
40 MIL VLDPE	SY	$3	$3	$6
60 MIL VLDPE	SY	$4	$3	$7
80 MIL VLDPE	SY	$5	$3	$8
GEOSYNTHETIC CLAY LINER	SY	$6	$1	$7
24" RCP DRAINAGE PIPE	LF	$40	$32	$72
RIPRAP	CY	$25	$3	$28
GAS VENT (8')	EA	$2,500	$1,600	$4,100

Table 3-3
Area and Volume Estimates for RBC Excavation Areas and Coal Tar Source Areas

EXCAVATION SCENARIO	Estimated Excavation Areas and Volumes						
	0-2' Depth Interval		2-4' Depth Interval		4'-6' Depth Interval		Total Volume
	Area	Volume	Area	Volume	Area	Volume	
RBC Excavation Area for $1x10^{-4}$ Risk	361,800	26,800	402,700	29,830	225,500	16,700	73,300
RBC Excavation Area for $1x10^{-5}$ Risk	412,600	30,560	490,300	36,300	241,000	17,850	84,700
RBC Excavation Area for $1x10^{-6}$ Risk	412,600	30,560	490,300	36,300	245,000	18,150	85,000
Coal Tar Source Area	100,300	7,500	100,300	7,500	100,300	7,500	22,500

Table 3-4 (Sheet 1 of 6)
Summary of Remedial Technology Screening

RESPONSE ACTION	TECHNOLOGY TYPE	TECHNOLOGY	EFFECTIVENESS	IMPLEMENTABILITY	COST	STATUS FOR ALTERNATIVE DEVELOPMENT
No Action	None	None	Not effective at achieving RAOs. Risks to future construction workers persist, brownfield development cannot be accomplished, and site contaminants continue to impact Coney Island Creek.	Readily implementable.	Low. Assumes long-term operation of Coney Island Creek IRM.	Retained
Institutional Controls	Various	• Access Controls • Deed Restrictions • Long-Term Monitoring • Health & Safety Plan • Notifications	Effective at preventing risks to future construction workers. Not effective at facilitating brownfield development or mitigating seepage to the Coney Island Creek.	Readily implementable.	Low. Monitoring to be performed semi-annually.	Retained for Alternative Development
Containment	Soil Cover System	Thin Cover System	Low permeability thin cover system is effective at controlling the pathways for worker exposure. Does not satisfy RAO for brownfield development. Does not mitigate floodplain concerns.	Technology is proven and cover can be constructed. Long-term maintenance concerns with flood inundation due to presence in 100-year floodplain.	Medium, relative to other cover systems. Requires extensive earthwork.	Not Retained
		Fill On Cover System	Low permeability cover system is effective at controlling the pathways for future construction worker exposure. Fill on cover system is preferred approach for brownfield development. Fill on cover system mitigates floodplain concerns.	Technology is proven and cover can be constructed. May need to consider use of relieving platform for foundations.	Medium, but higher cost than thin cover system. Requires extensive earthwork, particularly for overlying structural support.	Retained for Alternative Development

Table 3-4 (Sheet 2 of 6)
Summary of Remedial Technology Screening

RESPONSE ACTION	TECHNOLOGY TYPE	TECHNOLOGY	EFFECTIVENESS	IMPLEMENTABILITY	COST	STATUS FOR ALTERNATIVE DEVELOPMENT
Containment	Vertical Barrier Walls	Conventional Soil/ Bentonite Slurry Wall	Effective at meeting RAO for preventing further degradation of Coney Island Creek. May be difficult to construct due to widespread obstructions and poor quality of local soil. Disturbance of soils may generate volatile emissions and odors. Potential chemical compatibility concerns could undermine long-term performance. Lack of continuous confining layer is not critical as long as seep to Coney Island Creek is addressed.	Technology is proven and readily implemented. Materials and debris handling will require additional controls during installation. May need to construct under temporary enclosure to prevent off-site migration of emissions and odors.	Medium, but low relative to other vertical barrier technologies	Retained as Process Option
		Vibrating Beam Cutoff Wall	Effective at meeting RAO for preventing further degradation of Coney Island Creek. May be difficult to construct due to widespread obstructions. Minimal disturbance of soils. Potential chemical compatibility concerns could undermine long-term performance. Lack of continuous confining layer is not critical as long as seep to Coney Island Creek is addressed.	Technology is proven and readily implemented. Starter trench may need to be used to remove near-surface debris and obstructions which would otherwise prevent vibration of beam to desired depth.	Medium, but low relative to other vertical barrier technologies	Retained as Process Option
		Sheet Pile Barrier Wall	Effective at meeting RAO for preventing further degradation of Coney Island Creek. May be difficult to construct due to widespread obstructions. Minimal disturbance of soils. Lack of continuous confining layer is not critical as long as seep to Coney Island Creek is addressed. Can provide structural support of fill to be used as part of cover system	Technology is proven and readily implemented. Starter trench may need to be used to remove near-surface debris and obstructions which would otherwise hinder pile driving.	Medium, relative to other vertical barrier technologies	Retained for Alternative Development

Table 3-4 (Sheet 3 of 6)
Summary of Remedial Technology Screening

RESPONSE ACTION	TECHNOLOGY TYPE	TECHNOLOGY	EFFECTIVENESS	IMPLEMENTABILITY	COST	STATUS FOR ALTERNATIVE DEVELOPMENT
Containment	Air Emission and Odor Containment Technologies	Temporary Construction Enclosure	Addresses short-term adverse effects to surrounding areas from volatile emissions and noxious odors. Helps protect on-site workers by controlling environmental conditions around excavation areas.	Temporary construction enclosures have been used widely at MGP and other hazardous waste sites. May need to consider structural support when working along the creek bank. Rail systems and cranes can be used to carry enclosures across the site.	High, relative to other technologies such as foams and sprays	Retained for Alternative Development
Source Removal	Excavation	Excavation to RBC Levels	Provides long-term protection of human health by removal of soils with contaminant concentrations in excess of risk-based concentrations. Involves excavation of much of the site to a depth of six feet below ground surface. Residual contaminants in the subsurface pose future threat to construction workers; therefore, RAOs are not met completely, unless this technology is accompanied by institutional controls and/or a low permeability cover system.	Readily implementable. Excavation can proceed with conventional equipment. Large-scale removal will require environmental controls for dust, volatile emissions, odors, and stormwater.	High, relative to other excavation options under consideration	Retained for Alternative Development
		Coal Tar Source Removal	Removes most highly concentrated sources from the site to prevent further degradation of the environment. Does not meet RAO for unprotected future construction workers unless this technology is accompanied by institutional controls and a low permeability cover system.	Readily implementable. Excavation can proceed with conventional equipment. Requires less excavation than the RBC option; however, environmental controls are necessary due to the high concentrations of contaminants in coal tar source areas.	Medium, relative to other excavation options under consideration	Retained for Alternative Development

Table 3-4 (Sheet 4 of 6)
Summary of Remedial Technology Screening

RESPONSE ACTION	TECHNOLOGY TYPE	TECHNOLOGY	EFFECTIVENESS	IMPLEMENTABILITY	COST	STATUS FOR ALTERNATIVE DEVELOPMENT
Source Removal	Excavation	Clean Utility Corridor	Provides some protection to future construction workers but must be performed in conjunction with institutional controls and a low permeability cover system. Does not meet brownfield development RAO.	Readily implementable. Excavation can proceed with conventional equipment. Requires minimum level of excavation.	Low, relative to the other excavation options under consideration	Not Retained
	NAPL Capture	Horizontal/Vertical Wells	Effective at capturing subsurface fluids. Provides additional protection against off-site horizontal migration of contaminants by intercepting them before they encounter a vertical barrier wall. Modeling must be performed to predict zones of capture on the basis of well placement and design. May capture more water than necessary due to tidal influence and vicinity of creek.	Readily implementable. Wells can be installed to the shallow depths needed. Pumps would be sized to capture subsurface liquids and prevent releases to Coney Island Creek. Wells and pumps require frequent maintenance after installation and operation.	Low installation costs, but higher operation and maintenance costs relative to recovery trenches	Not Retained
		Recovery Trench	Effective at capturing subsurface fluids. Provides additional protection against off-site horizontal migration of contaminants by intercepting them before they encounter a vertical barrier wall.	Readily implementable. Excavation of recovery trenches uses conventional equipment and materials. Long-term performance is dependent on ability to prevent plugging, which can be facilitated with steam lines installed in the trench. Less maintenance is required for trenches than for wells.	Medium installation costs, but lower operation and maintenance costs relative to wells	Retained for Alternative Development
Soil Treatment	Materials Handling and Processing	Consolidation	Effective for consolidating hazardous and nonhazardous materials in one central location.	Readily implementable. Eliminates regulatory and cost implication associated with transporting the material.	Low	Retained for Alternative Development
		Screening	Effective at sizing soil particles and for removing debris from the material.	Readily implementable	Low	Retained for Alternative Development

Table 3-4 (Sheet 5 of 6)
Summary of Remedial Technology Screening

RESPONSE ACTION	TECHNOLOGY TYPE	TECHNOLOGY	EFFECTIVENESS	IMPLEMENTABILITY	COST	STATUS FOR ALTERNATIVE DEVELOPMENT
Soil Treatment	Materials Handling and Processing	Blending	Effective at stabilizing and rendering material nonhazardous by reducing the volatile compound concentration. Often used as a form of pretreatment for coburning.	Implementable. Requires input from boiler operator to determine coal mixture ratios.	Low	Retained for Alternative Development
	Recycle/Reuse	Cold-Mix Asphalt Batching	Effective at immobilizing coal tar constituents. Provides recycling of waste materials into a beneficial product.	Potentially implementable. Few vendors are accepting coal tar wastes for cold-mix asphalt batching. There is little long-term performance data for successful applications.	Low, compared to other recycle/reuse options under consideration	Retained as Process Option
		Hot-Mix Asphalt Batching	Effective at immobilizing coal tar constituents and eliminating volatile contaminants. Provides recycling of waste materials into a beneficial product.	Potentially implementable. Few vendors are accepting coal tar wastes for hot-mix asphalt batching. There is little long-term performance data for successful applications.	Medium, compared to other recycle/reuse options under consideration	Retained as Process Option
		Brick Manufacture	Proven effective for clayey and silty soils. Provides beneficial reuse of wastes.	Potentially implementable for soil waste streams, but not coal tars. Few vendors are accepting coal tar wastes for brick manufacturing. There is little long-term performance data for successful applications.	Medium, compared to other recycle/reuse options under consideration	Retained as Process Option

Table 3-4 (Sheet 6 of 6)
Summary of Remedial Technology Screening

RESPONSE ACTION	TECHNOLOGY TYPE	TECHNOLOGY	EFFECTIVENESS	IMPLEMENTABILITY	COST	STATUS FOR ALTERNATIVE DEVELOPMENT
Soil Treatment	Recycle/Reuse	Cement Manufacture	Technology has been proven effective in Europe and U.S. for beneficial reuse of many waste streams, including coal tars.	Potentially implementable. Few vendors are permitted for cement manufacturing. Low BTU waste streams tend to compete with high BTU waste streams.	High, compared to other recycle/reuse options under consideration	Retained as Process Option
		Coburning in a Utility Boiler	Proven to be a technically effective method of recovering value from coal tar wastes. May require blending with coal fines on-site, which could cause short-term impacts due to truck traffic, fugitive dust, and materials handling.	Potentially implementable. Few vendors are permitted for coburning.	High, compared to other recycle/reuse options under consideration	Retained as Process Option
	Treatment	Thermal Desorption	Effective form of treatment for soils with low to high levels of organic contamination. Technology has been used at other similar sites effectively.	Readily implementable. Many permitted facilities can receive waste streams.	Medium, but low compared to other treatment options under consideration	Retained for Alternative Development
Treated Water Disposal	Off-Site Discharge	POTW	Reliable and effective with proper maintenance and operation.	Readily implementable. Discharge permit required. Long-term sampling and analysis of effluent is typically required.	Medium, compared with creek discharge, due to POTW use fees	Retained for Alternative Development
		Discharge to Coney Island Creek	Reliable and effective.	Readily implementable. Will typically require a SPDES permit. Long-term sampling and analysis of effluent is typically required.	Low, compared with POTW discharge	Retained for Alternative Development

Table 3-5 (Sheet 1 of 2)
Summary Of Treatment Technologies For NAPL and Aqueous Waste

Technology	Applications	Advantages	Disadvantages	Status
Phase Separation	effective at removing: • free oil • suspended solids • grease • TPH	• relatively inexpensive • low maintenance • low energy cost • relatively safe • easy to operate	• does not remove dissolved constituents • required waste oil and sludge removal	commercially available
Metals Precipitation	effective as: • pretreatment for metals removal • removal of inorganics • removal of dissolved metals	• low maintenance • easy operation • low energy costs	• all chemicals do not have an optimum pH at which they precipitate • generation of hazardous sludge • proper storage is required • waste sludge disposal is required • costs for chemicals and flocculation aids	commercially available
Filtration	effective for the removal of: • free oil • emulsified oil • suspended solids • metals	• relatively safe • easy to operate • low energy costs	• backwashing is required • unit is susceptible to fouling	commercially available
Air Stripping	effective for the removal of: • BTEX • VOCs • some SVOCs • low molecular weight PAHs • chlorinated VOCs	• removes dissolved particles • somewhat safe • low capital cost	• high energy costs • difficult to maintain • susceptible to fouling • volatile emissions • no inorganic removal	commercially available
Aerobic Biological Treatment	effective at removing: • low concentration organics • some inorganics	• removes dissolved constituents • destruction process • relatively safe • low maintenance	• volatile emissions • groundwater may be too dilute to use activated sludge process • susceptible to shock and loading toxins • susceptible to climatic changes • depending on which type of technology is implemented, there may be high energy costs OR high capital and operating costs OR large land requirements	broadly used technology
Carbon Adsorption	effective at removing: • aqueous organics with: ➢high molecular weight ➢high boiling point ➢low solubility ➢low polarity • PAHs • naphthalene • petroleum	• removes dissolved contaminants • relatively safe • easy to operate • low capital cost	• spent carbon • fouling • odor and bacterial growth • high maintenance • excessive head loss due to solids accumulation • regeneration cost • replacement cost • disposal cost	conventional

Table 3-5 (Sheet 2 of 2)
Summary Of Treatment Technologies For NAPL and Aqueous Waste

Technology	Applications	Advantages	Disadvantages	Status
Neutralization	• effective at adjusting pH to acceptable discharge range • treat with acids or alkalies • treat with other process stream	fairly inexpensive	well-mixed system is required for completeness	common industrial process

Sources:

EPA/625/8-87/014
A Compendium of Technologies Used in the Treatment of Hazardous Wastes
Office for Environmental Research Information, Office of Research and Development
U.S. EPA, Cincinnati, OH 45268

Wastewater Treatment
"Chemical Engineering Progress"
August 1995
35, 40, 44, 51.

Table 3-6
Potentially Applicable Technologies Retained For Remediating Soils and NAPL

INSTITUTIONAL CONTROLS	CONTAINMENT	SOURCE REMOVAL	PREPARATION/ TREATMENT	DISPOSAL
Access Controls Deed restrictions Health & Safety Plan • Digging Permit Long-term monitoring Notifications	Soil • Cover System on Fill Groundwater/NAPL • Vertical Barrier ➢Conventional Slurry Wall ➢Vibrating Beam Slurry Wall ➢Interlocking Steel Sheet Piles Air and Emissions • Temporary Enclosures	Soil • Excavation of Soils in Excess of Risk-Based Concentrations • Coal Tar Source Area Excavation Groundwater/NAPL • Recovery Trench	Soil Preparation • Consolidation • Screening • Blending Off - Site Recycling/ Treatment of Soil • Cold-Mix Asphalt • Hot-Mix Asphalt • Brick Manufacture • Cement Manufacture • Cobuming in a utility boiler • Thermal Desorption NAPL • Phase Separation • Metals Precipitation • Filtration • Air Stripping • Carbon Adsorption • Neutralization • Aerobic Biological Treatment	Treated Effluent • Discharge to POTW • Discharge to Coney Island Creek

Table 4-1
Assessment of Differences Among Technologies for Development of Remedial Alternatives

General Response Actions	Technologies	Significant Differences	Discussion	Recommended Technology for Alternative Development
Institutional Controls	• Access Controls/Process Options • Deed restrictions • Health & Safety Plan • Digging Permit • Long-term monitoring • Notifications	• No significant differences. • Technologies are mutually exclusive of each other.	• Access controls are needed during and after construction. • Deed restrictions will be placed on the parcel. • A Health & Safety Plan appended to the agreement with the developer will be used to govern subsurface work and to respond to contingency issues. • Long-term monitoring will be required to confirm the effectiveness of remedial systems. • Notifications will alert the community about the risks and controls present at the site, including total cyanide detected at off-site locations.	Each technology is retained for consideration in all alternatives, except No Action, which is required by statute.
Containment	Soil • Cover System on Fill	Only one process option can meet RAOs.	Not needed.	Cover System on Fill is retained for consideration in all alternatives, except No Action.
	NAPL • Vertical Barrier ➢Conventional Slurry Wall ➢Vibrating Beam Slurry Wall ➢Interlocking Steel Sheet Piles	• Conventional slurry wall requires significant excavation, while the other two technologies do not. • Steel sheet pile barriers are relatively expensive compared to the other two technologies. • Steel sheet pile barriers can provide structural support.	• All three technologies can achieve RAO that prevents seepage in Coney Island Creek. • Steel sheet pile walls are more expensive; costs may be off-set by excavation needed for other technologies. • Structural support of cover system will be required.	• Steel sheet pile barrier is retained for consideration in all alternatives, except No Action. • Remedial design will optimize the vertical barrier wall. Optimization may involve a combination of the three technologies.
	Air and Emissions • Temporary Enclosure	Only one technology addresses the identified odor and emission technical issues.	Not needed.	Temporary enclosures are retained for use in all alternatives, except No Action.
Source Removal	Soil • Excavation of Soils in Excess of Risk-Based Concentrations • Coal Tar Source Area Excavation	• RBC excavation removes soils and source materials to meet RAO for construction worker. • Coal tar source area excavation removes large percentage of on-site contaminants, but requires a cover system and institutional controls to meet RAO. • Coal tar source area excavation volume and area of disturbance are approximately 25% of RBC excavation area and volume.	• Significant differences exist. • These differences involve attainment of RAOs, short-term environmental impacts, and cost.	RBC excavation and coal tar source area excavation will be evaluated in separate remedial alternatives.
	NAPL • Collection Trench	Only one technology addresses the removal of NAPL	A collection trench can be integrated with a barrier wall to prevent seepage into the Coney Island Creek.	A collection trench is retained for use in all alternatives, except No Action.
Preparation/ Treatment	Off-Site Recycling/ Treatment of Soil • Cold-Mix Asphalt • Hot-Mix Asphalt • Brick Manufacture • Cement Manufacture • Coburning in a utility boiler • Thermal Desorption	• Thermal desorption is not considered recycling or re-use, unless the treatment facility has agreements for reuse after treatment. • Thermal desorption is the most widely proven and available process option. • Thermal desorption and asphalt batching have relatively low costs.	• Several thermal desorption vendors are permitted to treat wastes off-site. Many of these vendors sell the treated material for use in road construction, as landfill cover, or in other reuse options. • Lack of available and permitted vendors for other process options makes them less favorable for alternative development in a focused setting.	• Thermal desorption is retained for consideration in all alternatives, except No Action. • Remedial design may consider pilot tests of selected technologies, if a competitive set of qualified vendors is available.
	NAPL ➢Phase Separation ➢Metals Precipitation ➢Filtration ➢Air Stripping ➢Carbon Adsorption ➢Neutralization ➢Aerobic Biological Treatment	Aerobic biological treatment can be used in place of air stripping and carbon adsorption.	Substitution of process option does not affect overall alternative evaluation and comparison.	• Air stripping and carbon adsorption are retained for consideration in all remedial alternatives, except No Action; aerobic biological treatment may be considered during detailed design optimization. • All other technologies are retained for use in all alternatives, except No Action.
Disposal	Treated Effluent • Discharge to POTW • Discharge to Coney Island Creek	• Both discharges are governed by different agencies. • Discharge to POTW has long-term cost dependent on discharge volume. • Discharge permits establish different criteria for the two options.	• Significant differences exist. • These differences involve the coordination of different agencies, long-term cost implications, degree of treatment for specific compounds, and long-term monitoring requirements.	POTW discharge and Coney Island Creek discharge will be evaluated in separate alternatives.

Table 4-2
Assessment of Common Alternative Elements and Technical Issues

Technical Issue	Alternative Element(s)	Feature(s)	Benefit(s)
100-Year Floodplain	Low permeability cover system.	Clean fill on cover system.	• Raises site elevation out of floodplain.
Preference for "clean" construction zone and unhindered future access	Low permeability cover system.	Clean fill on cover system.	• Provide clean work zone for installation and maintenance of foundations and utility lines.
Integration of remedy with final development	Low permeability cover system.	Concrete relieving platform.	• Provide necessary soil bearing capacity without complicating construction and clearly separates remediation from development.
Establishment of green space	Bank stabilization and restoration.	Bioengineered 50-foot ecological buffer zone.	• Provide structural support for cover system and erosion protection measures. • Create habitats for selected bird species. • Aesthetically pleasing. • Dissipate stormwater runoff. • Isolate monitoring wells from developed areas.
Low-profile remedial systems and components	NAPL collection and treatment systems.	• Small treatment plant. • Secured location. • Piping embedded in recovery trench. • Recovery trench located in 50-foot ecological buffer zone.	• Public does not have easy access to monitoring, extraction, maintenance, and operating equipment. • Plant is removed from development and does not draw attention. • Gas vents and well stick-ups can be surrounding by shrubs to hide them from view.
Proximity to railyard, elevated highway, and high-rise residences	• Vertical barrier. • Excavation.	• Vibratory versus hammer pile driving. • Use of construction enclosures.	• Sheet piles can be driven using hammer methods if vibrations have potential to damage nearby structures. • Construction enclosures limit visibility of activities and control release of emissions and odors.
Stability of creek bank	Bank stabilization and restoration.	Bioengineered 50-foot ecological buffer zone.	• Provide structural support for cover system and erosion protection measures. • Dissipate stormwater runoff.
100-Year Floodplain	Low permeability cover system.	Clean fill on cover system.	• Raises site elevation out of floodplain.
Integrity of low permeability subsurface layers	• Low permeability cover system. • Vertical barrier.	• Concrete relieving platform on drilled piles. • Steel sheet piles.	• Drilled piles under relieving platform can be installed using slurry and finished to minimize the creation of preferential contaminant migration pathways. • Steel sheets can be driven to key into existing low permeability layers.
Volume and quality of fill	Cover system on fill.	• Capacity to raise elevation out of floodplain.	• Import of high quality construction fill for clean zone allows low-quality, contaminated materials to be contained under the cover system.
Air emissions and odor control	Temporary construction enclosures.	• Negative pressure work environment. • Vapor abatement system.	• Excavation and materials handling can proceed in a controlled environment without releases of emissions or odors to off-site receptors.
Truck traffic	• Excavation. • Low permeability cover system.	• Traffic control plan.	• Truck traffic will be controlled and environmental controls will be instituted to prevent releases.
Dewatering	• Excavation. • Bank stabilization and restoration.	• Excavation limited to unsaturated zone soils. • Isolated work cells along creek bank are equipped with well points.	• Excavated materials from interior of site should not be saturated with water and not require dewatering. • Dewatering of spoils from creek bank should be limited due to small size of work cell and well-point extraction of water.
Technical impracticability of groundwater remediation	• Excavation. • NAPL collection and treatment systems.	• Excavation limited to unsaturated zone soils. • Recovery trench, sumps, and treatment plant units.	• Excavated materials from interior of site should not be saturated with water and not require dewatering. • Groundwater recovery and treatment plant components should be designed for long life and ease of maintenance.
Monitored natural attenuation	• Excavation and containment. • NAPL collection and treatment systems. • Monitoring wells in 50-foot ecological buffer zone.	• Excavation of coal tar sources. • Installation of cover system and perimeter barrier wall. • Recovery trench and monitoring wells to be sampled as part of performance monitoring.	• Source control addresses principal threat of contaminants. • Containment addresses long-term presence of contaminants. • Performance monitoring assesses contaminant concentrations both inside and outside the perimeter barrier over time.
Security and access	• Low permeability liner system. • Treatment plant. • 50-foot ecological buffer zone.	• Cover system elements • Security fence around treatment plant. • Wrought iron fence along buffer zone.	• Cover system elements have warning signs that alert construction workers prior to disturbance. • Fences keep the public away from remedial systems.
Contingency planning	All.	Design optimization process.	Systems and operation plans anticipate contingencies and have back-up systems and measures in place to address them.

Table 4-3
Preliminary Discharge Requirements (Sheet 1 of 2)

Compounds Present in Wastewater	Assumed Treatment Influent Concentration (ppb)	Assumed Treatment Effluent Concentration (ppb)	Preliminary POTW Discharge[1] Concentration (ppb)	Preliminary SPDES Discharge[2] Concentration (ppb)
PAH				
1-Methylnaphthalene	--			-
2-Methylnaphthalene	1344	ND		33
Acenaphthene	740	ND		-
Acenaphthylene	50	ND		-
Anthracene	660	ND		-
Benzo(a)anthracene	575	ND		-
Benzo(a)pyrene	420	ND		10
Benzo(b)fluoranthene	230	ND		-
Benzo(ghi)perylene	220	ND		-
Benzo(k)fluoranthene	285	ND		-
Chrysene	615	ND		10
Dibenzo(a,h)anthracene	210	ND		10
Fluoranthene	1220	ND		5
Fluorene	905	ND		3.2
Indeno(1,2,3-cd)pyrene	35	ND		-
Naphthalene	10950	ND		72
Phenanthrene	1720	ND		6
Pyrene	2080	ND		-
VOC				
1,2-Dichloroethane	--			
Acetone	--			
Benzene	1265	ND	10	1,350
Carbon Disulfide	17	ND		-
Chlorobenzene	--			
Ethylbenzene	4361	ND	10	510
Methylene Chloride	--			
Styrene	--			
Toluene	1656	ND	10	475
Total Xylenes	8200	ND	10	370
SVOC				
2,4-Dimethylphenol	--			
2-Methylphenol	--			
4-Methylphenol	--			
bis(2)Ethylhexyl)phthalate	4	ND		-
Dibenzofuran	--			
Phenol	9	ND		1,250
Pesticides/PCB				
Alpha-BHC	--			
Gamma-BHC (Lindane)	--			
Heptachlor	--			
Heptachlor epoxide	0.3	ND		0.08
Inorganics				
Arsenic	80	<20		23
Beryllium	2	<5		9.0

Table 4-3
Preliminary Discharge Requirements (Sheet 2 of 2)

Compounds Present in Wastewater	Assumed Treatment Influent Concentration (ppb)	Assumed Treatment Effluent Concentration (ppb)	Preliminary POTW Discharge[1] Concentration (ppb)	Preliminary SPDES Discharge[2] Concentration (ppb)
Chromium	90	<50	5000	560*
Copper	325	<10		2.9
Iron	20000	<500		-
Lead	100	<10	2000	4.8
Manganese	1800	<50		-
Nickel	150	<10	3000	500
Selenium	10	<10		79.3
Zinc	250	<50	5000	66
Cyanide-Total	10	<5	200	0.93

Notes:

1 POTW Discharge Regulations from NYCDEP, Bureau of Wastewater Pollution Control, Division of Pollution Prevention & Monitoring, Compliance Engineering Section

2 SPDES Discharge Regulations

\- No corresponding toxicity data or numerical criteria available for compound/analyte

NA Water quality criteria provided in verbal text and not expressed as numerical values in NYSDEC regulations

* Chromium valence form of Cr+3

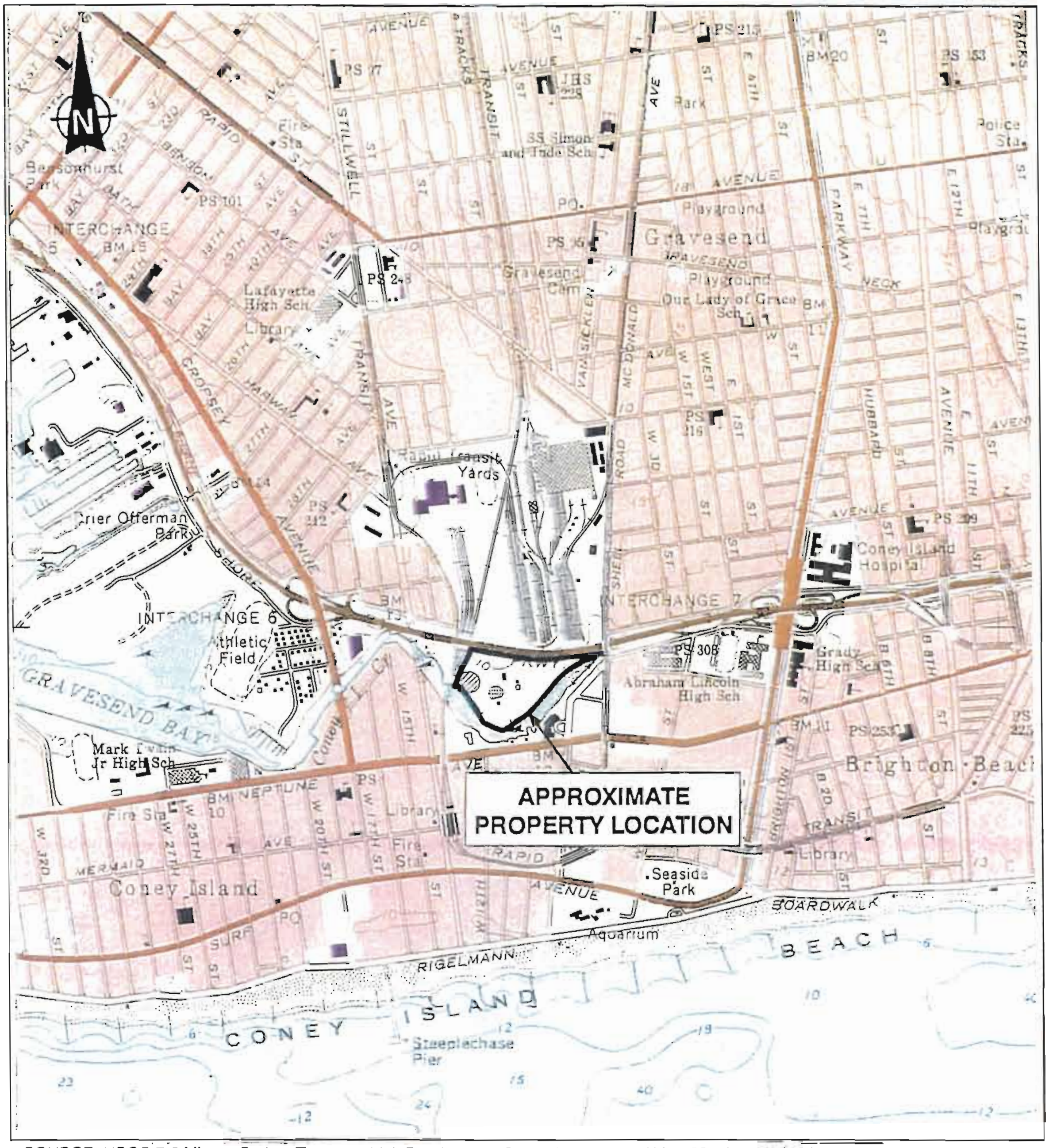
TABLE 4-4
SUMMARY OF ESTIMATED PRESENT WORTH COSTS
FOR REMEDIAL ACTION ALTERNATIVES

Alternative	Description	Capital Cost ($)	Annual O&M ($)	Present Worth
1	No Action	$0	$253,000	$4,667,000
2	RBC excavation with discharge to Creek	$27,508,000	$550,000	$37,653,000
3	RBC excavation with discharge to POTW	$27,508,000	$631,000	$39,147,000
4	Source Area excavation with discharge to Creek	$16,295,000	$550,000	$26,440,000
5	Source Area excavation with discharge to POTW	$16,295,000	$631,000	$27,934,000

FORMER BROOKLYN BOROUGH GAS WORKS SITE
BROOKLYN UNION GAS COMPANY

FIGURE 1-1
FFS REPORT
RETAIL REUSE CONCEPT PLAN

FOSTER WHEELER ENVIRONMENTAL CORPORATION



SOURCE: USGS 7.5 Minute Series (Topographic) Quadrangle: Coney Island, NY - NJ 1966, photorevised 1979.

SCALE 1:24,000

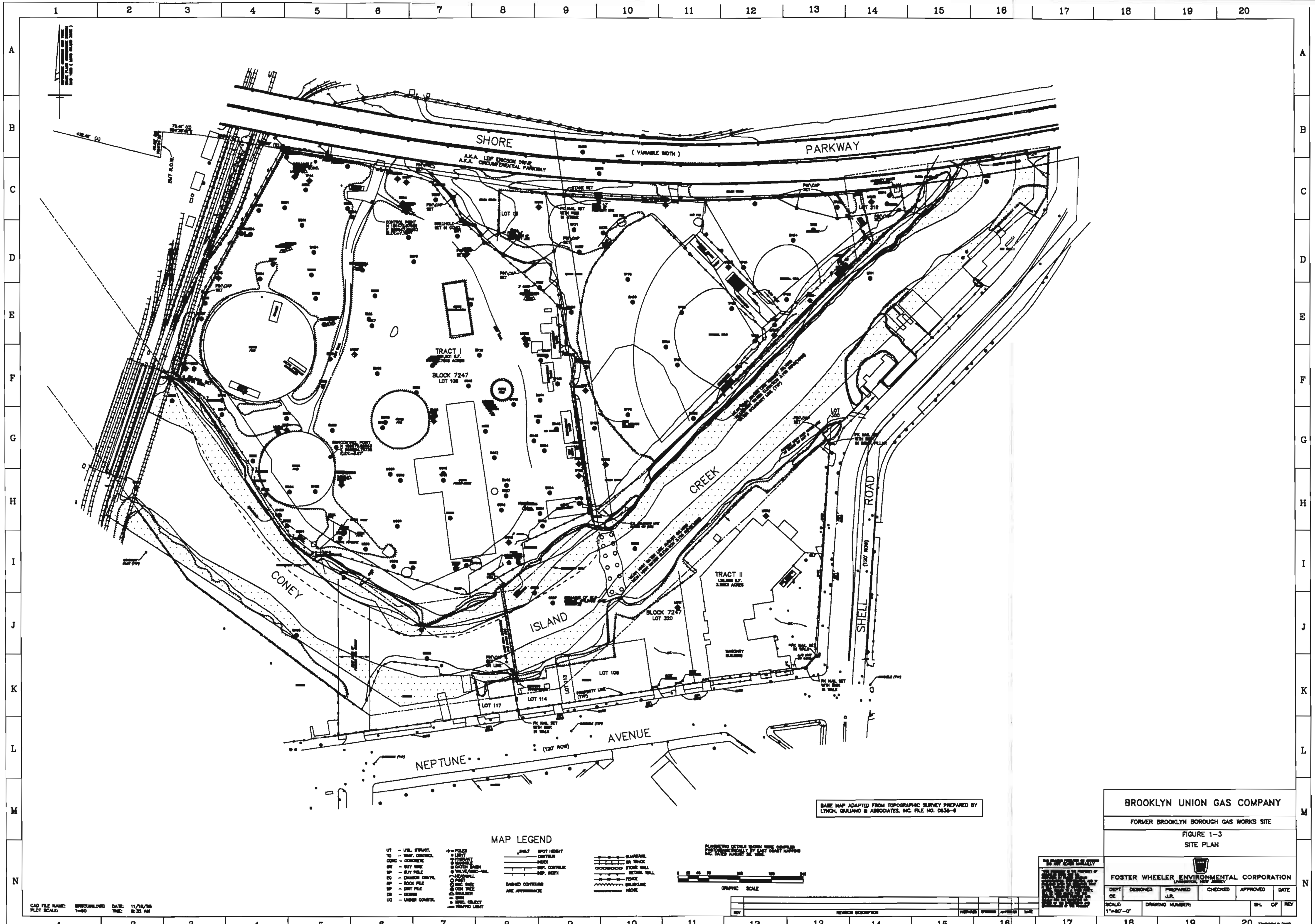
0 ½ 1 Mile

0 .5 1 Kilometer

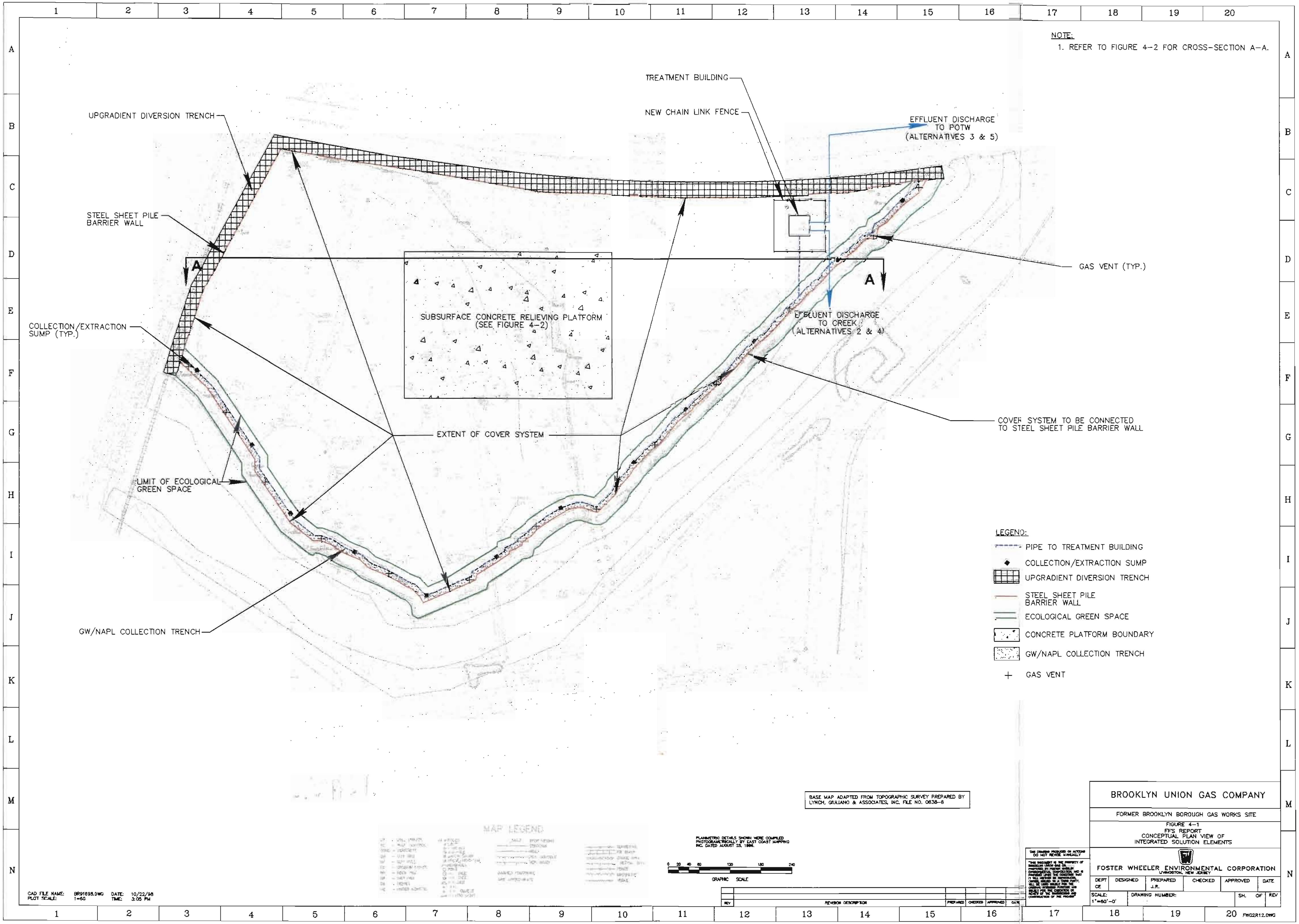
THIS DRAWING PRODUCED ON AUTOCAD DO NOT REVISE IT MANUALLY
BROOKLYN UNION GAS FOCUSED FEASIBILITY STUDY
FORMERLY BROOKLYN BOROUGH GAS WORKS
FIGURE 1–2 REGIONAL LOCATION MAP
FOSTER WHEELER ENVIRONMENTAL CORPORATION LIVINGSTON, NEW JERSEY

CAD FILE NAME: BUGBASE
PLOT SCALE: 1=1

FWA3R12.DWG



SHORE
PARKWAY
(VARIABLE WIDTH)
A.K.A. LEIF ERICSON DRIVE
A.K.A. CIRCUMFERENTIAL PARKWAY
TRACT I
BLOCK 7247
LOT 106
LOT 13
LOT 218
TRACT II
BLOCK 7247
LOT 320
LOT 300
LOT 108
LOT 117
LOT 114
LOT 113
CONEY
ISLAND
CREEK
SHELL
ROAD
(120' ROW)
NEPTUNE
AVENUE
BMT R.O.W.
MAP LEGEND
GRAPHIC SCALE
BASE MAP ADAPTED FROM TOPOGRAPHIC SURVEY PREPARED BY LYNCH, GIULIANO & ASSOCIATES, INC. FILE NO. 0838-6
BROOKLYN UNION GAS COMPANY
FORMER BROOKLYN BOROUGH GAS WORKS SITE
FIGURE 1-3
SITE PLAN
FOSTER WHEELER ENVIRONMENTAL CORPORATION


NOTE:
1. REFER TO FIGURE 4-2 FOR CROSS-SECTION A-A.
TREATMENT BUILDING
NEW CHAIN LINK FENCE
EFFLUENT DISCHARGE TO POTW (ALTERNATIVES 3 & 5)
UPGRADIENT DIVERSION TRENCH
STEEL SHEET PILE BARRIER WALL
COLLECTION/EXTRACTION SUMP (TYP.)
SUBSURFACE CONCRETE RELIEVING PLATFORM (SEE FIGURE 4-2)
GAS VENT (TYP.)
EFFLUENT DISCHARGE TO CREEK (ALTERNATIVES 2 & 4)
A
A
EXTENT OF COVER SYSTEM
COVER SYSTEM TO BE CONNECTED TO STEEL SHEET PILE BARRIER WALL
LIMIT OF ECOLOGICAL GREEN SPACE
GW/NAPL COLLECTION TRENCH
LEGEND:
PIPE TO TREATMENT BUILDING
COLLECTION/EXTRACTION SUMP
UPGRADIENT DIVERSION TRENCH
STEEL SHEET PILE BARRIER WALL
ECOLOGICAL GREEN SPACE
CONCRETE PLATFORM BOUNDARY
GW/NAPL COLLECTION TRENCH
GAS VENT
MAP LEGEND
BASE MAP ADAPTED FROM TOPOGRAPHIC SURVEY PREPARED BY LYNCH, GIULIANO & ASSOCIATES, INC. FILE NO. 0838-8
GRAPHIC SCALE
BROOKLYN UNION GAS COMPANY
FORMER BROOKLYN BOROUGH GAS WORKS SITE
FIGURE 4-1
FFS REPORT
CONCEPTUAL PLAN VIEW OF INTEGRATED SOLUTION ELEMENTS
FOSTER WHEELER ENVIRONMENTAL CORPORATION
LIVINGSTON, NEW JERSEY
SCALE: 1"=60'-0"
CAD FILE NAME: BR91698.DWG
PLOT SCALE: 1=60
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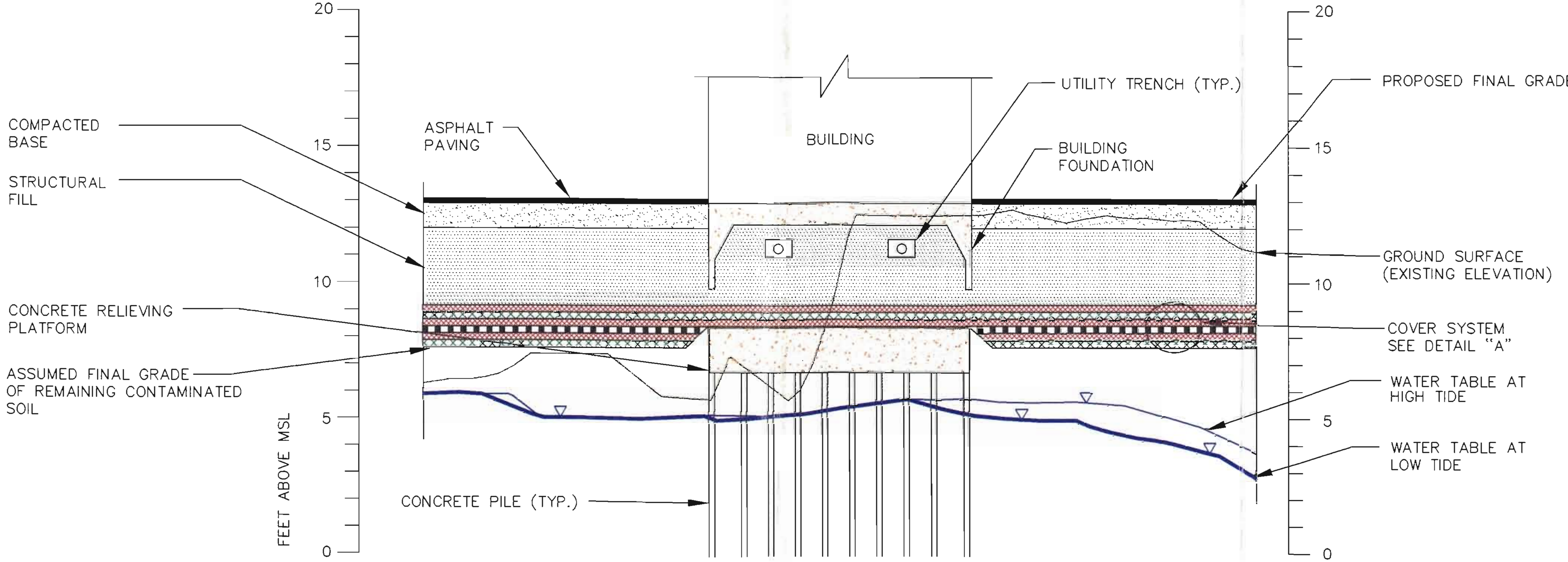
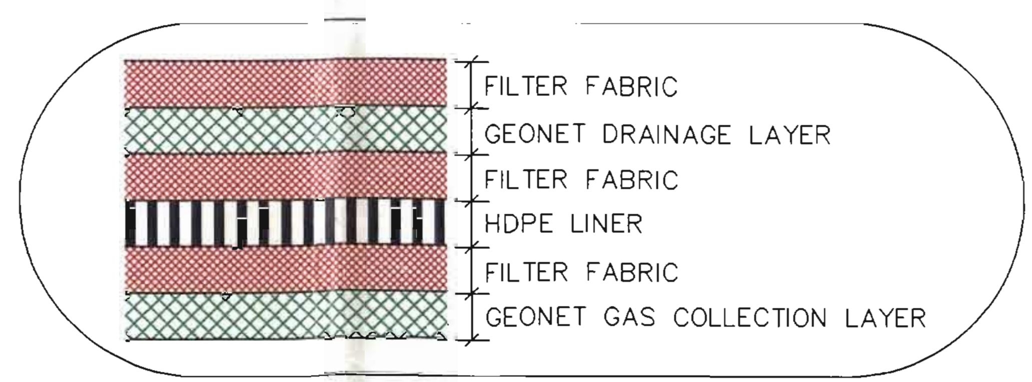


HORIZONTAL SCALE: NTS

LEGEND:

- CONCRETE
- COMPACTED BASE
- STRUCTURAL FILL
- EXISTING GRADE
- WATER TABLE ELEVATION
- ASPHALT PAVING
- GEOTEXTILE
- GEONET
- GEOMEMBRANE

DETAIL "A"



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BROOKLYN UNION GAS COMPANY

FORMER BROOKLYN BOROUGH GAS WORKS SITE

FIGURE 4-2
FFS REPORT
CONCEPTUAL COVER AND SURFACE CROSS-SECTION
DETAIL (CROSS-SECTION A-A)

FOSTER WHEELER ENVIRONMENTAL CORPORATION
LIVINGSTON, NEW JERSEY

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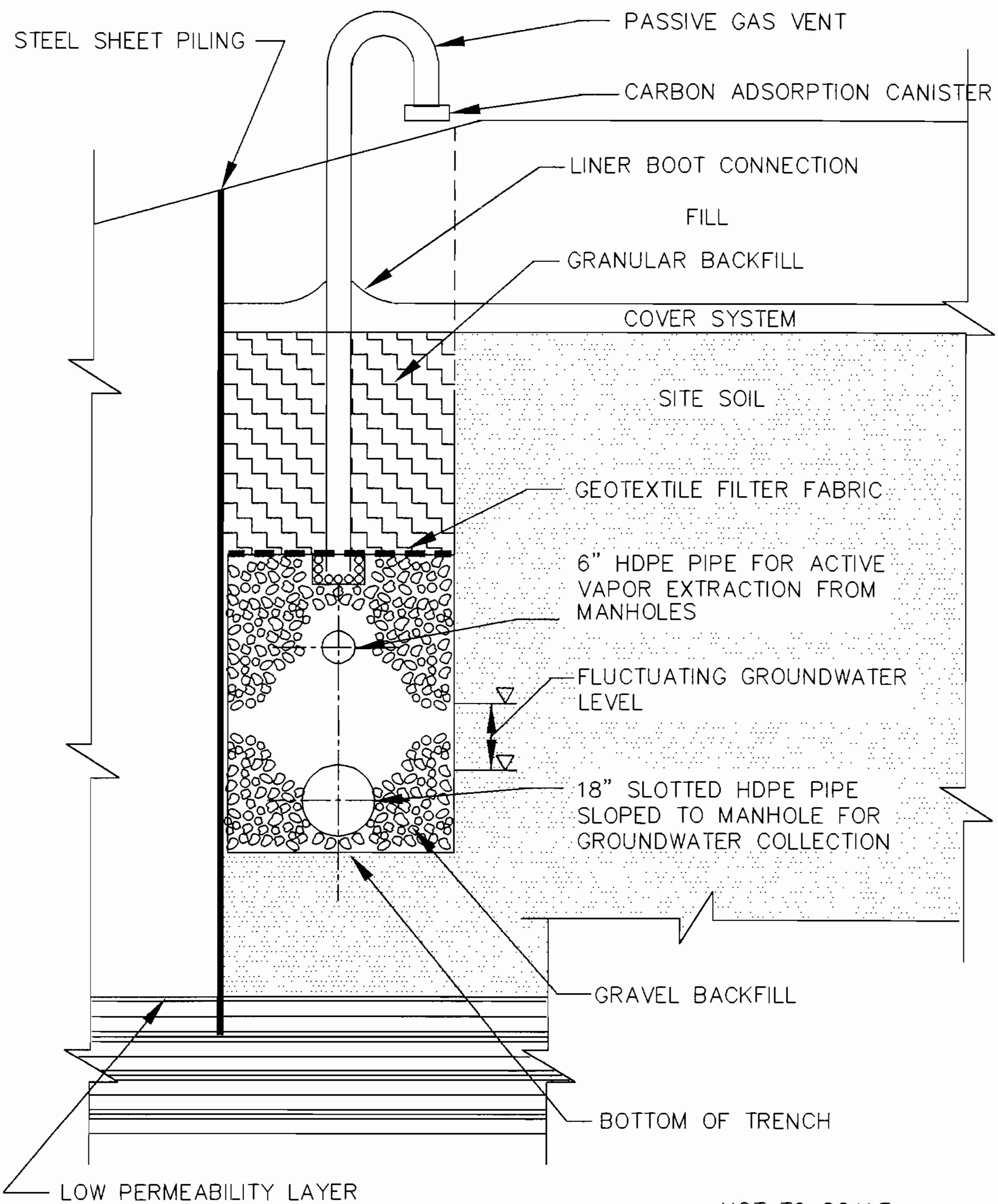

NOT TO SCALE

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FIGURE 4-3
FFS REPORT
CONCEPTUAL TRENCH CROSS-SECTION

FOSTER WHEELER ENVIRONMENTAL CORPORATION
LIVINGSTON, NEW JERSEY

CAD FILE NAME: BR102298.DWG DATE: 10/26/98
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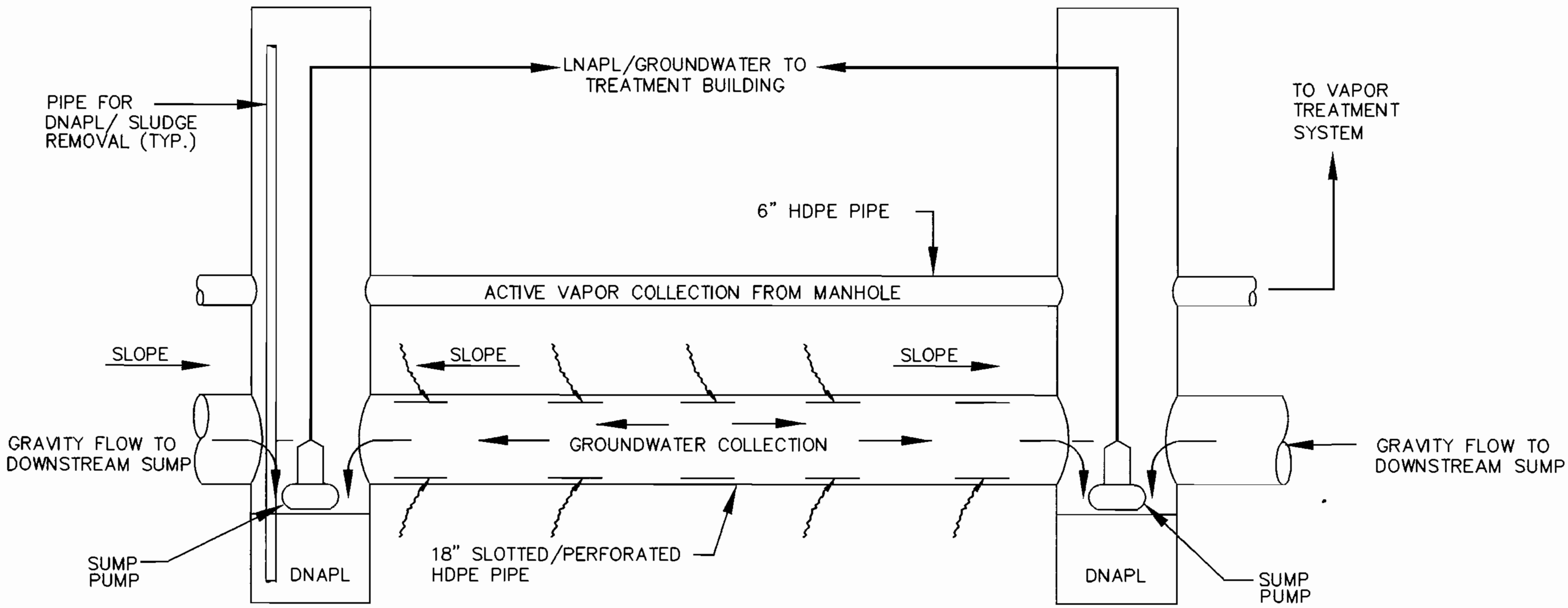

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BROOKLYN UNION GAS COMPANY
FORMER BROOKLYN BOROUGH GAS WORKS SITE
FIGURE 4-4 FFS REPORT CONCEPTUAL NAPL COLLECTION SYSTEM
FOSTER WHEELER ENVIRONMENTAL CORPORATION LIVINGSTON, NEW JERSEY

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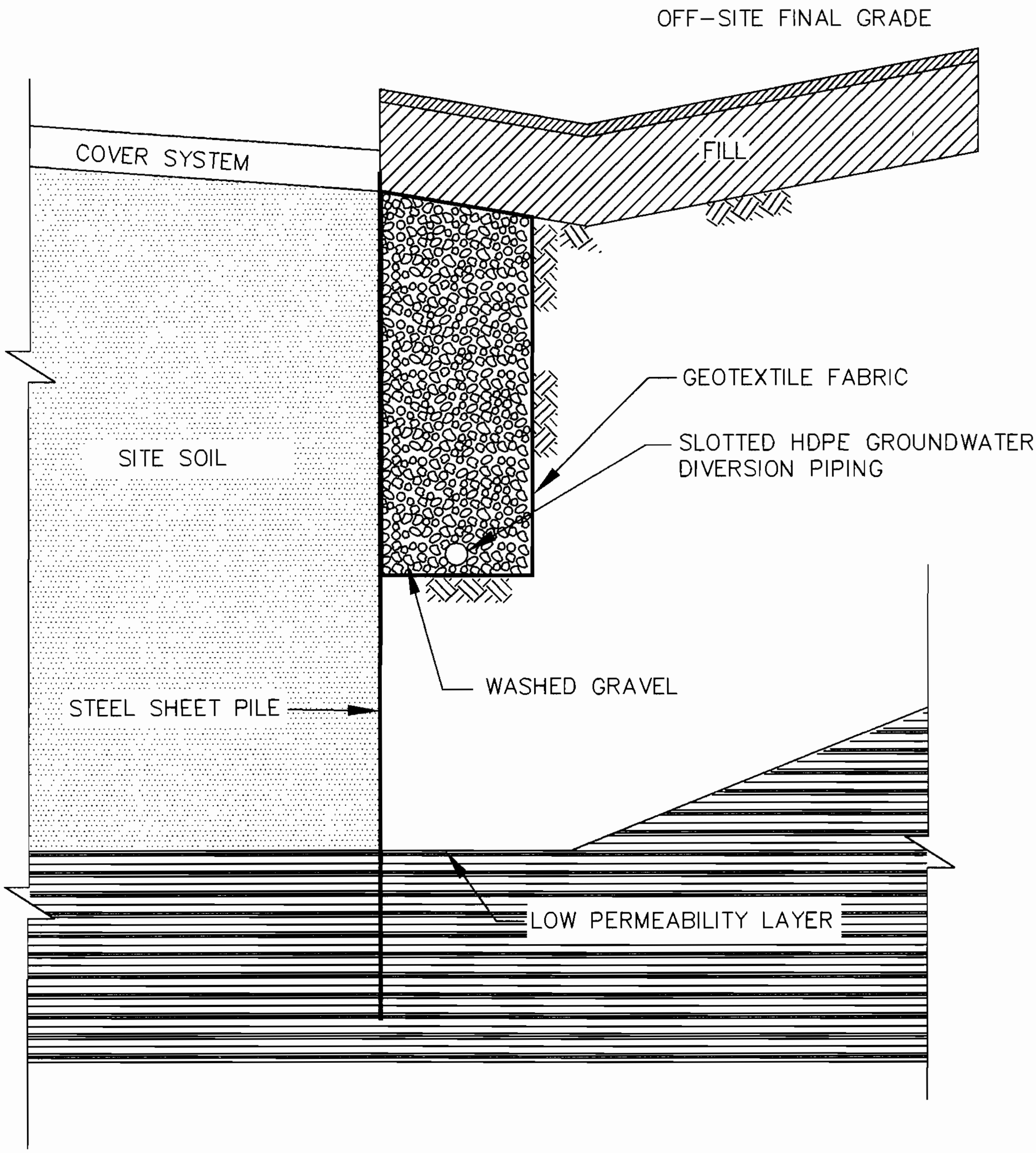

NOT TO SCALE

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FORMER BROOKLYN BOROUGH GAS WORKS SITE

FIGURE 4-5
FFS REPORT
CONCEPTUAL UPGRADIENT DIVERSION TRENCH SCHEMATIC

FOSTER WHEELER ENVIRONMENTAL CORPORATION
LIVINGSTON, NEW JERSEY

CAD FILE NAME: BR92198.DWG DATE: 10/26/98
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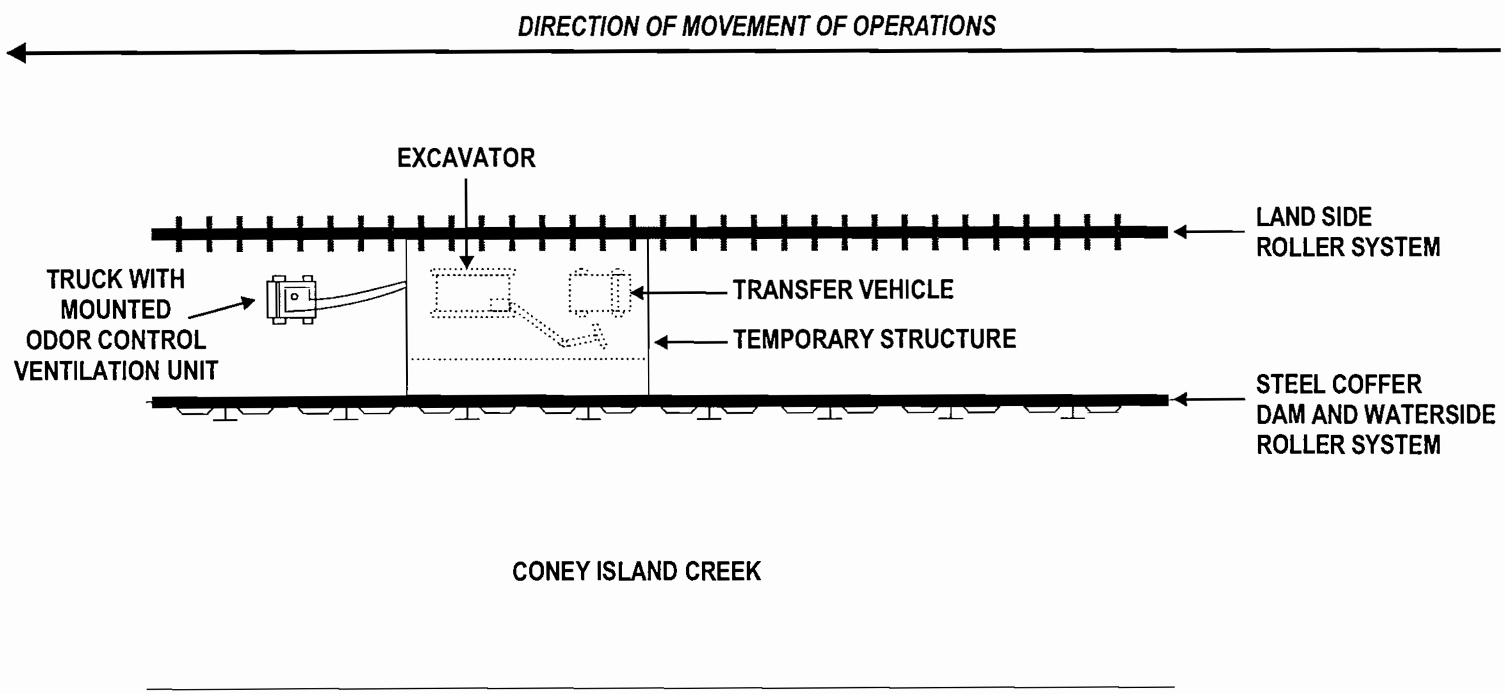
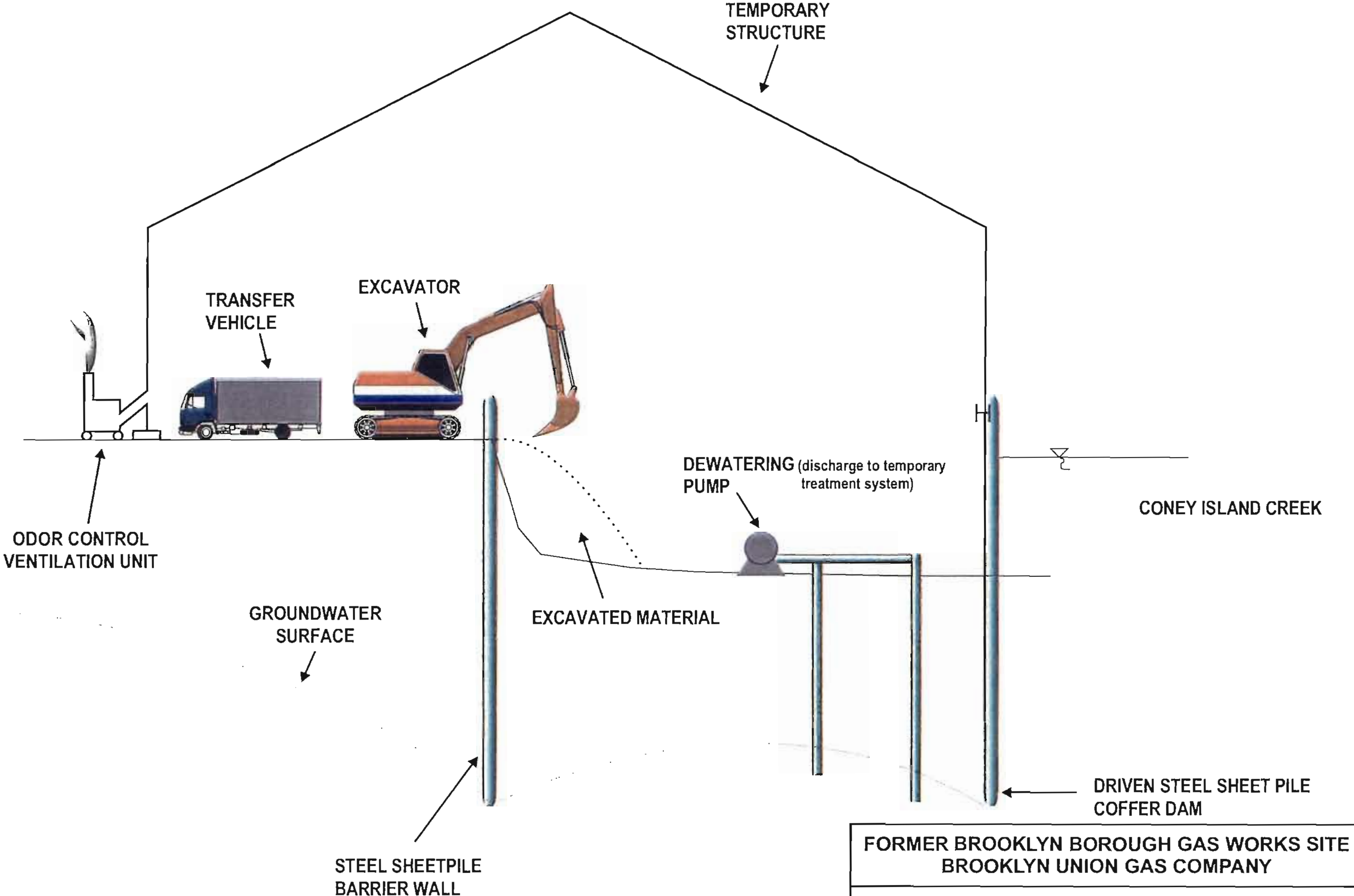


FORMER BROOKLYN BOROUGH GAS WORKS SITE
BROOKLYN UNION GAS COMPANY

FIGURE 4-6
FFS REPORT
CONCEPTUAL PLAN VIEW -
DURING STREAM BANK EXCAVATION

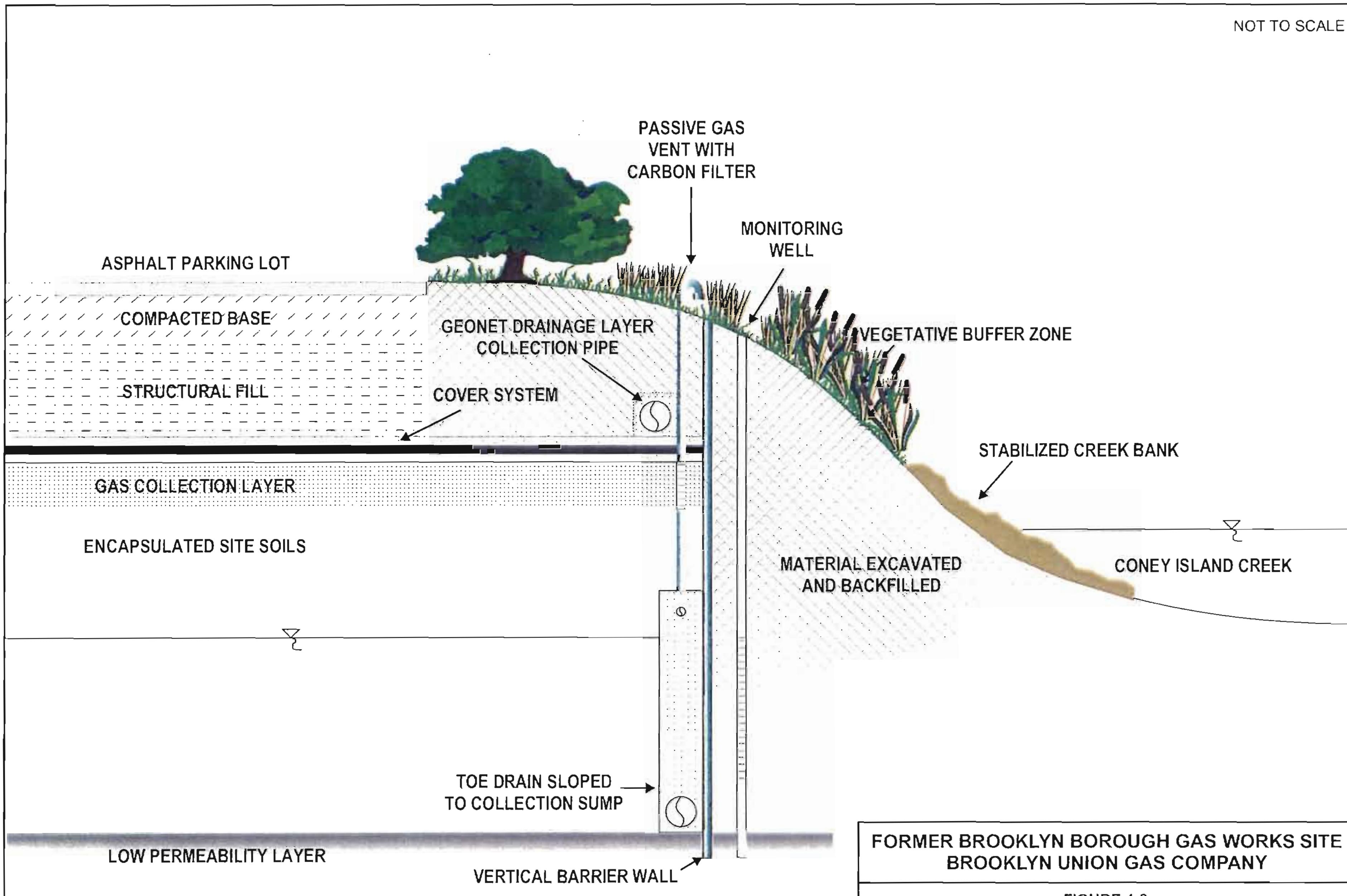
FOSTER WHEELER ENVIRONMENTAL CORPORATION



FORMER BROOKLYN BOROUGH GAS WORKS SITE
BROOKLYN UNION GAS COMPANY

FIGURE 4-7
FFS REPORT
CONCEPTUAL CROSS-SECTIONAL VIEW -
DURING STREAM BANK EXCAVATION

FOSTER WHEELER ENVIRONMENTAL CORPORATION



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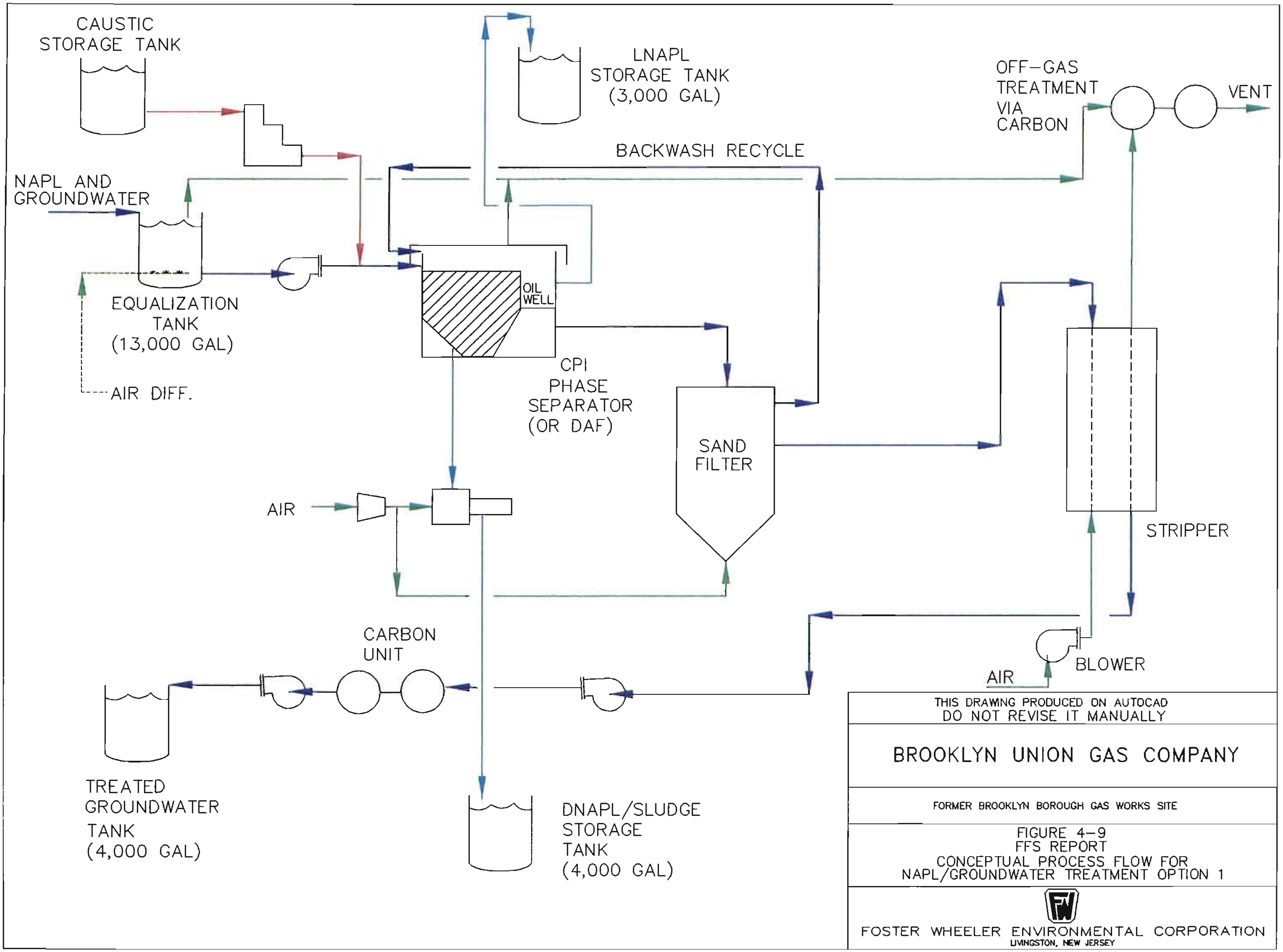
BROOKLYN UNION GAS COMPANY

FIGURE 4-8
FFS REPORT
CONCEPTUAL CROSS-SECTION OF RESTORED CREEK BANK

FOSTER WHEELER ENVIRONMENTAL CORPORATION



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BROOKLYN UNION GAS COMPANY

FORMER BROOKLYN BOROUGH GAS WORKS SITE

FIGURE 4-9
FFS REPORT
CONCEPTUAL PROCESS FLOW FOR
NAPL/GROUNDWATER TREATMENT OPTION 1

FOSTER WHEELER ENVIRONMENTAL CORPORATION
LIVINGSTON, NEW JERSEY

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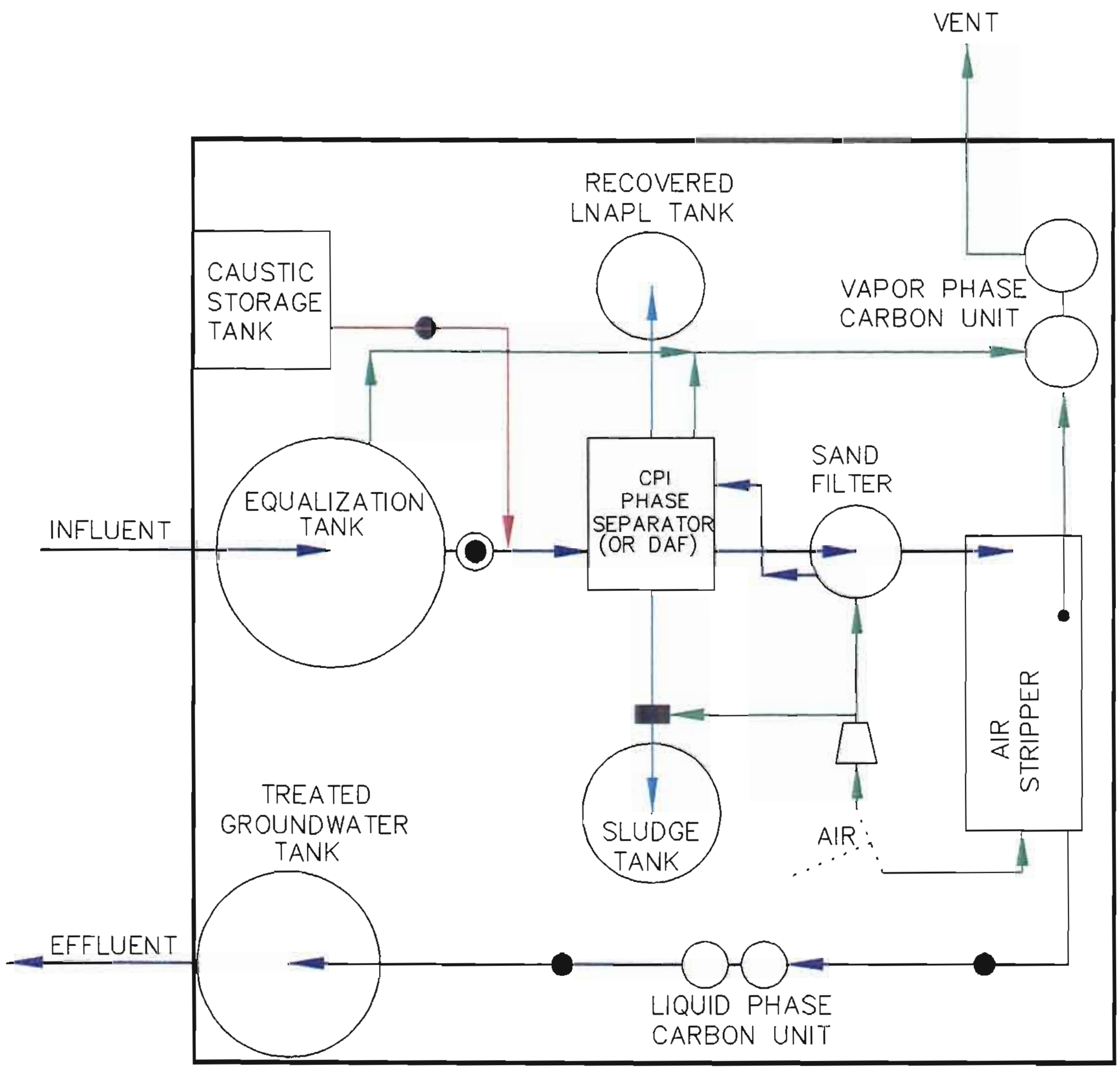
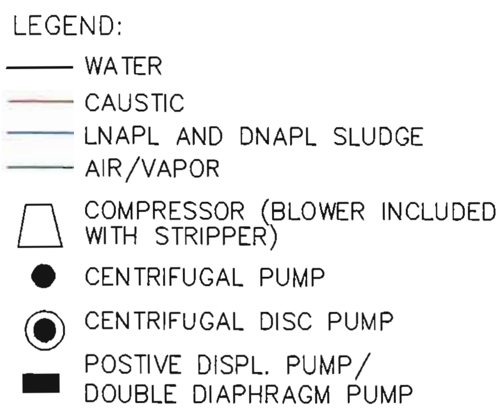
PLOT SCALE: 1=1 TIME: 3:25 PM





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BROOKLYN UNION GAS COMPANY

FORMER BROOKLYN BOROUGH GAS WORKS SITE

FIGURE 4-10
FFS REPORT
CONCEPTUAL PLAN VIEW OF NAPL/GROUNDWATER TREATMENT OPTION 1

FOSTER WHEELER ENVIRONMENTAL CORPORATION
LIVINGSTON, NEW JERSEY

CAD FILE NAME: BR91498B.DWG DATE: 10/9/98
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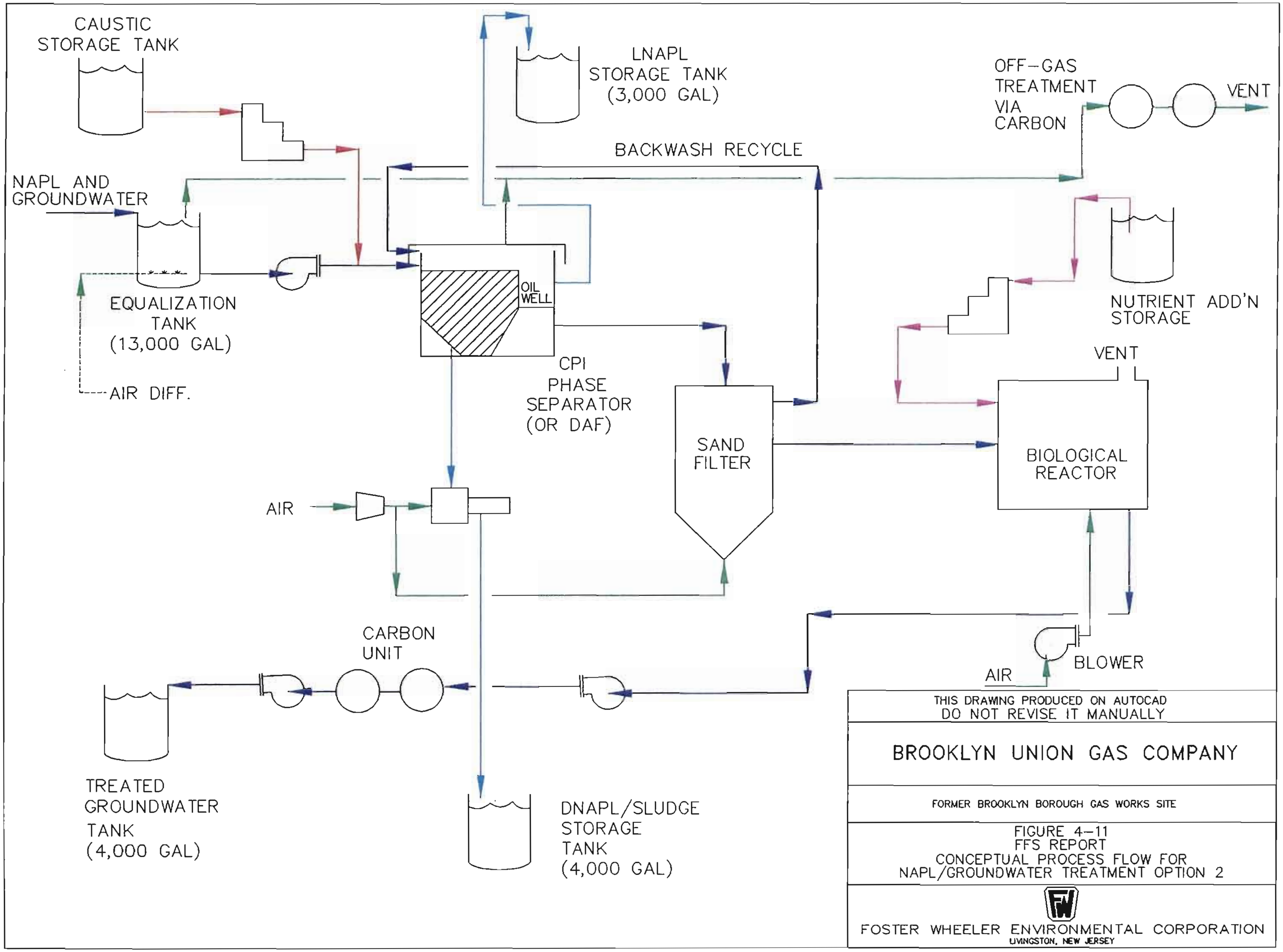

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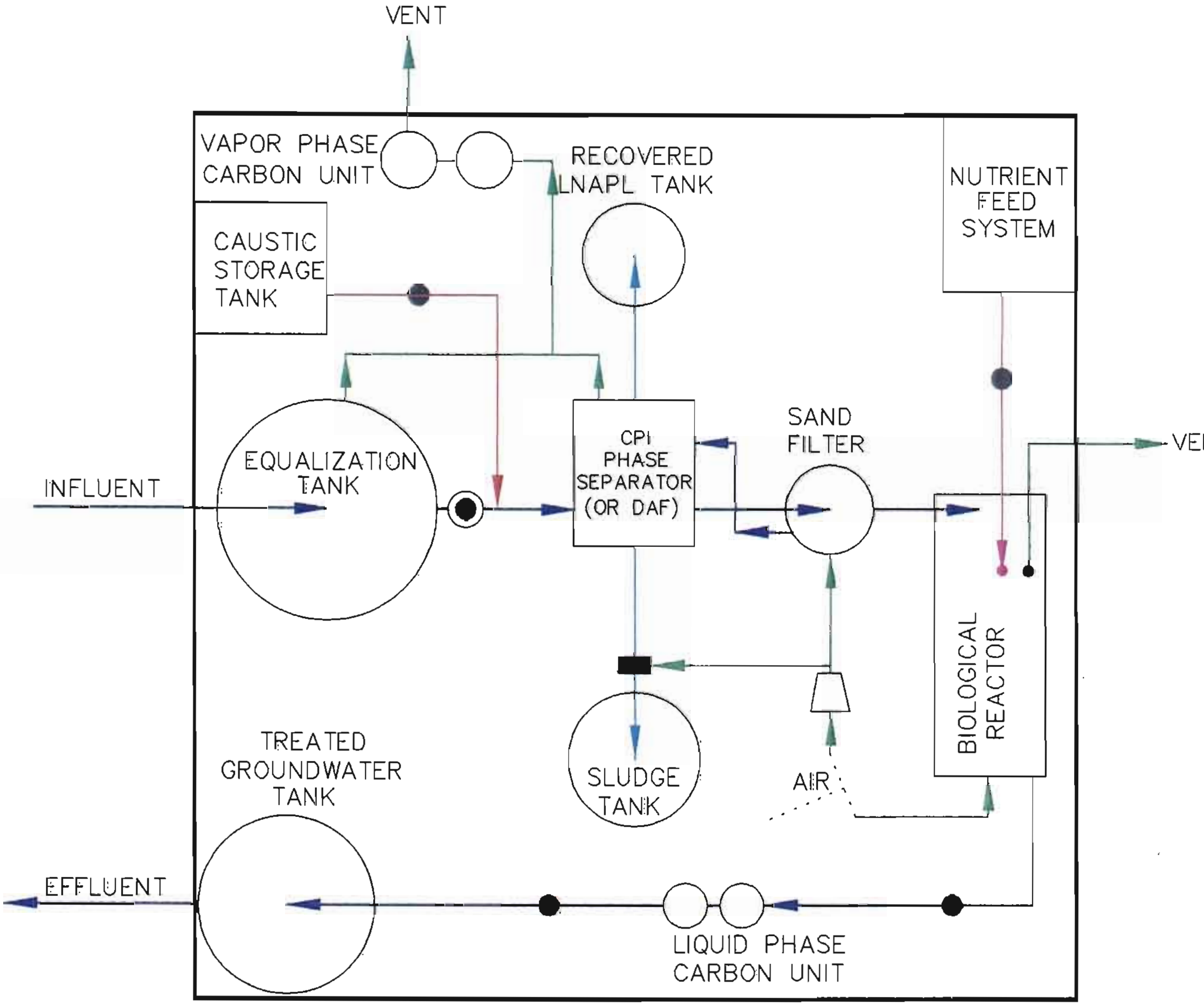
BROOKLYN UNION GAS COMPANY

FORMER BROOKLYN BOROUGH GAS WORKS SITE

FIGURE 4–11
FFS REPORT
CONCEPTUAL PROCESS FLOW FOR
NAPL/GROUNDWATER TREATMENT OPTION 2

FOSTER WHEELER ENVIRONMENTAL CORPORATION
LIVINGSTON, NEW JERSEY

PLOT SCALE: 1=1 TIME: 3:30 PM



LEGEND:

- WATER
- CAUSTIC
- LNAPL AND DNAPL SLUDGE
- AIR/VAPOR
- COMPRESSOR (BLOWER INCLUDED WITH STRIPPER)
- CENTRIFUGAL PUMP
- CENTRIFUGAL DISC PUMP
- POSTIVE DISPL. PUMP/ DOUBLE DIAPHRAGM PUMP

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BROOKLYN UNION GAS COMPANY

FORMER BROOKLYN BOROUGH GAS WORKS SITE

FIGURE 4-12
FFS REPORT
CONCEPTUAL PLAN VIEW OF
NAPL/GROUNDWATER TREATMENT OPTION 2

FOSTER WHEELER ENVIRONMENTAL CORPORATION
LIVINGSTON, NEW JERSEY

CAD FILE NAME: BR9498.DWG DATE: 10/9/98
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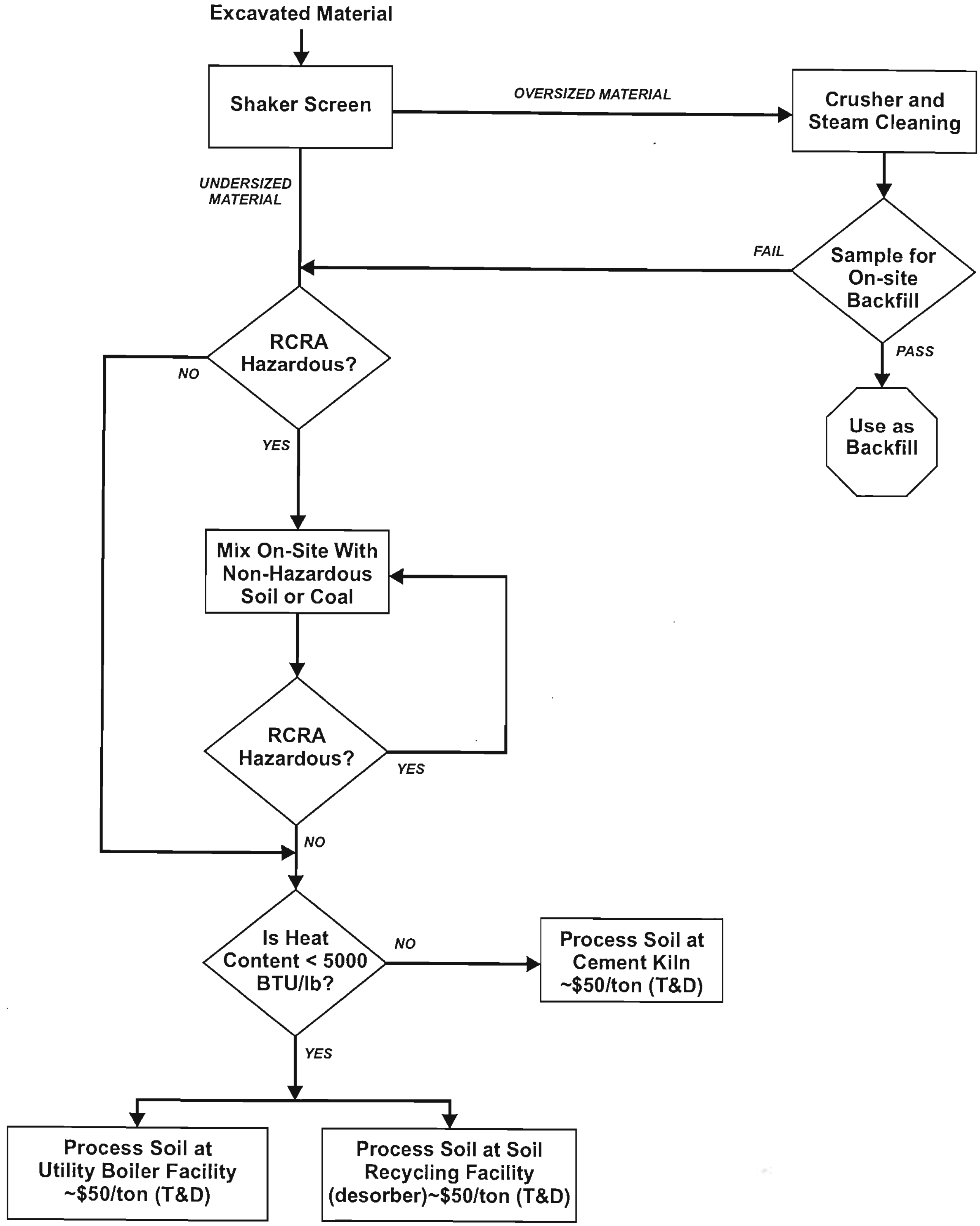
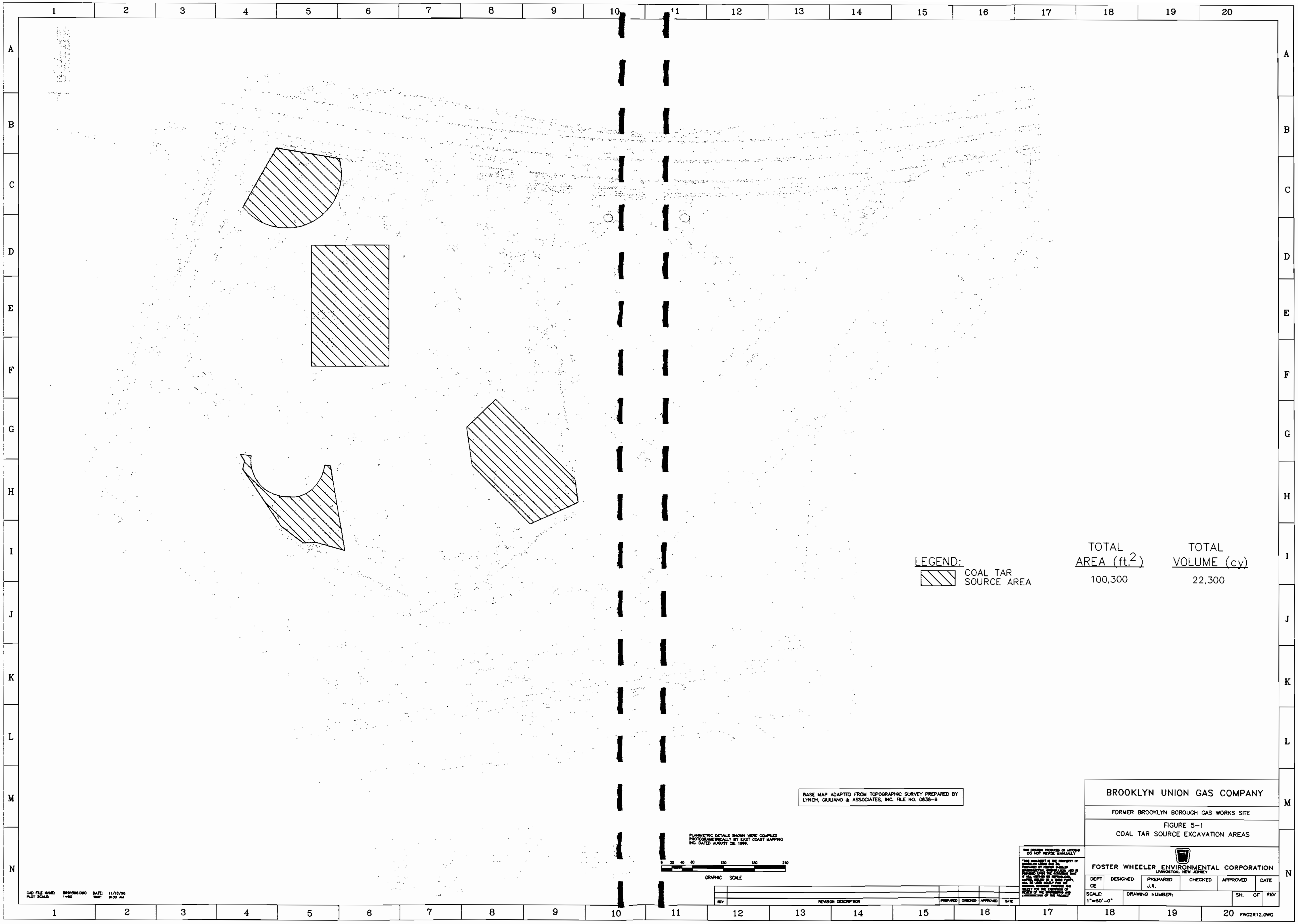


FORMER BROOKLYN BOROUGH GAS WORKS SITE
BROOKLYN UNION GAS COMPANY

FIGURE 4-13
FFS REPORT
EXCAVATED MATERIAL FLOW SCHEME

FOSTER WHEELER ENVIRONMENTAL CORPORATION


LEGEND:
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100,300
TOTAL VOLUME (cy)
22,300
BASE MAP ADAPTED FROM TOPOGRAPHIC SURVEY PREPARED BY LYNCH, GIULIANO & ASSOCIATES, INC. FILE NO. 0838-8
PLANIMETRIC DETAILS SHOWN WERE COMPILED PHOTOGRAMMETRICALLY BY EAST COAST MAPPING INC. DATED AUGUST 28, 1996.
GRAPHIC SCALE
0 20 40 80 120 160 240
REV
REVISION DESCRIPTION
PREPARED
CHECKED
APPROVED
DATE
BROOKLYN UNION GAS COMPANY
FORMER BROOKLYN BOROUGH GAS WORKS SITE
FIGURE 5-1
COAL TAR SOURCE EXCAVATION AREAS
FOSTER WHEELER ENVIRONMENTAL CORPORATION
LIVINGSTON, NEW JERSEY
DEPT CE
DESIGNED
PREPARED J.R.
CHECKED
APPROVED
DATE
SCALE: 1"=60'-0"
DRAWING NUMBER:
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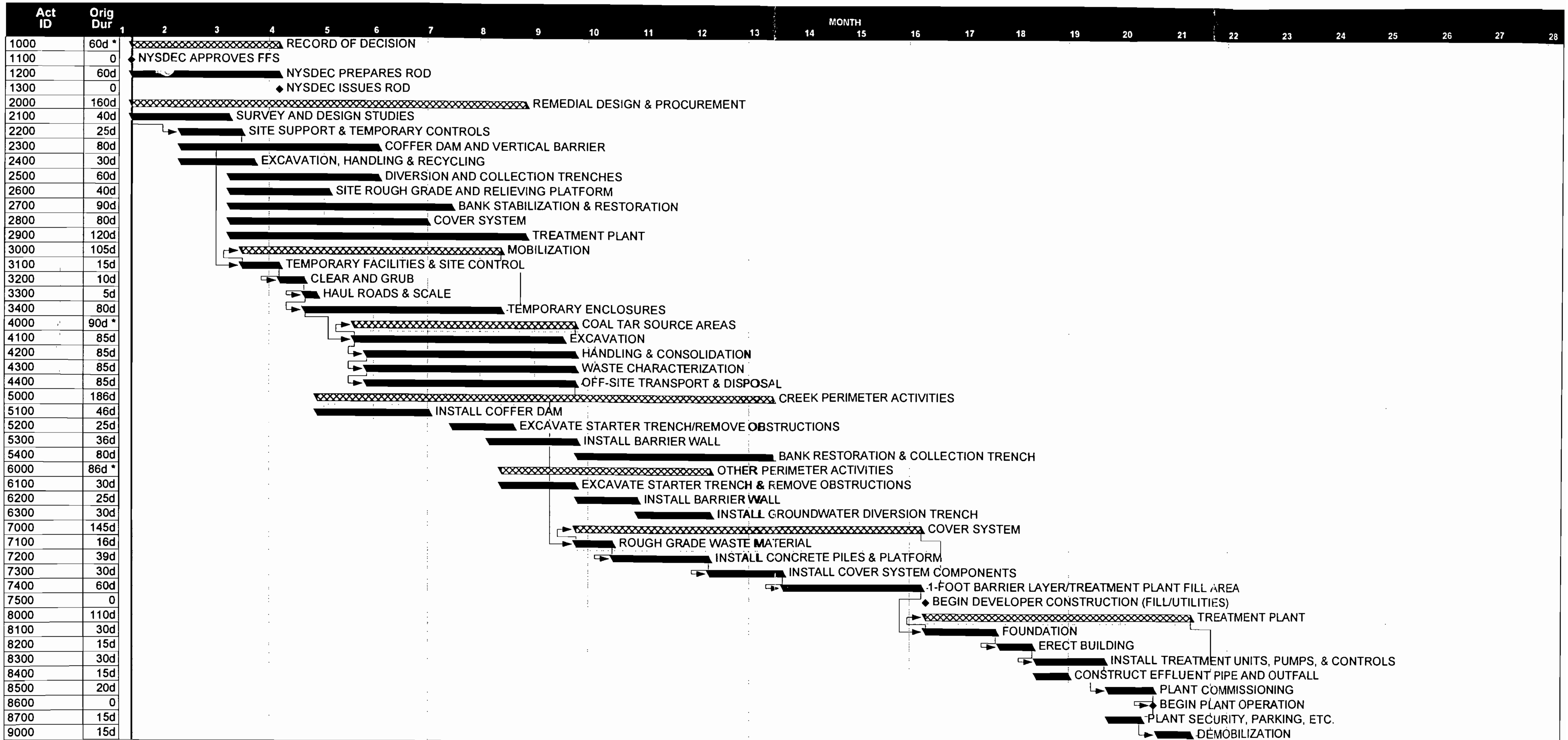

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Finish date	09JUN00
Data date	15OCT98
Run date	22OCT98
Page number	1A

BROOKLYN UNION GAS COMPANY
BROOKLYN BOROUGH GAS WORKS SITE
FFS REPORT

FIGURE 5-2
CONCEPTUAL DEVELOPMENT SCHEDULE

- Early bar
- ▼ Early start point
- ▲ Early finish point
- Progress bar
- Critical bar
- Summary bar
- ◆ Start milestone point
- ◆ Finish milestone point

APPENDIX A

COST ESTIMATES

TABLE A-1
PRESENT WORTH ANALYSIS FOR REMEDIAL ACTION ALTERNATIVES

Alternative	Description	Capital Cost ($)	Annual O&M ($)	Present Worth
1	No Action	$0	$253,000	$4,667,000
2	RBC excavation with discharge to Creek	$27,508,000	$550,000	$37,653,000
3	RBC excavation with discharge to POTW	$27,508,000	$631,000	$39,147,000
4	Source Area excavation with discharge to Creek	$16,295,000	$550,000	$26,440,000
5	Source Area excavation with discharge to POTW	$16,295,000	$631,000	$27,934,000

TABLE A-2
OPERATION AND MAINTENANCE COSTS FOR ALTERNATIVE 1

Item	Cost Component	Basis of Estimate	Year	Annual O&M Cost
1	**Semi-Annual Groundwater**			
	Performance Monitoring			
	Groundwater Sampling	2 people, $50/h, 10 h/day, 3 days/event, 2 events	1 thru 30	6000
	Laboratory Analysis	BTEX, PCB, metals, general H2O quality	1 thru 30	1600
	Report	1 person @ $90/h at 54 h/report, 2 reports/yr	1 thru 30	9720
2	**Site Security**	1 person, 24 h/day, 356 days/year, $25/h	1 thru 30	219000
3	**IRM Maintenance**			
	Labor	2 people, $50/h, 8 h/event, 1 event/month	1 thru 30	9600
	Miscellaneous Equipment & Expenses	$500/event	1 thru 30	6000
4	**Transport/Disposal of**	1 event/month, $1/gallon, 100 gallons/event	1 thru 30	1200
	Contaminated Liquid			
	SUBTOTAL ANNUAL O&M COST			**$253,000**
	PRESENT WORTH O & M	n=30, i=3.5%, P/A=18.446		**$4,667,000**

TABLE A-3
BASIS OF CONCEPTUAL COST ESTIMATE FOR ALTERNATIVES 2 AND 3

Area of Facility	16.4	Acre
Perimeter of facility	3600	LF
Duration of project	24	Month
Pre-Mobilization Activities		
Cost of topographic survey	$30,000.00	Each
Cost of geotechnical study	$250,000.00	Each
Cost of geophysical survey and modeling	$60,000.00	Each
Cost of remedial design	$750,000.00	Each
Cost of permits and engineering support	$50,000.00	Each
Mobilization Activities		
Security fence requiring repair	100	LF
Amount of road requiring repair	250	LF
Additional entry gates required	1	Each
Areas requiring clearing and grubbing	65000	SF
Areas requiring site improvement	22000	SF
Number of trailers required	3	Each
Spacing of construction dewatering wells	45	LF
Depth of each construction dewatering well	30	LF
Amount of debris requiring disposal	4	Cu. Yd.
Number of concrete pads to be used	3	Each
Amount of damaged concrete	62	LF
Perimeter of concrete pads	750	LF
Number of pieces of material handling equipment	3	Each
Number of enclosures required for material handling	1	Each
Amount of additional road required	750	LF
Number of pieces of excavation equipment required	3	Each
Excavation Activities - RBC Excavation Areas		
Number of enclosures required for excavation	1	Each
Material to be excavated	85000	Cu. Yd.
Capacity of transfer vehicle	22	Cu. Yd.
Stream Bank Excavation Activities		
Length of stream bank requiring excavation	1800	LF
Depth of penetration of coffer dam	40	LF
Depth of stream bank excavation	15	LF
Thickness of groundwater layer	6	LF
Depth to groundwater	4	LF
Length of collection trench to be installed	1800	LF
Width of vegetative buffer zone	50	LF
Number of enclosures required for stream bank excavation	1	Each
Perimeter Barrier Wall Activities		
Number of enclosures required for barrier wall activities	1	Each
Depth to impermeable stratum	25	LF
Thickness of groundwater layer	16	LF
Length of steel sheet pile barrier wall to be installed	3600	LF
Length of external perimeter drain to be installed	1800	LF
Cover System Construction Activities		
Thickness of backfill layer	2	LF
Thickness of soil cover layer	6	LF
Required depth of soil to be compacted	45	LF
Area of proposed buildings	75000	SF
Number of concrete piles to be installed	40	Each
Diameter of piles to be installed	10	LF
Depth of piles to be installed	20	LF
Area of proposed concrete relieving platform	90000	SF
Thickness of proposed concrete relieving platform	1	LF
Area of buffer zone	2	Acre
Thickness of top soil layer in buffer zone	2	LF

TABLE A-4
SUMMARY OF CONCEPTUAL CAPITAL COST ESTIMATES FOR ALTERNATIVES 2 AND 3

REMEDIAL ACTIVITY		ESTIMATED COST
Cost for remedial design activities:		$1,110,000
Cost for mobilization/demobilization (10% of construction):		$2,083,949
Cost for RBC excavation area removal activities:		$1,433,769
Cost for stream bank excavation and stabilization activities:		$1,834,956
Cost for perimeter barrier wall installation activities:		$1,232,436
Cost for construction of fill on cover system:		$4,040,245
Cost for off-site soil recycling:		$10,703,080
Cost for groundwater treatment and discharge:		$485,000
	Cost:	$22,923,435
	Health & Safety @ 3%	$687,703
	Construction Oversite @ 2%	$458,469
	15% Contingency:	$3,438,515
	Total Cost:	$27,508,000

TABLE A-5
CONCEPTUAL CAPITAL COST ESTIMATE BREAKDOWN FOR ALTERNATIVES 2 AND 3

PRE-MOBILIZATION ACTIVITES

Item	Quantity	Unit	Unit Cost	Adjusted Unit Cost	Total Cost
Topographic survey	1	LS	$30,000	$30,000	$30,000
Geotechnical study	1	LS	$250,000	$250,000	$250,000
Geophysical survey and modeling	1	LS	$60,000	$60,000	$60,000
Remedial design	1	LS	$750,000	$750,000	$750,000
Permits (engineering support and administrative fees)	1	LS	$50,000	$50,000	$50,000
				Total Cost for Pre-mobilization Activities:	$1,110,000

RBC EXCAVATION ACTIVITIES

Item	Quantity	Unit	Unit Cost	Adjusted Unit Cost	Total Cost
Materials handling temporary enclosure					
Construct temporary overhead structures	1	Each	$84,000.00	$84,000.00	$84,000
Install odor control ventilation system	1	Each	$5,000.00	$5,000.00	$5,000
Rental of temporary overhead structure	12	Month	$8,500.00	$8,500.00	$102,000
Source area removal					
Excavate soil and coal tar source material	85,000	Cu. Yd.	$4.15	$4.15	$352,750
Transfer material via covered vehicles					
Transfer to material handling area	102,000	Cu. Yd.	$2.13	$2.13	$217,260
Transfer material via covered conveyor belt system					
Mobilize conveyor system equipment	1	LS	$1,000.00	$1,000.00	$1,000
Construct conveyor belt from work area	750	LF	$115.00	$147.55	$110,659
Construct enclosure for conveyor belt	750	LF	$10.00	$10.00	$7,500
Backfill and compaction of excavations					
Backfill source areas with common fill	102,000	Cu. Yd.	$7.10	$7.10	$724,200
Compact common fill in source areas	102,000	Cu. Yd.	$0.20	$0.20	$20,400
				Total Cost for RBC Area Excavation Activities:	$1,433,769

TABLE A-5
CONCEPTUAL CAPITAL COST ESTIMATE BREAKDOWN FOR ALTERNATIVES 2 AND 3

STREAM BANK EXCAVATION AND STABILIZATION

Item	Quantity	Unit	Unit Cost	Adjusted Unit Cost	Total Cost
Install coffer dam and waterside tracks					
Rent pile driving equipment	72	Day	$2,200.00	$2,822.60	$203,227
Install sheet piles	72,000	SF	$11.95	$11.95	$860,400
Fabricate track system	1,800	LF	$17.25	$17.25	$31,050
Install landside tracks					
Install single railroad track	1,800	LF	$17.25	$17.25	$31,050
Temporary enclosure					
Construct temporary enclosure (stream excavation)	1	Each	$84,000.00	$84,000.00	$84,000
Install odor control ventilation system	1	Each	$5,000.00	$5,000.00	$5,000
Rental of temporary enclosure (stream excavation)	12	Month	$8,500.00	$8,500.00	$102,000
Removal and transfer of stream bank soil					
Excavate soil and timber bulkhead	25,000	Cu. Yd.	$10.85	$10.85	$271,250
Transfer to material handling area	6,250	Cu. Yd.	$2.13	$2.13	$13,313
Place compacted fill for excavation equipment					
Place structural fill	25,000	Cu. Yd.	$2.22	$2.22	$55,500
Compact structural fill	25,000	Cu. Yd.	$0.20	$0.20	$5,000
Install collection trench					
Excavate trench soil	1,667	Cu. Yd.	$2.94	$2.94	$4,900
Transfer to material handling area	2,000	Cu. Yd.	$2.13	$2.13	$4,260
Install NAPL collection system					
Place bedding material	83	Cu. Yd.	$11.10	$11.10	$925
Place geotextile filter	30,600	SF	$0.16	$0.16	$5,032
Install piping	1,800	LF	$52.80	$67.74	$121,936
Wrap pipe in geotextile	12,600	SF	$0.16	$0.16	$2,072
Install manholes	9	Each	$1,345.00	$1,345.00	$12,105
Place granular fill layer	1,000	Cu. Yd.	$20.00	$20.00	$20,000
Backfill trenches	800	Cu. Yd.	$2.22	$2.22	$1,776
Compact trenches	800	Cu. Yd.	$0.20	$0.20	$160
				Total Cost for Stream Bank Excavation and Stabilization Activities:	$1,834,956

TABLE A-5
CONCEPTUAL CAPITAL COST ESTIMATE BREAKDOWN FOR ALTERNATIVES 2 AND 3

PERIMETER BARRIER WALL

Item	Quantity	Unit	Unit Cost	Adjusted Unit Cost	Total Cost
Install steel sheet pile wall	90,000	SF	$11.95	$11.95	$1,075,500
Install upgradient external perimeter drain					
Excavate trench soil	4,167	Cu Yd	$2.94	$2.94	$12,250
Transfer to material handling area	5,000	Cu Yd	$2.13	$2.13	$10,650
Install piping	1,800	LF	$52.80	$67.74	$121,936
Backfill and compact trench	5,000	Cu Yd	$2.42	$2.42	$12,100
				Total Cost for Perimeter Barrier Wall Activities:	$1,232,436

COVER SYSTEM

Item	Quantity	Unit	Unit Cost	Adjusted Unit Cost	Total Cost
Relieving Platform System					
Mobilization / demobilization of compaction equipment	1	LS	$9,500.00	$9,500.00	$9,500
Perform compaction of soil	125,000	Cu. Yd.	$0.20	$0.20	$25,000
Install excavated concrete piles	40	Each	$2,500.00	$2,500.00	$100,000
Transfer contaminated cuttings to soil treatment area	559	Cu. Yd.	$2.13	$2.13	$1,190
Disposal of contaminated cuttings	894	Ton	$150.00	$150.00	$134,041
Regrade acceptable cuttings	2,234	Cu. Yd.	$1.88	$1.88	$4,200
Install concrete relieving platform	3,333	Cu. Yd.	$12.50	$12.50	$41,667
Cover System					
Excavate anchor trench	3,600	LF	$0.76	$0.76	$2,736
Place fabric bedding	714,384	SF	$0.16	$0.16	$117,476
Place gas collection layer	79,376	SY	$5.00	$5.00	$396,880
Place 60-mil HDPE liner	714,384	SF	$1.53	$1.53	$1,093,008
Place fabric bedding	714,384	SF	$0.16	$0.16	$117,476
Place drainage layer	79,376	SY	$5.00	$5.00	$396,880
Install drainage layer perimeter piping	1,800	LF	$52.80	$67.74	$121,936
Place soil cover layer	158,752	Cu. Yd.	$7.10	$7.10	$1,127,139
Backfill and compact anchor trench	3,600	LF	$2.09	$2.09	$7,524
40 ft. monitoring wells @ 300-ft. centers	6	Each	$5,000.00	$5,000.00	$30,000
Perimeter gas vents	13	Each	$4,100.00	$4,100.00	$53,300
Stabilize creek bank with riprap	3,480	Cu. Yd.	$36.00	$36.00	$125,284
Perimeter Buffer Zone					
Place top soil layer	6,453	Cu. Yd.	$18.80	$18.80	$121,323
Hydroseeding and mulch	87	1000 SF	$71.00	$71.00	$6,186
Trees and shrubs	1	LS	$7,500.00	$7,500.00	$7,500
				Total Cost for Cover System Activities:	$4,040,245

TABLE A-5
CONCEPTUAL CAPITAL COST ESTIMATE BREAKDOWN FOR ALTERNATIVES 2 AND 3

OFF-SITE SOIL RECYCLING

Item	Quantity	Unit	Unit Cost	Adjusted Unit Cost	Total Cost
Maximum particle size criteria					
Option 1 - Remove oversized material					
Mobilize appropriate shaker screen	1	LS	$6,500.00	$6,500.00	$6,500
Process material in shaker screen	136,000	Ton	$1.75	$1.75	$238,000
Sample oversized material	1	LS	$1,700,000.00	$1,700,000.00	$1,700,000
T&D of oversized material at landfill	13,600	Ton	$35.00	$35.00	$476,000
Option 2 - Reduce material size					
Mobilize crushing equipment	1	LS	$12,000.00	$12,000.00	$12,000
Treat material in crushing equipment	13,600	Ton	$3.75	$3.75	$51,000
Toxicity Criteria					
Mobilize soil blending equipment (pug mill)	1	LS	$2,500.00	$2,500.00	$2,500
Blend materials	32,000	Ton	$7.50	$7.50	$240,000
Transport & Disposal					
Sample at required frequency	102,000	Cu. Yd.	$10.00	$10.00	$1,020,000
Load trucks (20 yards per truck)	102,000	Cu. Yd.	$1.54	$1.54	$157,080
T&D of material	136,000	Ton	$50.00	$50.00	$6,800,000
				Total Cost for Off-Site Soil Recycling Activities:	$10,703,080

TREATMENT AND DISCHARGE OF COLLECTED NAPL

Item	Quantity	Unit	Unit Cost	Adjusted Unit Cost	Total Cost
Prepare treatment building area					
Construct building foundation	1	LS	$280,000.00	$280,000.00	$280,000
Construct pre-engineered building	2,000	SF	$95.00	$95.00	$190,000
Construct treatment system (Refer to Table A-9)	1	LS	$783,000	$783,000	$783,000
Discharge treated effluent					
Connect system to POTW or build outfall pipe to Creek	1	LS	$15,000.00	$15,000.00	$15,000
				Total Cost for NAPL Treatment and Discharge Activities:	$485,000

TABLE A-6
BASIS OF CONCEPTUAL COST ESTIMATE FOR ALTERNATIVES 4 AND 5

Area of Facility	16.4	Acre
Perimeter of facility	3600	LF
Duration of project	20	Month
Pre-Mobilization Activities		
Cost of topographic survey	$30,000.00	Each
Cost of geotechnical study	$250,000.00	Each
Cost of geophysical survey and modeling	$60,000.00	Each
Cost of remedial design	$750,000.00	Each
Cost of permits and engineering support	$50,000.00	Each
Mobilization Activities		
Security fence requiring repair	100	LF
Amount of road requiring repair	250	LF
Additional entry gates required	1	Each
Areas requiring clearing and grubbing	65000	SF
Areas requiring site improvement	22000	SF
Number of trailers required	3	Each
Spacing of construction dewatering wells	45	LF
Depth of each construction dewatering well	30	LF
Amount of debris requiring disposal	4	Cu. Yd.
Number of concrete pads to be used	3	Each
Amount of damaged concrete	62	LF
Perimeter of concrete pads	750	LF
Number of pieces of material handling equipment	3	Each
Number of enclosures required for material handling	1	Each
Amount of additional road required	750	LF
Number of pieces of excavation equipment required	3	Each
Excavation Activities - Coal Tar Source Excavation Areas		
Number of enclosures required for excavation	1	Each
Material to be excavated	22000	Cu. Yd.
Capacity of transfer vehicle	22	Cu. Yd.
Stream Bank Excavation Activities		
Length of stream bank requiring excavation	1800	LF
Depth of penetration of coffer dam	40	LF
Depth of stream bank excavation	15	LF
Thickness of groundwater layer	6	LF
Depth to groundwater	4	LF
Length of collection trench to be installed	1800	LF
Width of vegetative buffer zone	50	LF
Number of enclosures required for stream bank excavation	1	Each
Perimeter Barrier Wall Activities		
Number of enclosures required for barrier wall activities	1	Each
Depth to impermeable stratum	25	LF
Thickness of groundwater layer	16	LF
Length of steel sheet pile barrier wall to be installed	3600	LF
Length of external perimeter drain to be installed	1800	LF
Cover System Construction Activities		
Thickness of backfill layer	2	LF
Thickness of soil cover layer	6	LF
Required depth of soil to be compacted	45	LF
Area of proposed buildings	75000	SF
Number of concrete piles to be installed	40	Each
Diameter of piles to be installed	10	LF
Depth of piles to be installed	20	LF
Area of proposed concrete relieving platform	90000	SF
Thickness of proposed concrete relieving platform	1	LF
Area of buffer zone	2	Acre
Thickness of top soil layer in buffer zone	2	LF

TABLE A-7
SUMMARY OF CONCEPTUAL CAPITAL COST ESTIMATES FOR ALTERNATIVES 4 AND 5

REMEDIAL ACTIVITY	ESTIMATED COST
Cost for remedial design activities:	$1,110,000
Cost for mobilization/demobilization (10% of construction):	$1,234,487
Cost for Coal Tar Source excavation area removal activities:	$450,039
Cost for stream bank excavation and stabilization activities:	$2,063,490
Cost for perimeter barrier wall installation activities:	$1,232,436
Cost for construction of fill on cover system:	$4,040,245
Cost for off-site soil recycling:	$2,963,656
Cost for groundwater treatment and discharge:	$485,000
Cost:	$13,579,353
Health & Safety @ 3%	$407,381
Construction Oversite @ 2%	$271,587
15% Contingency:	$2,036,903
Total Cost:	$16,295,000

TABLE A-8
CONCEPTUAL CAPITAL COST ESTIMATE BREAKDOWN FOR ALTERNATIVES 4 AND 5

PRE-MOBILIZATION ACTIVITES

Item	Quantity	Unit	Unit Cost	Adjusted Unit Cost	Total Cost
Topographic survey	1	LS	$30,000	$30,000	$30,000
Geotechnical study	1	LS	$250,000	$250,000	$250,000
Geophysical survey and modeling	1	LS	$60,000	$60,000	$60,000
Remedial design	1	LS	$750,000	$750,000	$750,000
Permits (engineering support and administrative fees)	1	LS	$50,000	$50,000	$50,000
				Total Cost for Pre-mobilization Activities:	$1,110,000

COAL TAR SOURCE AREA EXCAVATION ACTIVITIES

Item	Quantity	Unit	Unit Cost	Adjusted Unit Cost	Total Cost
Materials handling temporary enclosure					
Construct temporary overhead structures	1	Each	$84,000.00	$84,000.00	$84,000
Install odor control ventilation system	1	Each	$5,000.00	$5,000.00	$5,000
Rental of temporary overhead structure	9	Month	$8,500.00	$8,500.00	$76,500
Source area removal					
Excavate coal tar source material	22,000	Cu. Yd.	$4.15	$4.15	$91,300
Transfer material via covered vehicles					
Transfer to material handling area	22,000	Cu. Yd.	$2.13	$2.13	$46,860
Transfer material via covered conveyor belt system					
Mobilize conveyor system equipment	1	LS	$1,000.00	$1,000.00	$1,000
Construct conveyor belt from work area	750	LF	$115.00	$147.55	$110,659
Construct enclosure for conveyor belt	750	LF	$10.00	$10.00	$7,500
Backfill and compaction of excavations					
Backfill source areas with common fill	26,400	Cu. Yd.	$7.10	$7.10	$187,440
Compact common fill in source areas	26,400	Cu. Yd.	$0.20	$0.20	$5,280
				Total Cost for RBC Area Excavation Activities:	$450,039

TABLE A-8
CONCEPTUAL CAPITAL COST ESTIMATE BREAKDOWN FOR ALTERNATIVES 4 AND 5

STREAM BANK EXCAVATION AND STABILIZATION

Item	Quantity	Unit	Unit Cost	Adjusted Unit Cost	Total Cost
Install coffer dam and waterside tracks					
Rent pile driving equipment	162	Day	$2,200.00	$2,822.60	$457,261
Install sheet piles	72,000	SF	$11.95	$11.95	$860,400
Fabricate track system	1,800	LF	$17.25	$17.25	$31,050
Install landside tracks					
Install single railroad track	1,800	LF	$17.25	$17.25	$31,050
Temporary enclosure					
Construct temporary enclosure (stream excavation)	1	Each	$84,000.00	$84,000.00	$84,000
Install odor control ventilation system	1	Each	$5,000.00	$5,000.00	$5,000
Rental of temporary enclosure (stream excavation)	9	Month	$8,500.00	$8,500.00	$76,500
Removal and transfer of stream bank soil					
Excavate soil and timber bulkhead	25,000	Cu. Yd.	$10.85	$10.85	$271,250
Transfer to material handling area	6,250	Cu. Yd.	$2.13	$2.13	$13,313
Place compacted fill for excavation equipment					
Place structural fill	25,000	Cu. Yd.	$2.22	$2.22	$55,500
Compact structural fill	25,000	Cu. Yd.	$0.20	$0.20	$5,000
Install collection trench					
Excavate trench soil	1,667	Cu. Yd.	$2.94	$2.94	$4,900
Transfer to material handling area	2,000	Cu. Yd.	$2.13	$2.13	$4,260
Install NAPL collection system					
Place bedding material	83	Cu. Yd.	$11.10	$11.10	$925
Place geotextile filter	30,600	SF	$0.16	$0.16	$5,032
Install piping	1,800	LF	$52.80	$67.74	$121,936
Wrap pipe in geotextile	12,600	SF	$0.16	$0.16	$2,072
Install manholes	9	Each	$1,345.00	$1,345.00	$12,105
Place granular fill layer	1,000	Cu. Yd.	$20.00	$20.00	$20,000
Backfill trenches	800	Cu. Yd.	$2.22	$2.22	$1,776
Compact trenches	800	Cu. Yd.	$0.20	$0.20	$160
				Total Cost for Stream Bank Excavation and Stabilization Activities:	$2,063,490

TABLE A-8
CONCEPTUAL CAPITAL COST ESTIMATE BREAKDOWN FOR ALTERNATIVES 4 AND 5

PERIMETER BARRIER WALL

Item	Quantity	Unit	Unit Cost	Adjusted Unit Cost	Total Cost
Install steel sheet pile wall	90,000	SF	$11.95	$11.95	$1,075,500
Install upgradient external perimeter drain					
Excavate trench soil	4,167	Cu Yd	$2.94	$2.94	$12,250
Transfer to material handling area	5,000	Cu Yd	$2.13	$2.13	$10,650
Install piping	1,800	LF	$52.80	$67.74	$121,936
Backfill and compact trench	5,000	Cu Yd	$2.42	$2.42	$12,100
				Total Cost for Perimeter Barrier Wall Activities:	$1,232,436

COVER SYSTEM

Item	Quantity	Unit	Unit Cost	Adjusted Unit Cost	Total Cost
Relieving Platform System					
Mobilization / demobilization of compaction equipment	1	LS	$9,500.00	$9,500.00	$9,500
Perform compaction of soil	125,000	Cu. Yd.	$0.20	$0.20	$25,000
Install excavated concrete piles	40	Each	$2,500.00	$2,500.00	$100,000
Transfer contaminated cuttings to soil treatment area	559	Cu. Yd.	$2.13	$2.13	$1,190
Disposal of contaminated cuttings	894	Ton	$150.00	$150.00	$134,041
Regrade acceptable cuttings	2,234	Cu. Yd.	$1.88	$1.88	$4,200
Install concrete relieving platform	3,333	Cu. Yd.	$12.50	$12.50	$41,667
Cover System					
Excavate anchor trench	3,600	LF	$0.76	$0.76	$2,736
Place fabric bedding	714,384	SF	$0.16	$0.16	$117,476
Place gas collection layer	79,376	SY	$5.00	$5.00	$396,880
Place 60-mil HDPE liner	714,384	SF	$1.53	$1.53	$1,093,008
Place fabric bedding	714,384	SF	$0.16	$0.16	$117,476
Place drainage layer	79,376	SY	$5.00	$5.00	$396,880
Install drainage layer perimeter piping	1,800	LF	$52.80	$67.74	$121,936
Place soil cover layer	158,752	Cu. Yd.	$7.10	$7.10	$1,127,139
Backfill and compact anchor trench	3,600	LF	$2.09	$2.09	$7,524
40 ft. monitoring wells @ 300-ft. centers	6	Each	$5,000.00	$5,000.00	$30,000
Perimeter gas vents	13	Each	$4,100.00	$4,100.00	$53,300
Stabilize creek bank with riprap	3,480	Cu. Yd.	$36.00	$36.00	$125,284
Perimeter Buffer Zone					
Place top soil layer	6,453	Cu. Yd.	$18.80	$18.80	$121,323
Hydroseeding and mulch	87	1000 SF	$71.00	$71.00	$6,186
Trees and shrubs	1	LS	$7,500.00	$7,500.00	$7,500
				Total Cost for Cover System Activities:	$4,040,245

TABLE A-8
CONCEPTUAL CAPITAL COST ESTIMATE BREAKDOWN FOR ALTERNATIVES 4 AND 5

OFF-SITE SOIL RECYCLING

Item	Quantity	Unit	Unit Cost	Adjusted Unit Cost	Total Cost
Maximum particle size criteria					
Option 1 - Remove oversized material					
Mobilize appropriate shaker screen	1	LS	$6,500.00	$6,500.00	$6,500
Process material in shaker screen	35,200	Ton	$1.75	$1.75	$61,600
Sample oversized material	1	LS	$440,000.00	$440,000.00	$440,000
T&D of oversized material at landfill	3,520	Ton	$35.00	$35.00	$123,200
Option 2 - Reduce material size					
Mobilize crushing equipment	1	LS	$12,000.00	$12,000.00	$12,000
Treat material in crushing equipment	3,520	Ton	$3.75	$3.75	$13,200
Toxicity Criteria					
Mobilize soil blending equipment (pug mill)	1	LS	$2,500.00	$2,500.00	$2,500
Blend materials	32,000	Ton	$7.50	$7.50	$240,000
Transport & Disposal					
Sample at required frequency	26,400	Cu. Yd.	$10.00	$10.00	$264,000
Load trucks (20 yards per truck)	26,400	Cu. Yd.	$1.54	$1.54	$40,656
T&D of material	35,200	Ton	$50.00	$50.00	$1,760,000
				Total Cost for Off-Site Soil Recycling Activities:	$2,963,656

TREATMENT AND DISCHARGE OF COLLECTED NAPL

Item	Quantity	Unit	Unit Cost	Adjusted Unit Cost	Total Cost
Prepare treatment building area					
Construct building foundation	1	LS	$280,000.00	$280,000.00	$280,000
Construct pre-engineered building	2,000	SF	$95.00	$95.00	$190,000
Construct treatment system (Refer to Table A-9)	1	LS	$783,000	$783,000	$783,000
Discharge treated effluent					
Connect system to POTW or build outfall pipe to Creek	1	LS	$15,000.00	$15,000.00	$15,000
				Total Cost for NAPL Treatment and Discharge Activites:	$485,000

TABLE A-9
DETAILED BREAKDOWN OF NAPL TREATMENT PLANT CONCEPTUAL CAPITAL COSTS

Facility/Construction	Quantity	Unit	Material, $ Unit Price	Material, $ Cost	Installation, $ Unit Price	Installation, $ Cost	Construction Cost, $
I. Pumping and Collection System							
1. Submersible/Sump Pumps	12	each	$ 2,500.00	$ 30,000	$ 750.00	$ 9,000	$ 39,000
2. Collection / Equalization Tank (13k - CS)	1	each	$ 15,000.00	$ 15,000	$ 2,500.00	$ 2,500	$ 17,500
3. Piping / Valving	4200	LF	INCL	INCL	$ 17.50	$ 73,500	$ 73,500
4. Wrought Iron Perimeter Fence	2400	LF	INCL	INCL	$ 150.00	$ 360,000	$ 360,000
5. Chain Link Fence w/ barbed wire	400	LF	INCL	INCL	$ 20.00	$ 8,000	$ 8,000
II. Precipitation / Separation / Filtration							
1. NaOH Feed System							
1) Feed Tank (500 gal CS)	1	each	$ 2,500.00	$ 2,500	$ 1,200.00	$ 1,200	$ 3,700
2. CPI Phase Separator	1	each	$ 8,500.00	$ 8,500	$ 2,000.00	$ 2,000	$ 10,500
3. Sand Filter	1	each	$ 36,000.00	$ 36,000	$ 8,000.00	$ 8,000	$ 44,000
III. Air Stripping System							
1. Air Stripping Tower	1	each	$ 15,000.00	$ 15,000	$ 3,000.00	$ 3,000	$ 18,000
IV. Activated Carbon Adsorp. System							
1. Vapor Carbon Unit for off-gas	2	each	$ 8,500.00	$ 17,000	$ 1,000.00	$ 2,000	$ 19,000
2. Liquid Carbon Unit	2	each	$ 12,000.00	$ 24,000	$ 2,000.00	$ 4,000	$ 28,000
V. Miscellaneous							
1. Pumps							
1) NaOH Feed Pump	1	each	$ 2,400.00	$ 2,400	$ 500.00	$ 500	$ 2,900
2) CPI Feed Pump	1	each	$ 5,750.00	$ 5,750	$ 1,500.00	$ 1,500	$ 7,250
3) Metals/DNAPL Discharge Pump	1	each	$ 2,800.00	$ 2,800	$ 750.00	$ 750	$ 3,550
4) Pump to Liquid Carbon Unit	1	each	$ 3,500.00	$ 3,500	$ 750.00	$ 750	$ 4,250
5) Pump to Treated GW Tank	1	each	$ 3,500.00	$ 3,500	$ 750.00	$ 750	$ 4,250
2. Air compressor	1	each	$ 6,500.00	$ 6,500	$ 1,400.00	$ 1,400	$ 7,900
3. Oil Removal Tank	1	each	$ 3,900.00	$ 3,900	$ 750.00	$ 750	$ 4,650
4. Metals/DNAPL Tank	1	each	$ 5,500.00	$ 5,500	$ 1,200.00	$ 1,200	$ 6,700
5. Treated Groundwater Tank	1	each	$ 5,500.00	$ 5,500	$ 1,200.00	$ 1,200	$ 6,700
6. Process Control System	1	each	$ 50,000.00	$ 50,000	$16,000.00	$ 16,000	$ 66,000
7. Instruments	22	each	$ 2,800.00	$ 31,600	$ 1,456.00	$ 16,432	$ 48,032
TOTAL CAPITAL COST							**$783,000**

* Note: unless installation costs were noted on vendor price quotes, the installation was calculated as a percentage of the capital cost, as follows:
fencing = 33%
storage tanks = 96%
pumps/compressors = 67%
all other equipment = 52%

(Based on Chemical Engineering. Guthrie)

TABLE A-10
OPERATION AND
MAINTENANCE COSTS FOR ALTERNATIVES 2 AND 4

Item	Cost Component	Basis of Estimate	Year	Annual O&M Cost
1	**Semi-Annual Groundwater**			
	Performance Monitoring			
	Groundwater Sampling	2 people, $50/h, 10 h/day, 3 days/event, 2 events	1 thru 30	$ 6,000.00
	Laboratory Analysis	BTEX, PCB, metals, general water quality	1 thru 30	$ 9,600.00
	Report	1 person @ $90/h at 54 h/report, 2 reports/yr	1 thru 30	$ 9,720.00
1A	**Quarterly Discharge Monitoring**			
	for Permit Compliance			
	Effluent Sampling	included in system ops.		
	Laboratory Analysis	BTEX, PCB, metals, general water quality	1 thru 30	$ 3,200.00
	Report	included in system ops.		
2	**Pumping and Collection**			
	System			
	Power for 12 submersible pumps	15 HP, $0.10 / KW-h	1 thru 30	$ 120,000.00
3	**Precipitation / Separation /**			
	Filtration			
	NaOH supply	$0.25/lb, 0.5 lb/hr	1 thru 30	$ 1,100.00
4	**Air Stripping System**			
	Power for Blower	7.5 HP, $0.10 / KW-h	1 thru 30	$ 5,000.00
5	**Activated Carbon Adsorption**			
	System			
	Vapor phase carbon replacement	2 units, 118 lb/day, $2.25/lb, 13 change-outs/yr	1 thru 30	$ 117,000.00
	Liquid phase carbon replacement	2 units, 84 lb/day, $2.25/lb, 8 change-outs/yr	1 thru 30	$ 90,000.00
6	**Miscellaneous**			
	Electric power for:			
	NaOH Feed Pump	1 HP, $0.10 / KW-h	1 thru 30	$ 660.00
	CPI Feed Pump	5 HP, $0.10 / KW-h	1 thru 30	$ 3,300.00
	Pump to Liquid Carbon Unit	3 HP, $0.10 / KW-h	1 thru 30	$ 1,980.00
	Pump to Treated GW Tank	3 HP, $0.10 / KW-h	1 thru 30	$ 1,980.00
	Air Compressor	15 HP, $0.10 / KW-h	1 thru 30	$ 9,900.00
	Process Control System & Instruments	$0.10 / KW-h	1 thru 30	$ 250.00
	Disposal of LNAPL	500 gal/month, $1.00/gal	1 thru 30	$ 6,000.00
	Disposal of Sludge/DNAPL	500 gal/month, $1.00/gal	1 thru 30	$ 6,000.00
7	**Maintenance Cost**			
	Building & Equipment	5% of Capital Cost	1 thru 30	$ 39,150.00
	Other Remedial Systems	1% of Capital Cost	1 thru 30	$ 58,796.22
8	**Labor**	$30/h, 8 h/day, 250 days/yr	1 thru 30	$ 60,000.00
	SUBTOTAL ANNUAL O&M COST			**$550,000**
	PRESENT WORTH O & M	n=30, i=3.5%, P/A=18.446		**$10,145,000**

Estimate.xls O&M - Alternatives 2 & 4
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TABLE A-11
OPERATION AND MAINTENANCE COSTS FOR ALTERNATIVES 3 AND 5

Item	Cost Component	Basis of Estimate	Year	Annual O&M Cost
1	**Semi-Annual Groundwater**			
	Performance Monitoring			
	Groundwater Sampling	2 people, $50/h, 10 h/day, 3 days/event, 2 events	1 thru 30	$ 6,000.00
	Laboratory Analysis	BTEX, PCB, metals, general water quality	1 thru 30	$ 9,600.00
	Report	1 person @ $90/h at 54 h/report, 2 reports/yr	1 thru 30	$ 9,720.00
1A	**Quarterly Discharge Monitoring**			
	for Permit Compliance			
	Effluent Sampling	included in system ops.		
	Laboratory Analysis	BTEX, PCB, metals, general water quality	1 thru 30	$ 3,200.00
	Report	included in system ops.		
2	**Pumping and Collection**			
	System			
	Power for 12 submersible pumps	15 HP, $0.10 / KW-h	1 thru 30	$ 120,000.00
3	**Precipitation / Separation /**			
	Filtration			
	NaOH supply	$0.25/lb, 0.5 lb/hr	1 thru 30	$ 1,100.00
4	**Air Stripping System**			
	Power for Blower	7.5 HP, $0.10 / KW-h	1 thru 30	$ 5,000.00
5	**Activated Carbon Adsorption**			
	System			
	Vapor phase carbon replacement	2 units, 118 lb/day, $2.25/lb, 13 change-outs/yr	1 thru 30	$ 117,000.00
	Liquid phase carbon replacement	2 units, 84 lb/day, $2.25/lb, 8 change-outs/yr	1 thru 30	$ 90,000.00
6	**Miscellaneous**			
	Electric power for:			
	NaOH Feed Pump	1 HP, $0.10 / KW-h	1 thru 30	$ 660.00
	CPI Feed Pump	5 HP, $0.10 / KW-h	1 thru 30	$ 3,300.00
	Pump to Liquid Carbon Unit	3 HP, $0.10 / KW-h	1 thru 30	$ 1,980.00
	Pump to Treated GW Tank	3 HP, $0.10 / KW-h	1 thru 30	$ 1,980.00
	Air Compressor	15 HP, $0.10 / KW-h	1 thru 30	$ 9,900.00
	Process Control System & Instruments	$0.10 / KW-h	1 thru 30	$ 250.00
	Disposal of LNAPL	500 gal/month, $1.00/gal	1 thru 30	$ 6,000.00
	Disposal of Sludge/DNAPL	3200 gal/month, $1.00/gal	1 thru 30	$ 6,000.00
	POTW Discharge Fee	50 gpm, $3/1000 gal	1 thru 30	$ 79,000.00
7	**Maintenance Cost**			
	Building & Equipment	5% of Capital Cost	1 thru 30	$ 39,150.00
	Other Remedial Systems	1% of Capital Cost	1 thru 30	$ 61,081.56
8	**Labor**	$30/h, 8 h/day, 250 days/yr	1 thru 30	$ 60,000.00
	SUBTOTAL ANNUAL O&M COST			**$631,000**
	PRESENT WORTH O & M	n=30, i=3.5%, P/A=18.446		**$11,639,000**