FINAL

FEASIBILITY STUDY WORK PLAN

Newark Bay Study Area

June 2017

Revision 1

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Acronyms and Abbreviations

AOC	Administrative Order on Consent
ARAR	applicable or relevant and appropriate requirement
(the) Bay	Newark Bay
BERA	Baseline Ecological Risk Assessment
BHHRA	Baseline Human Health Risk Assessment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COPC	constituent of potential concern
CRRNJ	Central Railroad of New Jersey
CSM	conceptual site model
CSO	combined sewer overflow
DQO	data quality objective
FS WP	Feasibility Study Work Plan
GSH	Glenn Springs Holdings, Inc.
HASCP	Health and Safety Contingency Plan
ICT	Identification of Candidate Technologies
LPRSA	Lower Passaic River Study Area
MLW	Mean Low Water
(the) Model	Lower Passaic River Study Area and Newark Bay Study Area Model
NBSA	Newark Bay Study Area
NGVD	National Geodetic Vertical Datum
NCP	National Contingency Plan
NJDEP	New Jersey Department of Environmental Protection
NOAA	National Oceanic and Atmospheric Administration
NY/NJ	New York/New Jersey
OSWER	Office of Solid Waste and Emergency Response
O&M	operation and maintenance
PAH	polycyclic aromatic hydrocarbon
PANYNJ	Port Authority of New York and New Jersey
PCB	polychlorinated biphenyl
PCDD	polychlorinated dibenzo-*p*-dioxin
PCDF	polychlorinated dibenzofuran

POTW	publicly owned treatment works
PRA	Probabilistic Risk Assessment
PRG	Preliminary Remediation Goal
RAO	Remedial Action Objective
RAS	Remedial Alternatives Screening
RI	Remedial Investigation
RI/FS	Remedial Investigation and Feasibility Study
ROD	Record of Decision
SOW	Statement of Work
SVOC	semivolatile organic compound
SWO	storm water outfall
Tierra	Tierra Solutions, Inc.
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
VOC	volatile organic compound

1 Introduction

Pursuant to the Administrative Order on Consent (AOC) CERCLA Index 02-2004-2010 (U.S. Environmental Protection Agency [USEPA] 2004) under the Comprehensive Environmental Response, Compensation, and Liability Act, a Remedial Investigation/Feasibility Study (RI/FS) is being conducted by Glenn Springs Holdings (GSH), on behalf of Occidental Chemical Corporation (the successor to Diamond Shamrock Chemicals Company [formerly known as Diamond Alkali Company]) within the Newark Bay Study Area (NBSA). The NBSA has been defined as the water column and sediments of Newark Bay (also called the Bay) and portions of the Hackensack River, Arthur Kill, and Kill van Kull, hereafter referred to as the "Site" (USEPA 2004) (Figure 1-1 and 1-2). As outlined in the AOC, since the Lower Passaic River Study Area (LPRSA) and the NBSA are hydrodynamically linked waterbodies, the RI/FS for Newark Bay must be conducted consistently with the CERCLA components of the Lower Passaic River Restoration Project. In addition, the Settling Parties[1] for the LPRSA are obligated, through a separate AOC[2], to develop a Site-wide numerical model that simulates hydrodynamics, sediment transport, contaminant fate and transport, and bioaccumulation. This Site-wide model (Model) covers the 17-mile LPRSA and the NBSA. Following approval of the model by USEPA, the USEPA team will take the lead on the modeling and will work collaboratively with the GSH team to complete the RI and FS tasks (USEPA 2016b).

The purpose of the RI/FS is to characterize the nature and extent of chemical contamination, develop and evaluate appropriate remedial options, and gather necessary information to select an appropriate remedy for the Site. As part of this RI/FS process, this Feasibility Study Work Plan (FS WP) was prepared.

1.1 Regulatory Setting

This FS WP was developed in accordance with the *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (USEPA 1988) and the NBSA AOC Statement of Work (SOW) (USEPA 2004).

The FS will be conducted under the requirements of CERCLA and the National Contingency Plan (NCP) and consistent with the following documents:

- February 13, 2004 Administrative Order on Consent for Remedial Investigation and Feasibility Study for the Newark Bay Study Area (USEPA 2004)
- February 17, 2004 First Amendment to Administrative Order on Consent for Remedial Investigation and Feasibility Study for the Newark Bay Study Area (USEPA 2004)

[1] The parties who signed the LPRSA Administrative Settlement Agreement and Order on Consent to complete a Remedial Investigation/Feasibility Study under CERCLA

[2] Administrative Order on Consent (AOC). Administrative Settlement Agreement and Order on Consent for Remedial Investigation/Feasibility Study, USEPA Region 2, CERCLA Docket No. 02-2007-2009. May 8, 2007.

- March 18, 2010 Second Amendment to Administrative Order on Consent for Remedial Investigation and Feasibility Study for the Newark Bay Study Area (USEPA 2004)
- *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (USEPA 1988)
- *Contaminated Sediment Remediation Guidance for Hazardous Waste Sites* (USEPA 2005)
- *Principles for Managing Contaminated Sediment Risks at Hazardous Waste Sites* (USEPA 2002a)
- *A Guide for Preparing Superfund Proposed Plans, Records of Decision, and Other Remedy Selection Decision Documents* (USEPA 1999)
- *A Guide for Developing and Documenting Cost Estimates During the Feasibility Study* (USEPA 2000a)
- *A Risk Management Strategy for PCB-Contaminated Sediments* (NRC 2001)

The following documents will also be consulted during development of the Feasibility Study:

- *Contaminated Sediment Remediation: Remedy Selection for Contaminated Sediments* [Interstate Technology and Regulatory Council (ITRC), August 2014]
- *Climate Change Adaptation Technical Fact Sheet: Contaminated Sediment Remedies* (EPA 542-F-15-009, April 2015)
- *Institutional Controls: A Guide to Planning, Implementing, Maintaining, and Enforcing Institutional Controls at Contaminated Sites* (EPA 540-R-09-001, December 2012).
- *The Feasibility Study: Detailed Analysis of Remedial Action Alternatives* (EPA OSWER Directive 9355.3-01FS4, March 1990).

Additional documents may be used to guide the FS if deemed appropriate for use at the time the FS is written. Additional documents available at the USEPA internet site, "Superfund Contaminated Sediments: Guidance Documents, Fact Sheets and Policies," may be incorporated in the FS.

1.2 Feasibility Study Process

The FS will serve as the mechanism for the development, screening and detailed evaluation of alternative remedial actions (USEPA 1988). The data collected in the RI, including the findings of the baseline risk assessments, influences the development of remedial alternatives in the FS, which in turn affects the data needs and scope of any treatability study and additional field investigations. Because the data collected in the RI influences the development of remedial alternatives in the FS, the FS Report cannot be completed until the RI Report is approved, so the results of the RI and the baseline risk assessments can be incorporated into the evaluation of alternative remedial actions.

1.3 Document Organization

This document is organized in accordance with the *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (USEPA 1988) along with the additional guidance documents outlined in Section 1.1 and in accordance with the requirements for the FS provided in the AOC. During implementation of the NBSA FS, the final, agency-approved version of the *Feasibility Study Work Plan, Lower Passaic River Restoration Project* (Integral 2015) will be considered as an additional guide.

- Section 2 provides a summary of the physical settings and the Site history of the NBSA;
- Section 3 summarizes the identification of data uses and needs;
- Section 4 provides the technical approach and summarizes the key tasks for the FS;
- Section 5 summarizes the schedule for the FS along with the list of FS-related reports that will be produced as outlined in the SOW contained in the AOC; and
- Section 6 provides a list of references cited in this document and additional documents that may be used in the development of the FS.

1.4 USEPA Sediment Guidance for the Newark Bay Study Area

The *Contaminated Sediment Remediation Guidance for Hazardous Waste Sites* guidance document (USEPA 2005) will be used extensively as the FS-related reports are prepared. This guidance document provides technical and policy guidance for making risk management decisions for contaminated sediment sites.

1.4.1 Sediment Management Principles for the Newark Bay Study Area

The Office of Solid Waste and Emergency Response (OSWER) Directive 9285.6-08, *Principles for Managing Contaminated Sediment Risks at Hazardous Waste Sites* (USEPA 2002a), presents eleven risk management principles that help project managers make scientifically sound and nationally consistent risk management decisions at contaminated sediment sites. This guidance promotes an iterative decision-making process that evaluates the short-term and long-term risks of all potential cleanup alternatives consistent with the NCP's nine remedy selection criteria, discussed in Section 4.6 of this FS WP. These principles form the basic framework for the investigation and remedy selection process and will be applied within the framework of USEPA's existing statutory and regulatory requirements. While this directive applies to all contaminants at sediment sites addressed under CERCLA or RCRA, its implementation at the NBSA will be tailored based on the size and complexity of this site, to the magnitude of the site risk, and to the type of action contemplated.

1. <u>Control Sources Early</u> – The FS for the NBSA will consider known direct and indirect continuing sources of significant contamination to the sediments within the NBSA to help evaluate the potential for future recontamination of sediments when selecting a response action. Project managers will assess continuing sources that may be controlled and by what mechanism(s).

That assessment will include information/data developed through the CSO/SWO assessment for the NBSA, starting in spring 2017. There are potentially three investigation phases planned: acquisition and assessment of on-line and publicly available information, field verification, and CSO/SWO sampling. The conduct of each phase is dependent upon the result of its predecessor. Therefore, the only phase currently being executed, is the "Combined Sewer Overflow and Storm Water Outfall Characterization - Phase I: Reconnaissance Work Plan - Information Gathering". Other sources to be considered include permitted discharges, accidental releases, and inputs from tributaries. On September 15, 2006 Tierra Solutions, Inc. (Tierra) submitted the Newark Bay Study Area *Report on Investigation of Sources of Pollutants and Contaminants* (Tierra 2006). This document will be consulted as a starting point for the review of other sources and will be evaluated to determine if changes have occurred and if new information is available that would impact the FS. Each of these sources must be evaluated in terms of mass of contaminant input and risk to human health and the environment.

2. Involve the Community Early and Often – As outlined in the AOC, USEPA will prepare a community relations plan in accordance with USEPA guidance and the NCP. As requested by USEPA, information will be provided to support USEPA's community relations plan and any public meetings, which may be held or sponsored by USEPA to explain activities at or concerning the NBSA.

3. Coordinate with States, Local Governments, Tribes, and Natural Resource Trustees – The NBSA project team will coordinate with the USEPA Region 2, which in turn coordinates with the Partner Agencies (i.e., the United States Fish and Wildlife Service (USFWS), the National Oceanic and Atmospheric Administration (NOAA), the United States Army Corps of Engineers (USACE), the New Jersey Department of Environmental Protection (NJDEP) and local governments).

4. Develop and Refine a Conceptual Site Model that Considers Sediment Stability – The NBSA Conceptual Site Model (CSM) (Tierra 2013) contains a basic discussion of cohesive sediments and sediment stability. The CSM is an evolving document that qualitatively (and to some degree, quantitatively) describes the current understanding of the NBSA, including the inter-relationship between sources, contaminated media, and receptors in this complex and dynamic estuary. The pending 2017 update to the CSM will contain an expanded section on hydrodynamics, sediment transport, and sediment stability, that will include assessment of the following data collected in the NBSA: currents, water properties, sediment physical properties (including deposition rates/stability), erosion rate as determined by SedFlume testing conducted by USEPA, and changing morphology of the system (i.e., through natural and anthropogenic forces). These data will be used to develop and refine the CSM by considering sediment stability to make risk management decisions and select potential remedial alternatives to protect human health and the environment.

5. Use an Iterative Approach in a Risk-Based Framework – The NBSA FS will use an iterative and adaptive management approach that incorporates the results of the Baseline Human Health Risk Assessment (BHHRA), Baseline Ecological Risk Assessment (BERA), and the Probabilistic Risk Assessment (PRA) completed through the RI. The *Principles for Managing Contaminated Sediment Risks at Hazardous Waste Sites* document (USEPA 2002a) indicates "an iterative

approach is defined broadly to include approaches which incorporate testing of hypotheses and conclusions and foster re-evaluation of site assumptions as new information is gathered. For example, an iterative approach might include pilot testing to define the effectiveness of various remediation technologies at a site." This iterative approach may also incorporate the use of phased, early, or interim actions and may propose phasing of the remediation.

6. Carefully Evaluate the Assumptions and Uncertainties Associated with Site Characterization Data and Site Models – The assumptions and uncertainties associated with the Site characterization data will be evaluated in the NBSA FS. The *Principles for Managing Contaminated Sediment Risks at Hazardous Waste Sites* document (USEPA 2002a) indicates "The uncertainties and limitations of site characterization data, and qualitative or quantitative models (e.g., hydrodynamic, sediment stability, contaminant fate and transport, or food-chain models) used to extrapolate site data to future conditions should be carefully evaluated and described." As identified in Administrative Order on Consent CERCLA No 02-2007-2009 (USEPA. 2007), the Cooperating Parties Group (CPG) is responsible for developing, calibrating, and delivering a model of both the Lower Passaic River Study Area and Newark Bay Study Area. Data have been collected by Tierra Solutions, Inc. on behalf of Occidental Chemical Corporation and incorporated into the Model. After the model is approved, the USEPA team will take the lead on the modeling and will work collaboratively with the GSH team to complete the RI and FS tasks (USEPA. 2016b). The guidance document *A Risk Management Strategy for PCB-Contaminated Sediments* (NRC 2001) provides a framework for application of the risk management approach for sediment sites:

    a. The first stage in the framework is defining the problem and setting management goals. This problem-definition stage is defined as being the most important step in application of the risk-management framework and the effort for this step must be commensurate to the size and complexity of the NBSA, to the magnitude of the site risk, and to the type of action contemplated. The management goals may need to be modified as information is gathered about the NBSA risks and the best strategy for managing them.

    b. The second stage in the risk management framework is analyzing the risks posed to human health and the environment through evaluation of the conceptual site model and completion of the risk assessments.

    c. The third stage is examining management options and evaluating their effectiveness, feasibility, costs, benefits, unintended consequences, and habitat, cultural, and social impacts. The pros and cons of the range of options are considered and often a combination of technologies can be needed at a site.

    d. The fourth stage in the framework is making a decision after the assumptions and uncertainties have been fully evaluated. During this stage of the framework, the project manager will review the information gathered during the analyses of risks and options to select the most appropriate risk management strategy. As outlined in the document, "The strategy selected should be one that actually reduces overall risk, not merely transfers risk to another site or another affected population. The decision-making process necessary to arrive at an optimal management strategy is complex and likely to involve numerous site-specific considerations. Management decisions must be made, even when information is imperfect. There are uncertainties associated with every decision that need to be weighed, evaluated, and communicated to affected parties. Imperfect knowledge must not become an excuse for not making a decision.

7. Select Site-specific, Project-specific, and Sediment-specific Risk Management Approaches that will Achieve Risk-based Goals – The NBSA is a complex and dynamic system. In accordance with USEPA's policy, there is no presumptive remedy for the NBSA. The appropriate remedial action will be selected based on an iterative, adaptive management approach using the Site-specific, project-specific and sediment-specific risk management information gathered through the comprehensive sampling program. A combination of remedial options will be evaluated using the NCP's nine remedy selection criteria to find the most effective way to manage the risk.

8. Ensure that Sediment Cleanup Levels are Clearly Tied to Risk Management Goals – Sediment cleanup levels will be developed using the CSM and will be based on the results of the risk assessments. The RAOs for the site will be based on the nine FS evaluation criteria and will meet the objectives to protect human health and the environment and meet applicable or relevant and appropriate requirements (ARARs). Although it is more practical to use measurements such as contaminant concentrations in sediment to define areas for remedial consideration, other measures may be the most relevant means of determining exposures of receptors to impacted sediment. As described in the *Principles for Managing Contaminated Sediment Risks at Hazardous Waste Sites* document (USEPA 2002a), these "measures may include direct measurements of indigenous fish tissue concentrations, estimates of wildlife reproduction, benthic macroinvertebrate indices, or other 'effects endpoints' as identified in the baseline risk assessment."

9. Maximize the Effectiveness of Institutional Controls and Recognize their Limitations – Institutional controls, such as fish consumption advisories and waterway use restrictions that are already in place for the NBSA may be a component of remedial decisions for the NBSA. If institutional controls are used, their limitations will be evaluated in the FS to ensure the overall remedial approach is protective.

10. Design Remedies to Minimize Short-term Risks while Achieving Long-term Protection – The remedial action selected for the NBSA will be designed to minimize short-term risks while achieving long-term protection. The FS will complete a thorough evaluation considering the advantages and disadvantages of available options while balancing the various risks, costs, and benefits associated with each option. Value engineering is a specialized cost-control technique that uses a systematic and creative approach to identify and reduce unjustifiably high costs in a project without sacrificing the reliability, efficiency, or original objectives of Superfund Fund-lead projects (USEPA 2005). The principles and systematic approach of value engineering will be incorporated in the FS.

11. Monitor During and After Sediment Remediation to Assess and Document Remedy Effectiveness – A physical, chemical, and biological monitoring program will be established, as appropriate, for the NBSA to determine if short-term and long-term health and ecological risks are being adequately mitigated at the Site and to evaluate if the RAOs and site-specific remediation goals are being met. The Phase III NBSA sampling that is further discussed in Section 3 may serve as the baseline or pre-remedy condition to assess the effectiveness of any sediment remediation.

1.4.2 Site-Specific Feasibility Study Considerations

In conducting the feasibility evaluation of potential remedial alternatives, it is important that Site-specific factors that may present unique challenges to remediation are identified and appropriately considered. The *USEPA Contaminated Sediment Remediation Guidance for Hazardous Waste Sites* (USEPA 2005) specifically highlights why sediment sites may present unique challenges, as noted below, and encourages remediation managers to consider these and other site-specific characteristics in the remedy selection. The FS is based on Site-specific data collected over time and will incorporate the CSM and the RI (including the risk assessments). Estimated and projected conditions developed through the Model have uncertainties that will be quantified to make risk management decisions. The NBSA is a complex and dynamic estuary. An evaluation of data collected for the RI, combined with the use of appropriate site-specific models, consideration of changes in the geomorphology and human use over time, and geochemical evaluation of interactions between the NBSA and its tributaries, will be used to characterize the estuary to a level that is appropriate for FS decision making. In addition, the change in use of the Bay over time has had, and will, in the future, have significant impacts.

- Sediment sites may have a large number of sources, some of which can be ongoing and difficult to control. The constituents of potential concern (COPCs) in NBSA sediment will not be addressed by a simple, single-source, single-contaminant remediation that lends itself to a straightforward remedial selection and implementation. Historical industrial activity and on-going urban and industrial practices have impacted conditions in the NBSA. Numerous COPCs have been detected in sediments, including polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), pesticides, herbicides, volatile and semivolatile organic compounds (VOCs and SVOCs), metals, and polychlorinated dibenzo-*p*-dioxins/polychlorinated dibenzofurans (PCDDs/PCDFs). This mix of COPCs, each with unique physicochemical characteristics, will need to be considered in remedy evaluation and selection. The NBSA also has a multitude of natural and anthropogenic contributions to its water body that can affect the remedy selection, not only from a physical implementation perspective but due to ongoing contaminant source loading. Such contributions include:
    a. Combined sewer overflows (CSOs)
    b. Storm water outfalls (SWOs)
    c. Upstream and downstream sources (caused by tides) and tributaries
    d. A publicly owned treatment works (POTW) emergency relief point
    e. Spills, leaks, and accidental discharges from marine and industrial discharger sources

f. Permitted industrial discharges

Loading from CSOs, SWOs, and wastewater treatment plants will be identified and characterized using information obtained from the planned CSO/SWO characterization program (Tierra 2017). Marine/industrial spills and releases will be investigated via public records. Information obtained from these efforts will be used, to the extent possible (e.g., while a release might be identified, it may not be possible to obtain a reasonable estimate of the mass of contaminant released) to develop an estimate of mass loadings of contaminants to Newark Bay that have the potential to impact potential remedies. Section 4, Sources of Contaminants, in the CSM contains further description of source categories and potential sources of concern.

- The sediment environment of the NBSA is dynamic as a result of natural and anthropogenic forces, acting on a variety of spatial scales, including tidal action, storm surges, tributary flows, and ship traffic turbulence. The impact these forces may have on the implementation and/or operation and maintenance (O&M) phases of a remedy must be considered during the FS.

  The NBSA is a complex junction, hydrodynamically, resulting from the following physical processes:

  - Astronomical forcing (including classical estuarine gravitational circulation) through the Kill van Kull and Arthur Kill tidal straits.
  - Freshwater tributary flows. The principal sources of freshwater are the Passaic and Hackensack Rivers. Minor contributors include the Peripheral Ditch and Piersons Creek (conduits for stormwater runoff), which empty directly into the Bay, as well as the Rahway and Elizabeth Rivers, Piles Creek, Morses Creek, and Fresh Kills Creek, which enter by way of the Arthur Kill tidal strait.
  - Local and regional meteorological effects including wind-wave effects (Herrington et al. 2002; Wakeman III 2006).

  These primary influences combine to produce complex, event-driven circulation and make it challenging to identify a long-term average pattern (Chant 2006). Consideration should be given to monitoring primary physical processes to the extent practical to improve the understanding of sediment and contaminant dynamics in the NBSA. These processes include, but may not be limited to, meteorological events (wind, pressure), currents, tides, water properties (temperature and salinity), and suspended sediment load. In addition to natural forces, navigational dredging, including improvements/deepening and maintenance, occur on a scale such that these activities have measureable and, at times, significant impacts on hydrodynamics.

  Due to the complexity of the system, it is important that calibrated/validated models of the hydrodynamics, sediment transport, and contaminant fate and transport, be used to inform decision-making during the FS by informing the assessment of impacts of storms, tides, wind-driven resuspension, and navigation, on any proposed remedy. The interpretation of model results, however, must take into account the uncertainty associated with each of the sub-models. These complex hydrodynamic factors will need to be considered in the remedy evaluation.

- The physical construct of the NBSA is comprised of multiple geomorphic areas, as noted below, that may affect the implementation strategy of certain remedial actions and therefore should be considered during the FS.
    - Subtidal flats
    - Historically disturbed subtidal flats
    - Transitional slopes
    - Navigation channels
    - Port channels
    - Intertidal areas
    - Industrial waterfront areas

- The NBSA has major infrastructure and commercial activities that must be taken into account. Key factors (and potential constraints) for certain remedial actions, including shoreline conditions (*e.g*., integrity of riprap or bulkheads), bridges, port facilities, a confined disposal facility, and commercial shipping traffic, will require consideration and evaluation. As part of the NBSA RI, a comprehensive study documenting the constructed shoreline of Newark Bay was completed in 2013. This study showed that over 70% of the shoreline was hardened with either riprap or bulkhead. The integrity of these physical constraints will need to be considered during the FS as part of the evaluation of remedies that may impinge on these physical barriers. However, additional shoreline surveys or investigations are not expected as part of the RI/FS.

- The presence of contaminant patterns, as revealed through the RI sediment chemical characterization programs. Some regions and geomorphic areas of the bay are more heavily impacted by certain contaminants than other regions and geomorphic areas, based on proximity to sources.

- Cleanup work in an aquatic environment is frequently difficult from an engineering perspective and may be more costly than other media. In the NBSA, in particular, being a large, active commercial port, there are unique challenges that will impact logistics, coordination, and, as yet undefined port operations.

- Contamination is often diffuse and the sites are often large and diverse (e.g., mixed use, numerous property owners). Newark Bay is a relatively wide body of water that includes both wide areas of subtidal flats and deep, man-made/maintained navigation channels, contributing to the naturally complex dynamics that will complicate any remedy under consideration.

- Many sediment sites contain ecologically valuable resources or legislatively protected species or habitats. Newark Bay is considered by the National Marine Fisheries Service (2007) to be essential fish habitat (EFH) for various life stages of several species including Atlantic herring, various flounders/hake, Atlantic mackerel, bluefish, butterfish, scup, and black seabass. In addition, the Bay is inhabited seasonally by two federally listed threatened and endangered fish species—the Atlantic and shortnose sturgeon.

- For large sites, a number of communities with differing views and opinions may be affected. The NBSA is bounded by two states (New Jersey and New York), 4 counties (NJ: Union, Essex, Hudson; NY: Richmond (coextensive with Staten Island)), and multiple cities, towns and communities. There may be highly varying views on any remedy decisions depending, in part, on proximity to each of these communities, thus impacting the feasibility assessment process.

The CSM, the RI, and the risk assessments will further expand on these challenges and summarize the latest understanding of the NBSA, and thus help guide the development of the FS. A brief overview of the NBSA setting as more fully described in the current version of the CSM (Tierra 2013) is below.

2 Study Area Setting

The NBSA includes Newark Bay and portions of the Hackensack River, the Arthur Kill, and the Kill van Kull, as described in NBSA AOC, Paragraph 2.r (USEPA 2004). This section of the FS WP provides a general overview of the physical setting and site history from the most current version of the CSM (Tierra 2013), which is an evolving document that will be updated in spring 2017 and used as the basis for the FS. The CSM will be updated as needed, predominately, during the RI, but could be updated after the RI if additional data are collected.

The NBSA is part of a tidally influenced estuarine system that is at the center of one of the most urbanized and industrialized areas in the United States and, as a result, environmental degradation has occurred over the past two centuries due to a variety of factors including shoreline and land development (USACE 2006), wetlands destruction, habitat degradation, garbage and sewage disposal, and releases of contaminants (Iannuzzi et al. 2002). As a result of urban and industrial practices, the NBSA is known to be contaminated with a number of COPCs, including PCBs, PAHs, pesticides, herbicides, VOCs, SVOCs, PCDDs/PCDFs, and metals (NOAA 1995; USEPA 1998).

2.1 Geographic Location

Newark Bay is situated within a highly industrialized and heavily populated region, adjacent to the cities of Newark, New Jersey and Elizabeth, New Jersey. It is bordered by Newark Liberty International Airport to the west; Jersey City, New Jersey and Bayonne, New Jersey to the east; Kearny Point and the Passaic and Hackensack Rivers to the north; and Staten Island, New York to the south.

2.2 History & Physical Setting

The Diamond Alkali Superfund site is a multi-party, multi-contaminant site that includes the former manufacturing facility at 80-120 Lister Avenue in Newark, New Jersey (Operable Unit 1), the Lower 8.3 miles of the Passaic River Study Area (Operable Unit 2), the 17-mile Lower Passaic River Study Area (Operable Unit 3) and the Newark Bay Study Area (Operable Unit 4). The locations of the Operable Units are shown on Figure 1-1. The RI for the NBSA is currently on-going and is estimated to be completed in 2020.

As part of the New York/New Jersey Harbor Estuary, Newark Bay has evolved into a key shipping port and has been an ideal setting for myriad industries for over two centuries (Meyers 1945; Cunningham 1954, 1966a, 1966b; Brydon 1974). The CSM (Tierra 2013) describes changes in the NBSA over time. Summary figures from the 2013 CSM are included for reference; an historical timeline of some major construction and storm activities inside and neighboring the NBSA is presented on Figure 2-1, and the locations of the historical features as well as estimates of the historical shoreline within the NBSA are presented on Figure 2-2.

Dredging was first initiated in Newark Bay in 1874 to accommodate deep-draft vessels (USACE 2007). Between 1891 and 1934, substantial development by the federal government led to the construction of a series of federal Navigation Channels. The City of Newark began to “reclaim” the meadowlands along the western shore of Newark Bay in the early 1900s to establish the city as a major shipping port with access to nearby New York City (NYT 1915). The process of reclaiming the meadowlands involved enclosing an area of meadow with dikes and transporting sediment to fill the area and allowing the new area to drain (NYT 1926). Around the same time, the development of ports in the NBSA began with a large marine terminal at Port Newark (City of Newark) between the late 1800s and 1915 as access into the estuary increased with the development of the federal Navigation Channels (USACE 2006). Filling portions of the Bay for new construction became commonplace (NYT 1915, 1926). Development of the NBSA shoreline over the past two centuries has led to the destruction of wetlands and a sharp decline in habitats for plants and animals (Iannuzzi et al. 2002). More recently, the USACE conducted a harbor improvement project to deepen the navigation channels within the Port of New York and New Jersey to -50ft mean low water National Geodetic Vertical Datum (MLW NGVD29) (USACE 2006). The deepening included dredging the Kill van Kull and Newark Bay channels as well as the northern section of the Arthur Kill Channel to -50ft MLW (construction depth). The purpose of the improvement project was to accommodate a new fleet of larger Maersk “S” Class (48ft draft) ships.

As a result of natural sedimentation processes, the USACE also conducts routine maintenance dredging to support industrial and commercial activities. Sedimentation rates will be an important consideration in the development of remedial alternatives for Newark Bay. Of the seven (7) geomorphic areas identified in Newark Bay (Tierra 2013), the Subtidal Flats and the Port and Navigation Channels generally bracket the range of sedimentation rates.

In summary, the cumulative historical anthropogenic impacts on shoreline filling and development, dam and channel development, and the overall urbanization/industrialization of the land surrounding Newark Bay have had a significant influence on the present conditions of the NBSA.

3 Identification of Data Uses and Needs

The need for Site data is evaluated relative to meeting the Site-specific RI/FS objectives. The SOW in the AOC outlines the following goals for the RI:

- Determine the horizontal and vertical distribution and concentration of PCDDs, PCDFs, PCBs, PAHs, pesticides and metals, for the NBSA sediments in accordance with the SOW;
- Determine the primary human and ecological receptors (endpoints) of PCDDs, PCDFs, PCBs, PAHs, pesticides and metals contaminated sediments in the NBSA; and
- Determine the significant direct and indirect continuing sources of PCDDs, PCDFs, PCBs, PAHs, pesticides and metals to the sediments in the NBSA, in accordance with USEPA guidance "Principles for Managing Contaminated Sediment Risks at Hazardous Waste Sites" (USEPA 2002a).

The SOW also includes completion of the BHHRA, BERA, and PRA.

Previous NBSA RI sampling has been conducted in two phases, comprising a total of 119 sampling locations representing 4,189 acres. A third phase of sampling (Phase III Sediment Investigation) is being conducted to better understand the nature and extent of COPCs in the NBSA. Specifically, the objectives of the Phase III Sediment Investigation are to:

- Determine the approximate boundaries of subunits within Newark Bay that contain statistically distinct concentrations of COPCs, especially dioxin;
- Determine the means and variances of COPC concentrations within these subunits; and
- Determine how surface sediment COPC concentrations within these subunits vary with time.

The results from the Phase III Sediment Investigation will be used along with the results from samples collected during Phase I and Phase II, and Secondary Data for Newark Bay, to conduct the risk assessments and RI of the NBSA. The Feasibility Study will include a summary of chemicals from the human health risk assessment that have a hazard index greater than 1 or risk outside of the acceptable risk range. The results from the RI will be incorporated into the NBSA CSM and used to determine any additional data that may be needed to develop and evaluate remedial alternatives (including the no-action alternative). If additional data are needed, the intended uses of the data will be identified, strategies for sampling and analyses will be developed, data quality objectives (DQOs) will be established, and priorities will be assigned according to the importance of the data in meeting the objectives of the RI/FS.

The following are examples of potential additional sources of data that may be needed and used to support the FS:

- Surface water flow data for modeling and/or assessment of ongoing non-CSO and non-SWO sources;
- Bathymetric data and plan for additional deepening to evaluate changes in Newark Bay channels;
- Additional chemical and flow data to characterize the CSOs and SWOs in the NBSA;
    - Master plans on the local, state and federal level;
    - PANYNJ and USACE Master Plans; and
    - CSO input from source/chemical input and SWO input – includes historical and current inputs.
- Ship track data and associated dynamics to evaluate the impact of ship traffic on the Newark Bay sediments;
- Physical changes to the shoreline, land use, and populations to assess physical and sociological changes;
- Identification and characterization of utilities within the area of impact to support evaluation of alternatives;
- Identification and characterization of remnant structures to support evaluation of alternatives;
- Collection of data needed to refine the subunits within the NBSA (based on the results of the Phase III Sediment Investigation);
- Data to refine the PRA to decrease uncertainty to protect the most sensitive receptors; and
- Data to support any treatability studies, if conducted.

4 Technical Approach

The technical approach for completing the FS will comply with the requirements of the AOC and will consist of seven tasks:

- Task 1 – Description of Remedial Action Objectives and Preliminary Risk-Based Remediation Goals
- Task 2 – Description of Current Situation and Proposed Response
- Task 3 – Development of Alternatives
- Task 4 – Initial Screening of Alternatives
- Task 5 – Technology Identification & Treatability Studies
- Task 6 – Detailed Evaluation of the Alternatives
- Task 7 – Preparation of Draft Feasibility Study Report

Details of each of these tasks are presented below and summarized on Figure 4-1. Tasks associated with the FS may be conducted in parallel to enhance the overall FS program.

4.1 Task 1 – Description of Remedial Action Objectives and Preliminary Risk-Based Remediation Goals

Objective: Conduct an analysis of ARARs and describe the cleanup objectives (RAOs), which incorporate specific Preliminary Remediation Goals (PRGs), to establish the focus and framework for the feasibility study. To Be Considered (TCB) criteria will also be examined along with ARARs.

- RAOs specify the objectives that are expected to be met by the remedial alternatives evaluated during the FS.
- PRGs are risk-based concentrations of individual COPCs in environmental media and will be developed through completion of the human health and ecological risk assessments. PRGs will be protective of human health and the environment, and they will meet ARARs (or provide grounds for invoking a waiver).

Work Effort: The RAOs and PRGs are driven by, and derived through, the BHHRA and BERA. The RAOs and PRGs will be established and presented in the Newark Bay risk assessments (BERA, BHHRA, and PRA).

Deliverable: RAOs and PRGs.

4.2 Task 2 – Description of Current Situation and Proposed Response

Objective: Preparation of a Site synopsis and statement of purpose.

Work Effort: The work will include:

- Summarization of the site background and the nature and extent of COPC-impacted materials that will have been fully described and detailed in the approved RI Report.
- Preparation of a site-specific statement of purpose for the response, identifying the actual or potential exposure pathways identified in the human health and ecological risk assessments that will be addressed by remedial alternatives.

Deliverable: The synopsis will be incorporated into, and submitted as part of, the RAS Technical Memorandum (Task 4).

4.3 Task 3 – Development of Alternatives

Objective: Identify a preliminary range of remedial action alternatives and associated technologies. This identification is not a detailed investigation of alternatives, but a more general classification of potential remedial actions based upon the initially identified potential routes of exposure and associated receptors from the risk assessments. The identification of potential technologies at this stage will help ensure data, necessary for further detailed evaluations, can be collected as early as possible. In addition, the early identification of technologies will help establish the appropriate scope for a treatability study(ies), if deemed necessary.

Work Effort: Following the *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (USEPA 1988), a list of broadly defined alternatives will be developed that reflects the goal of presenting a range of distinct, viable options. The list of alternatives will be limited to only those that are relevant and have significant potential for being implemented at the NBSA based on their ability to meet the threshold criteria of being protective of human health and the environment and meeting ARARs (or provide grounds for invoking a waiver).

The remedial alternatives will be assembled using individual or combinations of technologies that will meet the RAOs. Consistent with the Guidance and the AOC, these alternatives will include no action, monitored natural recovery, sediment removal, and/or capping, and any promising innovative technologies, such as *in-situ* treatment. As outlined in the *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (USEPA 1988), "Innovative technologies would normally be carried through the screening phase if there were reason to believe that the innovative technology would offer significant advantages. These advantages may be in the form of better treatment performance or implementability, fewer adverse impacts than other available approaches, or lower costs for similar levels of performance."

The No Action alternative is a statutory requirement of CERCLA and is intended to represent a baseline scenario for comparison to other response actions (USEPA 1988). At a minimum, the following alternatives will be considered:

- Treatment alternatives for source control of contaminated Newark Bay tributary sediments that would eliminate the need for long-term management;
- Alternatives involving treatment as a principal element to reduce the toxicity, mobility or volume of waste;
- An alternative that involves containment of waste with little or no treatment, but provides protection of human health and the environment primarily by preventing potential exposure or reducing the mobility of the waste;
- An alternative that involves containment of waste with *in-situ* treatment (e.g., an amended cap);
- Alternatives including Institutional Controls;
- Sediment removal;
- Monitored Natural Recovery; and
- A No Action alternative.

The FS will identify areas or volumes of media to which general response actions may apply, taking into account requirements for protectiveness as identified in the RAOs and the biological, chemical and physical characteristics of each specific area in the NBSA. To the extent it is appropriate, alternatives and other considerations will be developed into Site-specific alternatives. Details concerning methods, locations, and other criteria to be evaluated for each alternative will be developed. Estimated time frames for alternatives to achieve cleanup levels and RAOs will be identified to the extent possible with the information available at the time the FS is drafted.

Because of the complexity of the NBSA and the variability in physical and chemical characteristics, the alternatives developed will make use of adaptive management approaches, such as the use of phased remediation, if such approaches can be demonstrated to be both protective of human health and the environment and cost-effective.

Deliverable: A summary of the development of the remedial action alternatives will be incorporated into, and submitted as part of, the RAS Technical Memorandum (Task 4).

4.4 Task 4 – Initial Screening of Alternatives

Objective: Screen the preliminary range of remedial action alternatives developed in Task 3. This screening will focus on eliminating alternatives that are clearly ineffective or not implementable, or that are clearly inferior to other alternatives being considered in terms of protecting human health and the environment, effectiveness, implementability, or cost, prior to undertaking the more detailed evaluations in Tasks 5 and 6.

Work Effort: The preliminary range of remedial action alternatives will be screened based on the NCP, CERCLA, and the rules promulgated under CERCLA. The methodology for screening remedial alternatives will be consistent with the *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (USEPA 1988) based on the effectiveness, implementability, and cost as outlined below:

- *Effectiveness* – this evaluation will focus on the potential effectiveness of the alternatives in handling the estimated areas or volumes of media and meeting the remediation goals identified in the RAOs and the PRGs (based on the ARARs), potential impacts to human health and the environment, and how proven and reliable the process is with respect to the contaminants and conditions at the Site. The alternatives will be evaluated as to its effectiveness in providing protection and the reductions in toxicity, mobility or volume that it will achieve. Both the short- and long-term components of effectiveness will be evaluated when comparing the alternatives. The reduction of toxicity, mobility, or volumes refers to the changes in one or more characteristics of the hazardous substances or contaminated media by the use of treatment that decreases the inherent threats or risks associated with the hazardous material.
- *Implementability* – this evaluation encompasses both the technical and administrative feasibility of implementing a technology process. The technical implementability will be used as the initial screen of technology types and alternatives to eliminate those that are clearly ineffective or unworkable at the Site. The more detailed administrative evaluation of alternatives places greater emphasis on the institutional aspects of implementability, such as the ability to obtain necessary permits for off-site actions, the availability of treatment, storage and disposal services (including capacity), and the availability of necessary equipment and skilled workers to implement the technology.
- *Cost* – this evaluation is made on the basis of engineering judgment where each alternative is categorized as to whether costs are high, medium, or low relative to other alternatives in the same technology type.

Deliverable: Upon completion of Tasks 1, 2, 3, and 4, the results will be incorporated into the RAS Technical Memorandum to be submitted for review and approval by the USEPA. The RAS Technical Memorandum will include the following:

- A summary of the USEPA-approved RAOs and PRGs for the NBSA COPCs (Task 1);
- The site synopsis from Task 2 that provides a description of the current situation of the NBSA and presents the site-specific statement of purpose identifying the actual or potential exposure pathways that will be addressed by remedial alternatives;
- A presentation of the development of remedial alternatives conducted and the areas or volumes of media to which the general response actions may apply as part of Task 3; and
- A summary of the work efforts and results of the screening of alternatives, including an alternatives array summary.

The RAS Technical Memorandum will summarize the reasoning employed in screening, arraying alternatives that remain after screening, and identifying ARARs for the alternatives that remain after screening. The RAS Technical Memorandum will document the methods, rationale, and results of the alternatives screening process and demonstrate that the proposed alternatives meet the goals of protecting human health and the environment and meets ARARs. The RAS Technical Memorandum will be submitted to the USEPA for review and approval pursuant to Section VIII of the AOC. The alternatives will be modified, if required by the USEPA's comments, to assure identification of a complete and appropriate range of viable alternatives to be considered in the detailed analysis. Upon approval of the final RAS Technical Memorandum, the set of remedial alternatives will be carried forward into the detailed analysis of alternatives (Task 6).

4.5 Task 5 – Technology Identification & Treatability Studies

Objective: To identify the various technologies that may be tested to support the remedial action alternatives defined in Task 4 and to determine if studies would be beneficial to provide sufficient data to allow the alternatives to be more fully developed and evaluated during the detailed analysis (Task 6). Depending on the studies identified, bench and/or pilot studies may also be used. The results of such studies may reduce the cost and performance uncertainties for alternatives to acceptable levels so that a remedy can be selected (USEPA 1988) and may also be used to support the remedial design of a selected alternative. The following are criteria that may be used to determine the need for a treatability study, bench-scale study and/or pilot study:

- A candidate technology has shown promise in the scientific/engineering community (e.g., in situ bioremediation) but limited data exists to evaluate effectiveness, implementability, and/or cost.
- A candidate technology is only conceptual but a stakeholder(s) is promoting its evaluation.
- Site-specific data are necessary for a promising candidate technology to better evaluate effectiveness, implementability, and/or cost.
- An iterative (adaptive management) approach is desired, e.g., conducting a thin-layer capping pilot study in a representative area of the site.
- Prior studies for a promising candidate technology were inadequately designed and/or implemented.
- The body of knowledge has advanced in recent years for a promising candidate technology whose prior study(s) was unsuccessful/inconclusive.

Work Effort: The initial work included in this task will be the identification/listing of candidate technologies that may be used to implement the remedial action alternatives developed from Task 4. The listing of candidate technologies will cover the range of technologies required for alternatives analysis. A literature survey will be conducted to gather information on performance, relative costs, applicability, removal efficiencies, O&M requirements, and implementability of candidate technologies. Based on the results of this work, a technical memorandum will be prepared, referred to as The Identification of Candidate Technologies Memorandum (ICT Memorandum). This ICT Memorandum will present the list of potentially applicable technologies, a qualitative discussion of the availability and usefulness of existing information (in the context of conducting a FS) associated with each of the technologies, and a recommendation regarding the potential benefits of a treatability study(ies) to the advancement of the FS.

The ICT Memorandum will be submitted to USEPA for review and approval pursuant to Section VIII of the AOC. If the ICT Memorandum recommends treatability studies and there is consensus that such studies on one or more of the technologies would benefit the FS, then additional work products, as outlined below, will be developed and submitted for USEPA review.

- Treatability Testing Work Plan

  A treatability testing work plan will be prepared, and submitted for USEPA review, that includes the following:

  - Site background;
  - Remedial technology(ies) to be tested and the rationale for their selection;
  - Test objectives;
  - Experimental methods and procedures;
  - Treatability conditions to be tested;
  - Measurements of performance;
  - Analytical methods;
  - Data management and analysis;
  - Health and safety plan that includes procedures to protect workers and, if needed, the community; and
  - Residual waste management.

The DQOs for treatability testing will also be documented in the work plan. If pilot scale treatability testing is to be performed, a pilot scale work plan will be prepared that describes pilot test installation and start-up, pilot test O&M procedures, operating conditions to be tested, a sampling plan to determine pilot test performance, and a detailed health and safety plan. If testing is to be performed off-site, permitting requirements will be included.

- Treatability Study Sampling and Analysis Plan(s)

  If treatability study sampling is needed and a protocol for collection or analysis is not already in place with an existing sampling and analysis plan, quality assurance project plan, and/or health and safety/contingency plan, these documents will either be amended or new plans will be developed for the treatability testing for USEPA review. These plans will address protection of the community members during the treatability study through specific considerations of potential hazards to the community and means of preventing or limiting those exposures.

- Treatability Study Evaluation Report

  Following completion of any treatability testing, the results will be summarized and evaluated in a Treatability Study Evaluation Report. Depending on the sequence of activities, this report may be a part of the RI/FS report or a separate deliverable. The technical report will summarize and evaluate each technology's effectiveness, implementability, cost, and actual results as compared with predicted results. The Treatability Study Evaluation Report will also evaluate full scale application of the technology, including a sensitivity analysis identifying the key parameters affecting full-scale operation. The Treatability Study Evaluation Report will be submitted to USEPA for review and approval.

Deliverable: At a minimum, the deliverable associated with Task 5 will include the ICT Memorandum. If treatability studies are to be conducted, deliverables will also include a Treatability Testing Work Plan and Treatability Study Evaluation Report. In addition, it may be necessary to develop a Treatability Study Sampling and Analysis Plan if existing plans do not include the procedures needed for the proposed treatability studies.

4.6 Task 6 – Detailed Evaluation of the Alternatives

Objective: To conduct a detailed evaluation of remedial alternatives followed by a comparative analysis of remedial alternatives.

Work Effort: In accordance with CERCLA and the NCP, a more detailed analysis of alternatives outlined in the approved RAS Technical Memorandum (submitted as part of Task 4) will be conducted. This will involve two subtasks:

Subtask 1: The alternatives will be analyzed using the first seven of the nine evaluation criteria outlined in the CERCLA guidance and the NCP.

Subtask 2: The alternatives will be compared to one another using the same nine evaluation criteria as a basis for comparison.

The nine evaluation criteria outlined in the NCP are:

1. Overall protection of human health and the environment
2. Compliance with ARARs
3. Long-term effectiveness and permanence
4. Reduction of toxicity, mobility, or volume through treatment
5. Short-term effectiveness
6. Implementability
7. Cost
8. State acceptance
9. Community acceptance

These criteria are further categorized into three groups:

- Threshold criteria (criteria 1 and 2) - Overall protection of human health and the environment and compliance with ARARs (unless a specific ARAR is waived) are threshold requirements that each alternative must meet in order to be eligible for selection.
- Primary balancing criteria (criteria 3-7) - The five primary balancing criteria are long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; and cost.
- Modifying criteria (criteria 8 and 9) - State and community acceptance are modifying criteria that will be addressed in the Record of Decision once comments on the RI/FS Report and Proposed Plan have been received.

As part of Subtask 1, the first seven of these nine criteria will be applied to the assembled remedial alternatives outlined in the approved RAS Technical Memorandum. The goal will be to identify the remedial alternatives that will:

- Be protective of human health and the environment;
- Be in compliance with, or justify a waiver of, ARARs;
- Be cost-effective;
- Utilize permanent solutions and alternative treatment technologies, or resource recovery technologies, to the extent practicable; and
- Address the statutory preference for treatment.

As part of Subtask 2, the comparative advantages and disadvantages of each remedial alternative will be identified. Specifically, the factors to be considered are:

- Effectiveness
    - Degree to which the alternative is protective of human health and the environment;
    - Reliability of the alternative;
    - Potential health risks or impacts on environmental receptors posed by the alternative; and
    - Degree to which mobility, toxicity or volume of hazardous substance, pollutant, or contaminant is reduced
- Implementability
    - Technical feasibility of the alternative
    - Availability of needed equipment, expertise or other resources
- Cost
    - Short-term costs
    - Long-term operation and maintenance costs (using present value)

Deliverable: The results of the remedial alternatives evaluation (Subtask 1) and the comparative analysis (Subtask 2) will be summarized in a Remedial Alternatives Evaluation Technical Memorandum and will be submitted to USEPA for review and approval pursuant to Section VIII of the AOC.

4.7 Task 7 – Preparation of Draft and Final Feasibility Study Report

The draft FS Report will summarize the results of Tasks 1 through 6 from the SOW (outlined above) and will conform to the terms of the AOC and the final USEPA-approved FS WP. The draft FS Report will be submitted to USEPA for review and comment, and subsequently revised per USEPA's comments, and resubmitted for review and approval of the final FS Report.

The FS Report will consist of the following sections, in accordance with the suggested format described in Table 6-5 of USEPA's *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (USEPA 1988):*

- Introduction, including Purpose and Background Information (summarized from the RI Report and the Treatability Study Report);
- Identification and Screening of Technologies;
- Development and Screening of Alternatives;
- Detailed Analysis of Alternatives; and
- Summary and Conclusions.

5 Reporting and Schedule

This section lists the deliverables that will be produced through the FS process and submitted for USEPA review and approval pursuant to Section VIII (USEPA Review and Submissions) of the AOC and in accordance with the Project Schedule (to be updated pending USEPA approval of this FS WP). The FS deliverables specified in the SOW include:

- The Remedial Action Objectives and the Preliminary Remedial Goals
- Remedial Alternatives Screening Technical Memorandum
- Identification of Candidate Technologies Memorandum
- Treatability Study Deliverables, if conducted
  - Treatability Testing Work Plan – bench and/or pilot
  - Treatability Study SAP, QAPP, HASCP, if needed
  - Treatability Study Evaluation Report
- Remedial Alternatives Evaluation Technical Memorandum
- Draft Feasibility Study Report
- Final Feasibility Study Report

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Figures

City: SYR Div/Group: IM Created By: K. SINSABAUGH Last Saved By: ksinsabaugh
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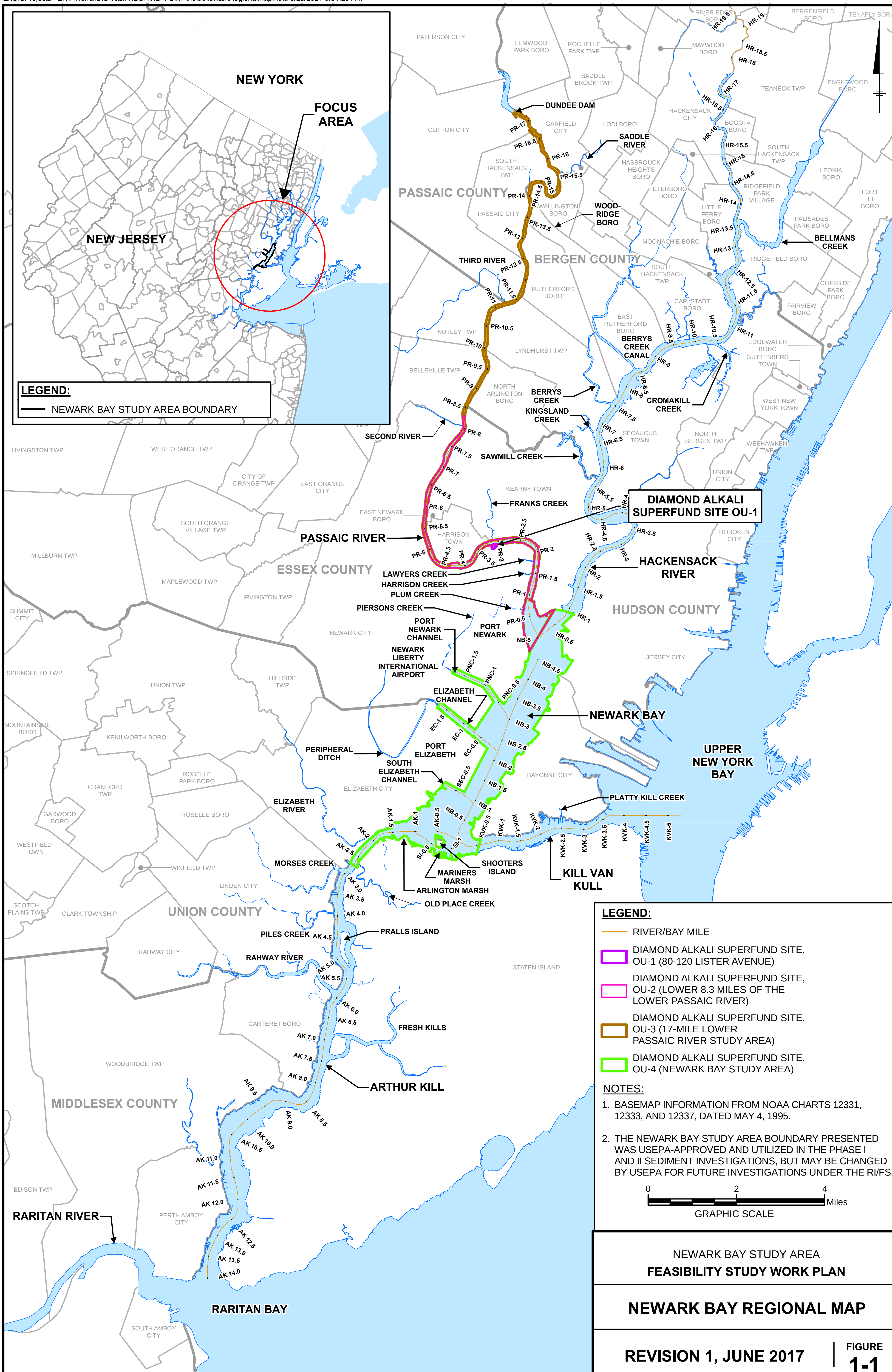

NOTES:

1. BASEMAP INFORMATION FROM NOAA CHARTS 12331, 12333, AND 12337, DATED MAY 4, 1995.
2. THE NEWARK BAY STUDY AREA BOUNDARY PRESENTED WAS USEPA-APPROVED AND UTILIZED IN THE PHASE I AND II SEDIMENT INVESTIGATIONS, BUT MAY BE CHANGED BY USEPA FOR FUTURE INVESTIGATIONS UNDER THE RI/FS.

NEWARK BAY STUDY AREA
FEASIBILITY STUDY WORK PLAN

NEWARK BAY REGIONAL MAP

REVISION 1, JUNE 2017

FIGURE
1-1

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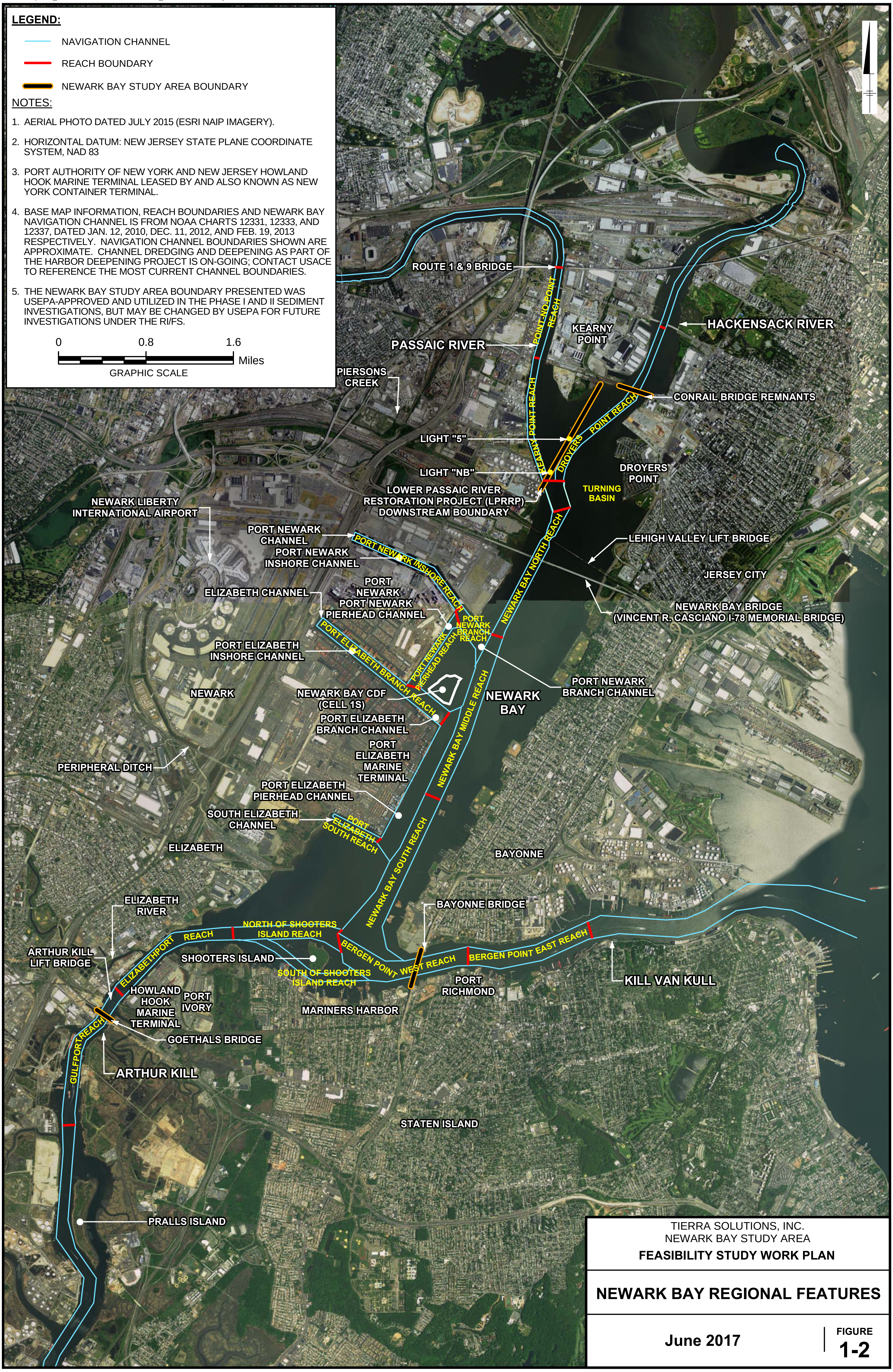
LEGEND:

- NAVIGATION CHANNEL
- REACH BOUNDARY
- NEWARK BAY STUDY AREA BOUNDARY

NOTES:

1. AERIAL PHOTO DATED JULY 2015 (ESRI NAIP IMAGERY).
2. HORIZONTAL DATUM: NEW JERSEY STATE PLANE COORDINATE SYSTEM, NAD 83
3. PORT AUTHORITY OF NEW YORK AND NEW JERSEY HOWLAND HOOK MARINE TERMINAL LEASED BY AND ALSO KNOWN AS NEW YORK CONTAINER TERMINAL.
4. BASE MAP INFORMATION, REACH BOUNDARIES AND NEWARK BAY NAVIGATION CHANNEL IS FROM NOAA CHARTS 12331, 12333, AND 12337, DATED JAN. 12, 2010, DEC. 11, 2012, AND FEB. 19, 2013 RESPECTIVELY. NAVIGATION CHANNEL BOUNDARIES SHOWN ARE APPROXIMATE. CHANNEL DREDGING AND DEEPENING AS PART OF THE HARBOR DEEPENING PROJECT IS ON-GOING; CONTACT USACE TO REFERENCE THE MOST CURRENT CHANNEL BOUNDARIES.
5. THE NEWARK BAY STUDY AREA BOUNDARY PRESENTED WAS USEPA-APPROVED AND UTILIZED IN THE PHASE I AND II SEDIMENT INVESTIGATIONS, BUT MAY BE CHANGED BY USEPA FOR FUTURE INVESTIGATIONS UNDER THE RI/FS.

0 0.8 1.6 Miles
GRAPHIC SCALE

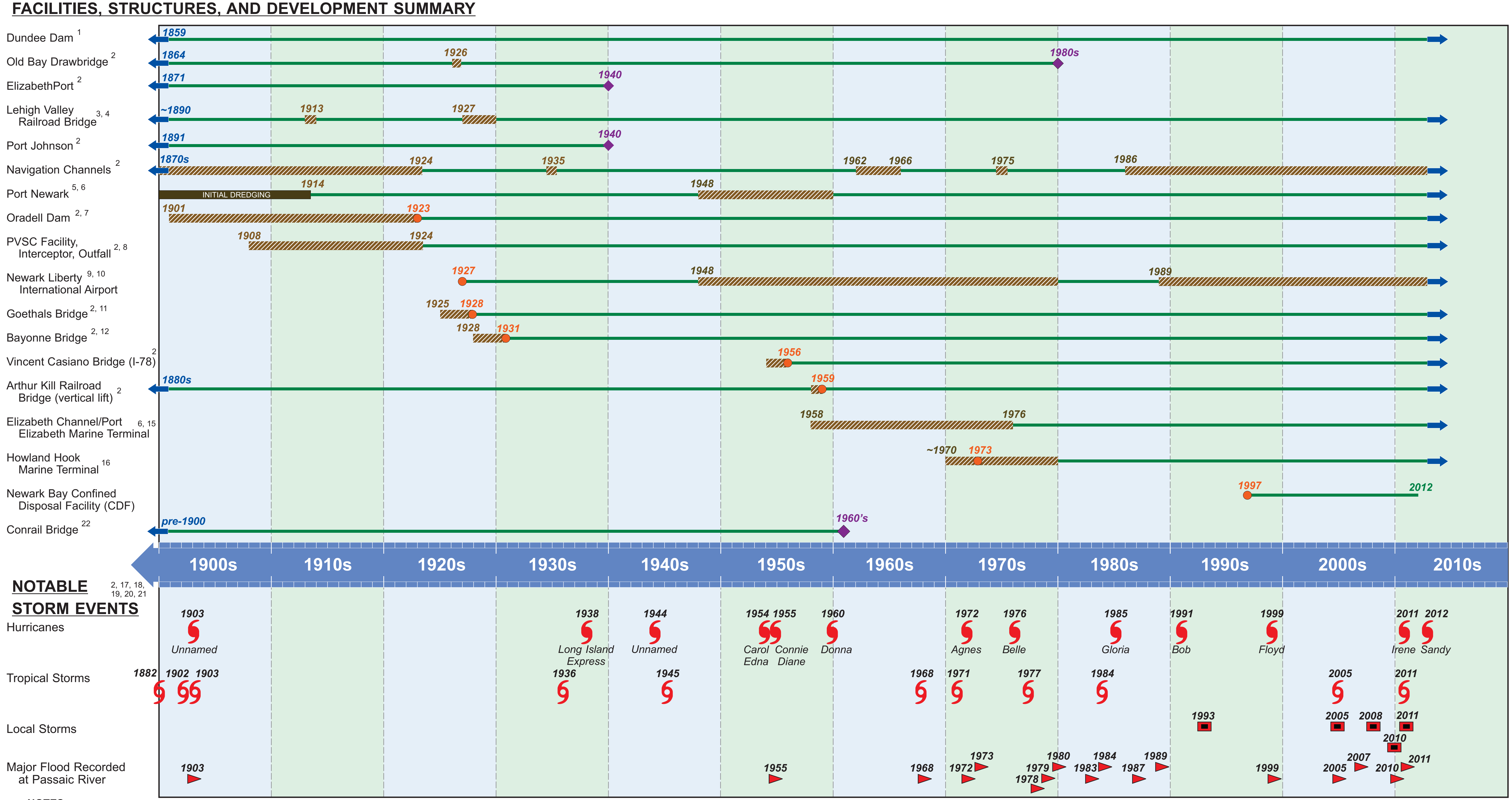


TIERRA SOLUTIONS, INC.
NEWARK BAY STUDY AREA
FEASIBILITY STUDY WORK PLAN

NEWARK BAY REGIONAL FEATURES

June 2017

FIGURE
1-2



NOTES:

1. NEW YORK TIMES (NYT). 1999.
2. U.S. ARMY CORPS OF ENGINEERS (USACE). 2006b.
3. NYT. 1891.
4. NYT. 1913a; 1913b; 1927a; 1927b.
5. NYT. 1926.
6. PANYNJ. 2012a.
7. NYT. 2011.
8. PASSAIC VALLEY SEWERAGE COMMISSION (PVSC). 2011.
9. NYT. 1927c; 1927d.
10. PANYNJ. 2012b.
11. PANYNJ. 2012c.
12. PANYNJ. 2012d.
13. NYT. 1955
14. EASTERN ROADS, 2012.
15. NYT. 1972.
16. NEW YORK CONTAINER TERMINAL (NYCT). 2011.
17. USACE. 2012.
18. NOAA. 2011.
19. HURRICANES SHOWN THAT WERE LISTED AS IMPACTING THE STATES OF NEW YORK AND/OR NEW JERSEY IN NOAA 2007.
20. TROPICAL STORMS AND LOCAL STORMS IDENTIFIED IN USACE 2006.
21. PASSAIC RIVER FLOODS LISTED ARE DEFINED AS "MAJOR" FLOODS ACCORDING TO NOAA 2011.
22. NJDEP 2009.
23. INFORMATION ABOUT THE CAUSE OF MAJOR FLOOD EVENTS WITHOUT AN ASSOCIATED STORM IS NOT AVAILABLE.

LEGEND:

- Opened
- Construction/Development Activities
- Demolished
- In Use/Maintained
- Hurricane
- Tropical Storm/Extra-Tropical Storm
- Local Storm
- Major Flood

NEWARK BAY STUDY AREA

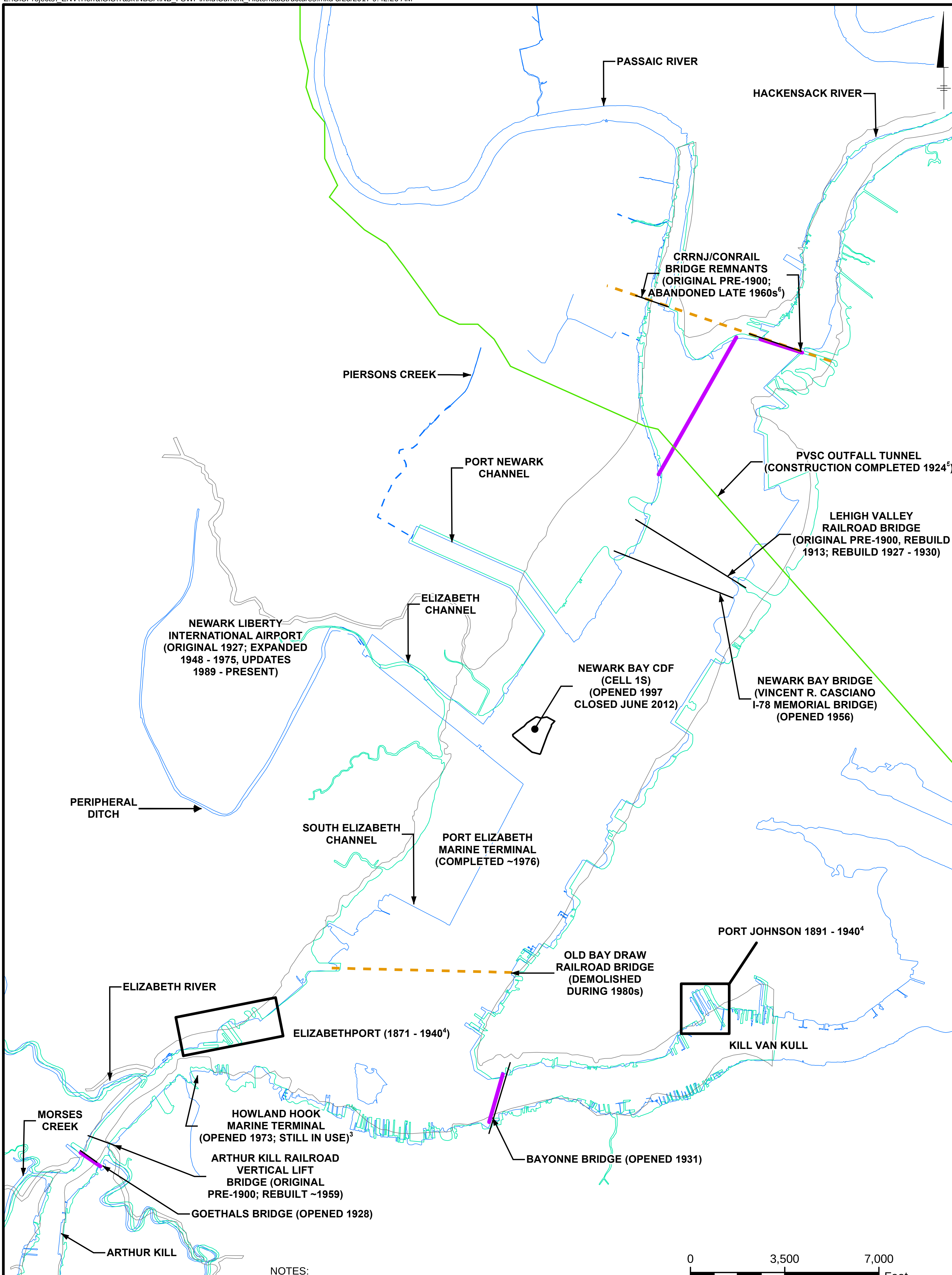
FEASIBILITY STUDY WORK PLAN

TIMELINE SUMMARY OF NBSA ACTIVITIES

REVISION 1, JUNE 2017

FIGURE **2-1**

City: SYR Div/Group: IM Created By: K. SINSABAUGH Last Saved By: ksinsabaugh
Newark Bay (B09989.0045.00001)
Z:\GISProjects_ENV\Tierra\GIS\Task\NBSA\NB_FSWP\mxd\Current_HistoricalStructures.mxd 5/23/2017 9:42:26 AM



LEGEND:

- 1940 SHORELINE
- 1845 SHORELINE
- SHORELINE
- UNDERGROUND TRIBUTARY
- HISTORICAL STRUCTURE (ABOVE GROUND)
- NEWARK BAY STUDY AREA BOUNDARY
- PVSC TUNNEL

NOTES:

1. SHORELINE IS DIGITIZED FROM AERIAL PHOTO DATED JULY 2002 (INTRASEARCH, ENGLEWOOD, CO).
2. HORIZONTAL DATUM: NEW JERSEY STATE PLANE COORDINATE SYSTEM, NAD 83.
3. DATE FROM NEW YORK CONTAINER TERMINAL HISTORY. www.nycterminal.com/t3/index.php?id=240.
4. DATE FROM USACE (2006).
5. DATES AND TUNNEL AVAILABLE FROM ww.nj.gov/pvsc.
6. DATE FROM NJDEP (2009).
7. HISTORICAL SHORELINES DIGITIZED FROM NOAA CHARTS DOWNLOADED FROM http://historicalcharts.noaa.gov/historicals/search

NEWARK BAY STUDY AREA

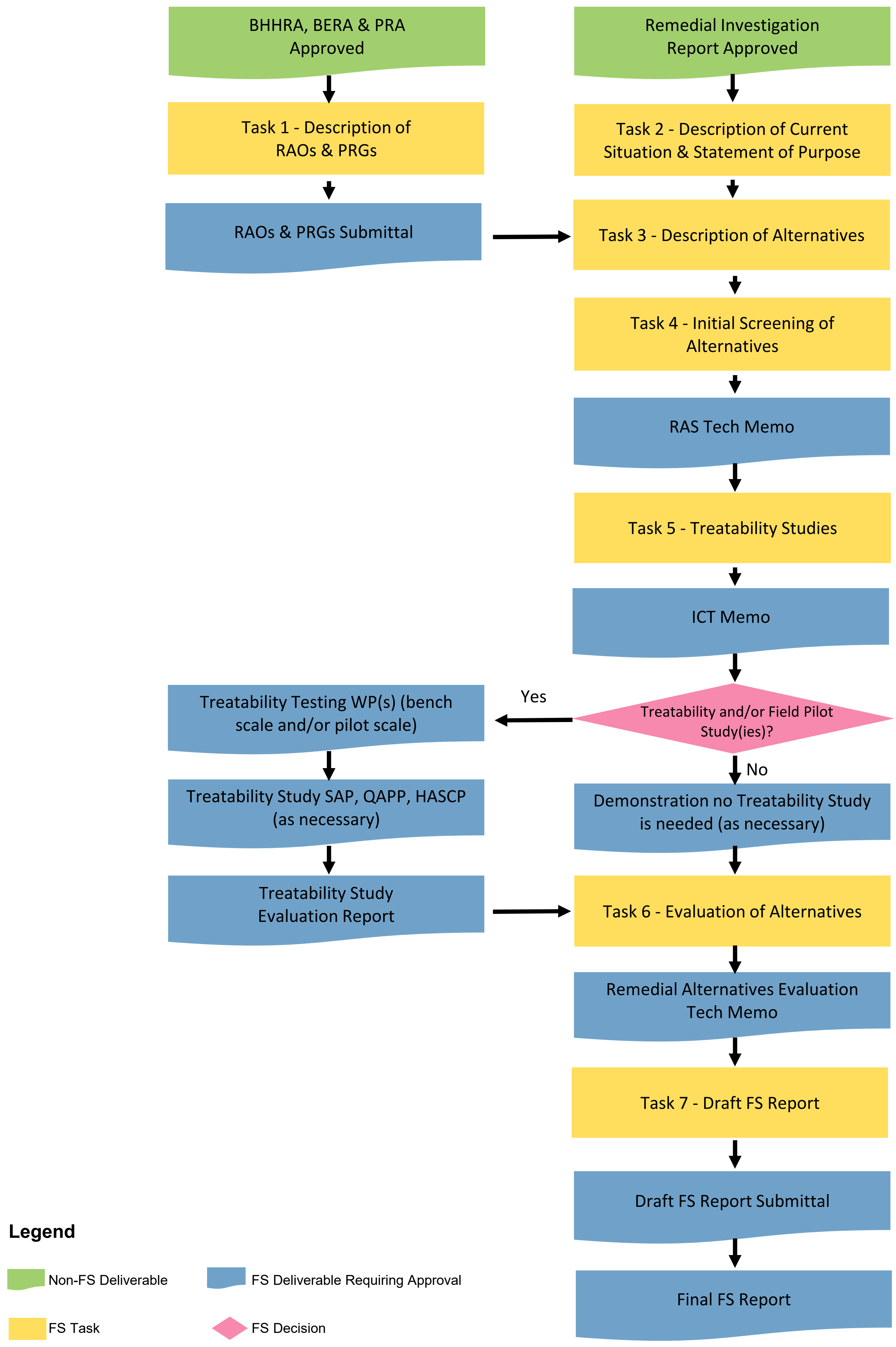
FEASIBILITY STUDY WORK PLAN

MAP OF HISTORICAL AND CURRENT STRUCTURES IN THE NBSA

REVISION 1, JUNE 2017

FIGURE

2-2



Acronym Definitions

BERA - Baseline Ecological Risk Assessment
BHHRA - Baseline Human Health Risk Assessment
FS - Feasibility Study
HASCP - Health and Safety Contingency Plan
ICT - Identification of Candidate Technologies
PRGs - Preliminary Remediation Goals
QAPP - Quality Assurance Project Plan
RAO - Remedial Action Objectives
RAS - Remedial Alternatives Screening
SAP - Sampling and Analysis Plan
Tech - Technical
WP - Work Plan

FIGURE 4-1
Feasibility Study Flowchart
NEWARK BAY FEASIBILITY STUDY WORK PLAN
Revision 1, June 2017