Diamond Alkali Natural Resource Damage Assessment

Study Plan for Evaluating Upper-Trophic Fish Injury in the Lower Passaic River

DRAFT for PUBLIC REVIEW and COMMENT

January 2021

Prepared for:

Passaic River/Newark Bay Complex Natural Resource Federal Trustees

The United States Department of Commerce
National Oceanic and Atmospheric Administration

and

The United States Department of the Interior
United States Fish and Wildlife Service

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EXECUTIVE SUMMARY

The Federal Trustees ("Trustees") of the Diamond Alkali Superfund Site and Environs – the United States Department of Commerce, represented by the National Oceanic and Atmospheric Administration (NOAA), and the United States Department of the Interior, represented by the United States Fish and Wildlife Service (USFWS) – are conducting a Natural Resource Damage Assessment (NRDA) for resources exposed to hazardous substances within the Passaic River/Newark Bay Complex (PRNBC). The final Damage Assessment Plan (DAP) provides additional detail regarding the environment in this area, the presence of hazardous substances, the role of the Trustees, and the plan for moving forward with the NRDA (Federal Trustees 2020).

The Lower Passaic River (LPR) is an approximately 17-mile portion of the Passaic River that runs from Dundee Dam (at approximately river mile [RM] 17.4) to the river mouth at Newark Bay (RM zero). The lower eight miles of the Passaic River, from the confluence with Newark Bay at RM zero to RM 8.3, are tidally influenced and heavily industrialized. The United States Environmental Protection Agency's (USEPA's) selected remedy for this reach will require dredging large volumes of contaminated sediment and is scheduled to begin in 2022 (USEPA 2020). Contaminant chemistry information is available for fish tissue and sediment samples collected from the LPR; these data have supported the USEPA's remediation process (e.g., USEPA 2019). The 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD or "dioxin") concentrations in fish tissues are orders of magnitude higher in the LPR compared to fish tissues collected above the Dundee Dam (CPG 2010, 2011, 2019a). Similarly, surface sediment concentrations of dioxin are several orders of magnitude higher within the LPR than in sediments collected above the Dundee Dam. An ecological risk-based analysis conducted by USEPA identified additional contaminants of concern for the LPR, which include DDx (sum of all six dichlorodiphenyltrichloroethane [DDT] isomers [2,4′-dichlorodiphenyldichloroethane (DDD), 4,4′-DDD, 2,4′-dichlorodiphenyldichloroethylene (DDE), 4,4′-DDE, 2,4′-DDT and 4,4′-DDT]), total polychlorinated biphenyls (PCBs), and polychlorinated dibenzo-p-dioxin/polychlorinated dibenzofurans (PCDDs/PCDFs or "dioxins/furans") (USEPA 2019).

In order to assess and quantify potential injury to upper trophic level fish in the LPR due to their exposure to LPR-related hazardous substances, the Trustees are undertaking a study on white perch. The objectives of this study are:

1. Identify and, as appropriate, quantify injury in adult white perch of the LPR compared to the Mullica River (MR), the reference area for this study.
2. Identify and, as appropriate, quantify injury in the sensitive ELS of white perch from the LPR and MR populations.

3. Use contaminant-exposure experiments in ELS white perch to determine relative contribution of injuries from maternal transfer of contaminants to eggs versus direct egg exposure from site contaminants.

Primary activities to achieve these objectives include collection of gravid white perch, implementation of a laboratory exposure experiment, and analysis of contaminant chemistry in fish tissues and exposure experiment sediment. In late winter/early spring 2021, gravid white perch from LPR and MR locations will be collected for use in spawning to generate embryos for exposure experiments and for assays of adults for health and reproductive impairment. The generated embryos will be used to implement a two-way factorial experiment (population source × sediment type) in which embryos from LPR and MR fish will be exposed to a dilution series of LPR sediments mixed in stepwise proportions with clean sediment from the MR, with a water-only control. Mortality of embryos will be quantified and larvae resulting from these embryos will be evaluated for a variety of physiological, genetic, and bioenergetic assays indicative of impairment, developmental abnormalities, and disease. The investigation of a wide suite of characteristics and multiple endpoints provides a more holistic understanding of the impact of LPR contaminants has on both individuals and a population. The analytical chemistry component will measure the concentrations of hazardous substances in LPR and MR fish tissues and stomach contents in order to identify the route of contaminant exposure within adult fish and their offspring and to evaluate the level of observed adverse effects relative to concentrations in fish tissues and exposure experiment sediment.

Laboratory exposure experiments will take place at the NOAA Northeast Fisheries Science Center's James J. Howard Marine Sciences Laboratory at Sandy Hook, New Jersey. Biological samples and sediment samples from the exposure experiments will be sent to an analytical laboratory to quantify the concentrations of contaminants of concern, which include DDx, metals, PCBs, polycyclic aromatic hydrocarbons (PAHs), and dioxins/furans. The analytical requirements for this work will be developed in collaboration with an appropriate contract analytical laboratory and will be consistent with the Quality Assurance Management requirements of the final DAP (see Appendix A of Federal Trustees 2020). The results from this study will be used to inform Trustee understanding of injury to white perch in the LPR through changes in mortality and reproduction.

The Trustees are interested in receiving feedback on this draft study plan from the public and are thus issuing this draft study plan for public review and comment. Comments should be submitted by February 15, 2021. These comments will help the Trustees plan and conduct NRDA that is scientifically valid and cost effective and that incorporates a broad array of perspectives. The Trustees request that you review this draft study plan and submit any comments electronically to greg.baker@noaa.gov with "DANRD Upper Trophic Fish Study" in the subject line. Alternatively, comments may be submitted in writing to:

Greg Baker
c/o Industrial Economics
2067 Massachusetts Avenue
Cambridge, MA 02474

A copy of this document is available for review online in the case administrative record at NOAA's website for Lower Passaic River and Greater Newark Bay, or on the Department of the Interior's (DOI's) Damage Assessment Tracking System website at Diamond Alkali Superfund Site.

CHAPTER 1 | INTRODUCTION

1.1 BACKGROUND

The Federal Trustees ("Trustees") of the Diamond Alkali Superfund Site and Environs include the United States Department of Commerce, represented by the National Oceanic and Atmospheric Administration (NOAA) and the United States Department of the Interior, represented by the United States Fish and Wildlife Service (USFWS) (referred to herein as "Trustees"). Acting under their authority as natural resource trustees pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), the Trustees are conducting a Natural Resource Damage Assessment (NRDA) for resources exposed to hazardous substances within the Passaic River/Newark Bay Complex (PRNBC). The PRNBC includes the Lower Passaic River; Newark Bay; and portions of the Hackensack River, Kill van Kull, and Arthur Kill (Exhibit 1-1).

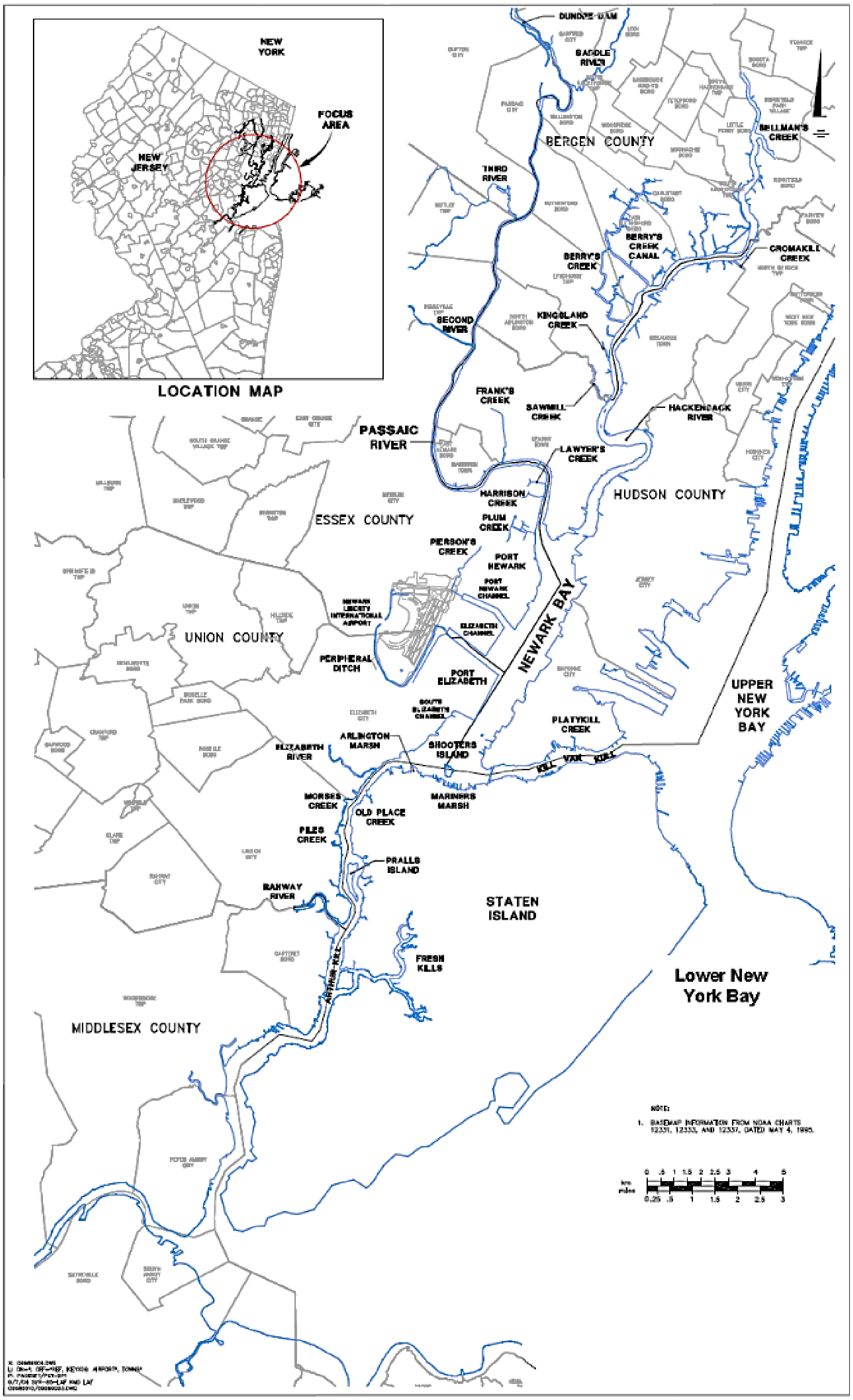
Consistent with the assessment activities described in the final Damage Assessment Plan (DAP), the Trustees are proceeding with the NRDA by conducting studies to fill data gaps with respect to fish toxicity, including early life-stage (ELS) and adult toxicity, due to contaminated sediment exposure (Federal Trustees 2020). Specifically, this study plan details the Trustees' goals and general procedures for collecting data on the response of fish to the contamination in the Lower Passaic River (LPR).

1.2 STUDY AREA AND CONTAMINANTS OF CONCERN

The lower eight miles of the LPR, from the confluence with Newark Bay at river mile (RM) zero to RM 8.3, are tidally influenced and heavily industrialized. The United States Environmental Protection Agency's (USEPA's) selected remedy for this reach will require dredging large volumes of contaminated sediment and is scheduled to begin in 2022 (USEPA 2020). The upper section of the LPR, from RM 8.3 to the Dundee Dam at RM 17.4, is generally freshwater and is characterized by less legacy contamination than the lower eight miles. However, the saline, contaminated waters and sediments of the lower miles influence water quality upstream due to regular tidal mixing and the movement of the freshwater-saltwater boundary. The entire LPR, from the confluence with Newark Bay to the Dundee Dam, is the subject of this study.

The presence of hazardous substances in fish in the LPR has been known for decades: see Chapter 2 of the final DAP for more information regarding hazardous substances in this area and Chapter 4 for more information regarding fish consumption advisories (Federal Trustees 2020). While these fish consumption restrictions protect human health from exposure to contaminated fish, fish continue to utilize the LPR as habitat and are adversely affected by the presence of hazardous substances.

EXHIBIT 1-1 PASSAIC RIVER, NEWARK BAY, NEW YORK/NEW JERSEY HARBOR, AND ENVIRONS (FROM FEDERAL TRUSTEES 2020)



1.3 PREVIOUS INVESTIGATIONS

Most existing data on fish uptake of contaminants from the LPR originates from studies conducted in support of the USEPA's remediation work and focuses on understanding chemical concentrations rather than conducting fish toxicity studies. Several extensive fish sampling events occurred in 2009, 2010, and 2012 as part of the Baseline Ecological Risk Assessment (BERA) (USEPA 2019). These included fish and decapod sampling events in late summer and early fall of 2009, fish community survey and tissue collection events in late spring and early summer of 2010, and a fish tissue background area sampling event in 2012 (CPG 2010, 2011, 2019a). In particular, levels of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD or "dioxin") in fish tissue samples collected from the LPR are orders of magnitude higher than fish tissue samples collected from the Passaic River above the Dundee Dam (situated at approximately RM 17). Tissue sampling conducted in the LPR, together with information in the existing body of literature regarding fish accumulation of and adverse effects due to environmental pollutants, suggest that contamination in the LPR is sufficient to cause injury as defined in 43 C.F.R. § 11.62 (f)(1)(i).

1.4 STUDY OBJECTIVES

The Trustees intend to assess natural resource injuries caused by hazardous substance releases, quantify those injuries, seek damages from the parties responsible for releasing the hazardous substances, and use those damages to restore, rehabilitate, and/or replace injured natural resources. Data collected under this study will support the Trustees' evaluation of natural resource injuries as part of the ongoing NRDA. Specifically, data on fish response to contamination will be used in the Trustees' evaluation of injury to invertebrate-consuming and piscivorous fish (i.e., upper trophic level fish) that are exposed to LPR-related hazardous substances. Further, the Trustees aim to collect ephemeral data prior to remedial dredging in order to understand current natural resource conditions in the LPR before the effects of remedy implementation occur.

In order to assess and quantify potential injury to upper trophic level fish in the LPR due to their exposure to LPR-related hazardous substances, the Trustees are undertaking a study on white perch. The objectives of this study are:

1. Identify and, as appropriate, quantify injury in adult white perch of the LPR compared to the Mullica River (MR), the reference area for this study.
2. Identify and, as appropriate, quantify injury in the sensitive ELS of white perch from the LPR and MR populations.
3. Use contaminant-exposure experiments in ELS white perch to determine relative contribution of injuries from maternal transfer of contaminants to eggs versus direct egg exposure from site contaminants.

Targets for analytical chemistry of contaminants in fish (adult) tissue and stomach contents include DDx, metals, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), and polychlorinated dibenzo-p-dioxin/polychlorinated dibenzofurans (PCDDs/PCDFs or "dioxins/furans").[1] Similarly, the sediment for the exposure study will be analyzed for the same suite of chemicals. Fish collections will take place in late winter/early spring 2021, prior to anticipated dredging of the LPR in 2022.

1.5 PUBLIC NOTICE AND COMMENT DETAILS

Public participation and review are an integral part of any NRDA. The Trustees have made this draft study plan available for review and comment for a period of 30 calendar days. The Trustees will incorporate public comments into the final study plan and will respond to those comments as part of the Report of Assessment.

Comments may be submitted electronically to greg.baker@noaa.gov with "DANRD Upper Trophic Fish Study" in the subject line. If submitting comments by e-mail, please include your name and mailing address. Alternatively, comments may be submitted in writing to:

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[1] For the purposes of this study plan, DDx is defined as the sum of all six dichlorodiphenyltrichloroethane (DDT) isomers (2,4′-dichlorodiphenyldichloroethane [DDD], 4,4′-DDD, 2,4′-dichlorodiphenyldichloroethylene [DDE], 4,4′-DDE, 2,4′-DDT and 4,4′-DDT).

CHAPTER 2 | STUDY DESIGN AND RATIONALE

2.1 OVERVIEW OF STUDY DESIGN AND RATIONALE

Data collected as part of this study will support the Trustees' determination and quantification of natural resource injuries for resources exposed to hazardous substances within the PRNBC as part of the ongoing NRDA. The Trustees have determined that white perch (*Morone americana*) is an appropriate fish species for this investigation for a number of reasons, including that they, in common with other fish species, represent a critical link in the Passaic River food web and are exposed to LPR-related hazardous substances in multiple ways.

Why study fish in general?

First, fish experience a wide range of habitats and exist at different levels of the food web during their life history. During the embryonic stage, especially for those fish that have negatively buoyant and adhesive eggs, individuals are largely immobile and fixed on or near the bottom sediments. Shortly after spawning, such eggs sink and adhere to bottom substrate. During this time and as they are residing on sediments, embryos progress through a number of key developmental events. Importantly, many of the LPR contaminants of concern are hydrophobic, becoming enmeshed in the sediment matrix. The fact that these eggs are closely associated with potential toxicant-impacted substrates at these critically sensitive times is potentially problematic for successful hatching and normal embryonic development and in subsequent ELS.

Second, the proximal source of a large fraction of the toxicants that an ELS individual is exposed to might be due to maternal transfer of toxicants to the embryo via the lipid-rich egg yolk. An adult fish from an impacted area has likely been bio-accumulating the same hydrophobic/lipophilic toxicants or their derivatives that are found in the sediment matrix. It has likely consumed bottom-associated prey directly or consumed predators of those benthic prey and may live in close association with the benthic habitat. Given this multi-level exposure, the maternal transfer of toxicants via lipid-rich ripened ova is an especially potent and likely mechanism of offspring impairment.

Why study white perch specifically?

The Trustees have chosen white perch for this study for several reasons. First, white perch is a dominant member of the estuarine fish community in the LPR as well as other local and regional waterways. As adults, this species occupies the upper trophic level of the fish community and has large influences on the trophic web and community structure throughout its life cycle. Upper trophic level organisms tend to accumulate and transfer contaminants to other long-lived, upper trophic level organisms, such as predatory fish and wildlife that feed on fish (Federal Trustees 2020). Second, the life history of white perch places it at potentially high-risk of contamination-related impacts because all of its life stages (embryos, young pre-feeding larvae, juveniles, and adults) dwell in benthic habitat. Third, white perch are generalists that consume a diverse diet that includes invertebrates inhabiting the benthos and other smaller fishes that themselves consume benthic invertebrates. Lastly, white perch is a popular recreationally and commercially fished species, especially in coastal bays of the Mid-Atlantic, and are expected to spawn in sufficient numbers in the LPR and MR for use in this study (see Section 2.2.2).

Study Design and Rationale

White perch are semi-anadromous with adults seasonally migrating within the respective river systems. During most of the year, the adults occupy relatively saline waters (five to 15 parts per thousand) of the estuary and lower tidal river. In spring, adults migrate upstream to low salinity (less than five parts per thousand) tidal waters, where spawning occurs during March through May. Eggs are negatively buoyant, settling to the substrate where they reside until hatching within a week, depending on temperature. The combination of a mobile adult with generalist feeding habits (including piscivory) and a benthic embryo means that the sensitive ELS organism could be exposed to contaminants by direct contact of the embryos to sediments and by transfer from female fish to their offspring via the egg. This study is designed to quantify the damage to adult white perch due to its occupation of a known contaminant-rich system (i.e., the LPR), to evaluate damage to the sensitive ELS and the potential for resilience under conditions that mimic outcomes of mitigation, and determine if LPR white perch exhibit impairment due to maternal transfer of contaminants and/or to genetic damage.

Objective 1 will be met by the collection of white perch adults from the LPR and MR study sites and their transport to the NOAA Howard Marine Sciences Laboratory (Sandy Hook, New Jersey), where the fish will be processed. Morphometrics will be based on lengths, weights, and images obtained at the time of capture. Histological samples will be prepared for gonadal, spleen, liver, and gill tissues. Genetic sequence, gene expression, protein synthesis, and endocrine profiles will be compared between LPR and MR fish in order to identify alterations known to be associated with impaired health and reproduction due to environmental contamination. Egg quality will be estimated from the sizes (diameters) of mature, extruded ova at the time of induced spawning in the laboratory, and fertility will be quantified as the proportion of eggs that are fertilized in controlled spawning in the laboratory.

Objectives 2 and 3 will be addressed by a two-way factorial experiment. The first factor is the degree of sediment contamination over which embryos will be incubated, and the second factor is the source population (LPR or MR) from which embryos are created for the laboratory experiments.

In 2020 Department of the Interior and University of Maryland researchers collected sediments systematically from different locations in the LPR; chemical analysis of these different batches of sediment is in progress and the sediments are stored frozen (USFWS 2020). Contaminated sediment from these collected batches will be used for the first factor in this study. To create several experimental exposure treatments the contaminated sediment from the LPR will be diluted in stepwise proportions with clean sediment from the MR, with a water-only control. This will provide sediments with a known range of contaminant levels to which sets of embryos will be exposed in the laboratory experiment. (Dilution series sediments will be analyzed to confirm post-dilution contaminant levels.) Each treatment will be conducted in triplicate. This dilution series will reveal the types, severity, and shape of the biological responses of ELS white perch to sediments that range across a broad spectrum of contamination levels found in the LPR (see Objective 2). Data from this part of the laboratory study will be evaluated for use in modeling reproductive impairment and failure site-wide.

The second factor in the two-way factorial experiment is the source population (LPR versus MR) of white perch adults to be used to produce the offspring (embryos) for the laboratory studies. The contrast of early life stage sensitivities between the LPR and MR groups, in particular for embryos and larvae from LPR fish that are incubated and raised on clean MR sediment, will reveal potential for resiliency in LPR white perch populations following anticipated LPR site remedial actions. In other words, if there is little to no improvement in reproductive success when LPR embryos incubate on MR sediment, that would suggest that adverse reproductive effects are principally driven by inherent adverse conditions in the adults, either through maternal transfer of contaminants to offspring, or through an altered underlying genetic basis that affects reproductive outcomes regardless of environmental conditions into which embryos are incubated. In contrast, observations of improved reproductive outcomes for LPR embryos raised in MR sediment would suggest that embryonic and larval exposure to sediment contaminants *in situ* in the LPR is the dominant driver of observations of reproductive impairment (see Objective 3). Data from this part of the laboratory will be evaluated for use in modeling potential future recovery of white perch and other upper trophic level fish in the LPR.

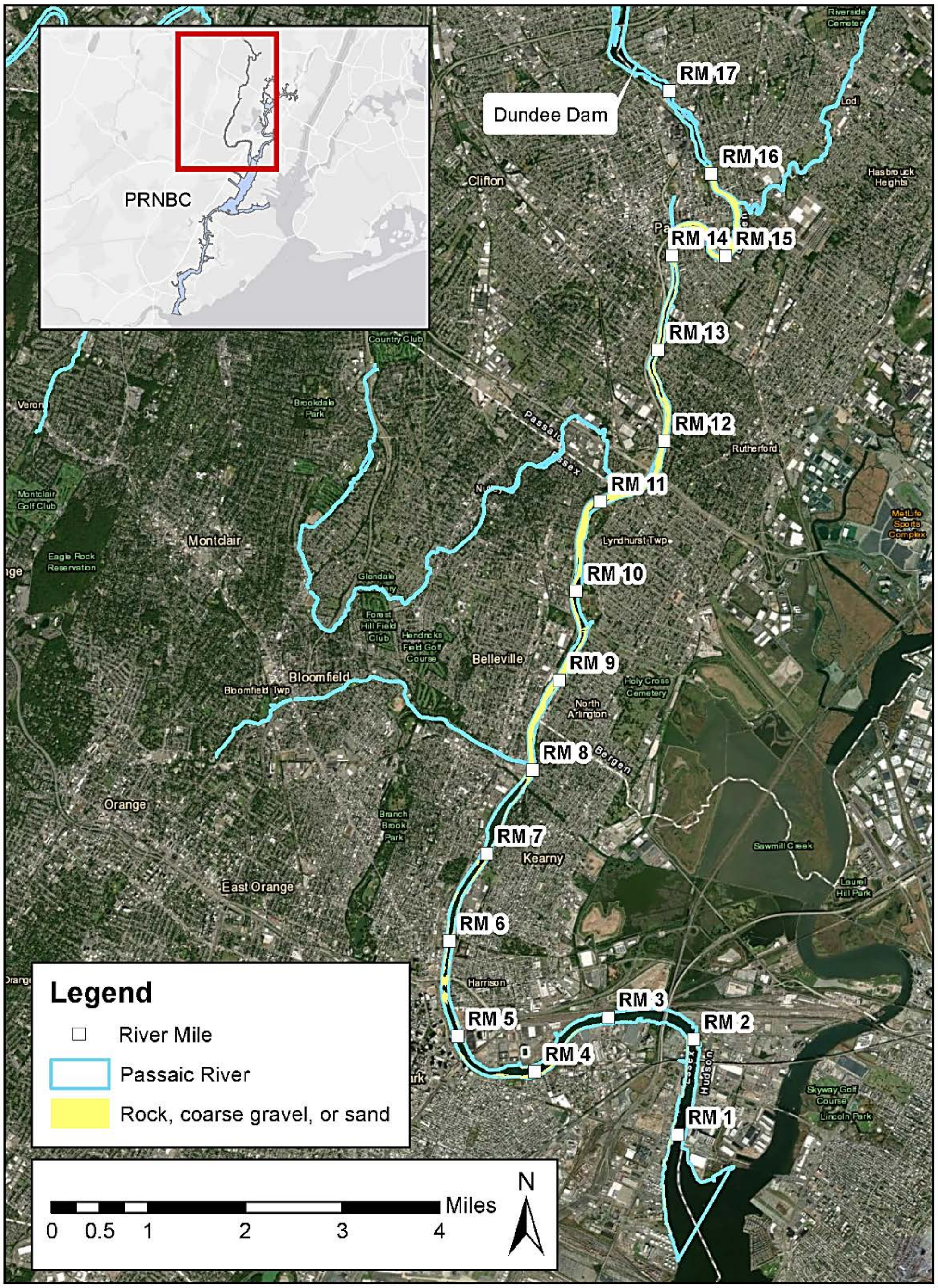
2.1.1 SCHEDULE

The Trustees anticipate the field collection to occur in late winter/early spring of 2021. This estimate encompasses the expected timeframe of white perch spawning activity in the LPR and MR. The laboratory components of this study are expected to conclude by the fall of 2021. A study report describing the field collection activities and laboratory results (toxicity and analytical chemistry) will then be prepared. The Trustees’ anticipated study schedule is subject to change given the ongoing COVID-19 pandemic; all relevant and applicable federal, state, and agency guidelines will be followed.

2.2 FIELD COMPONENT STUDY DESIGN DETAILS

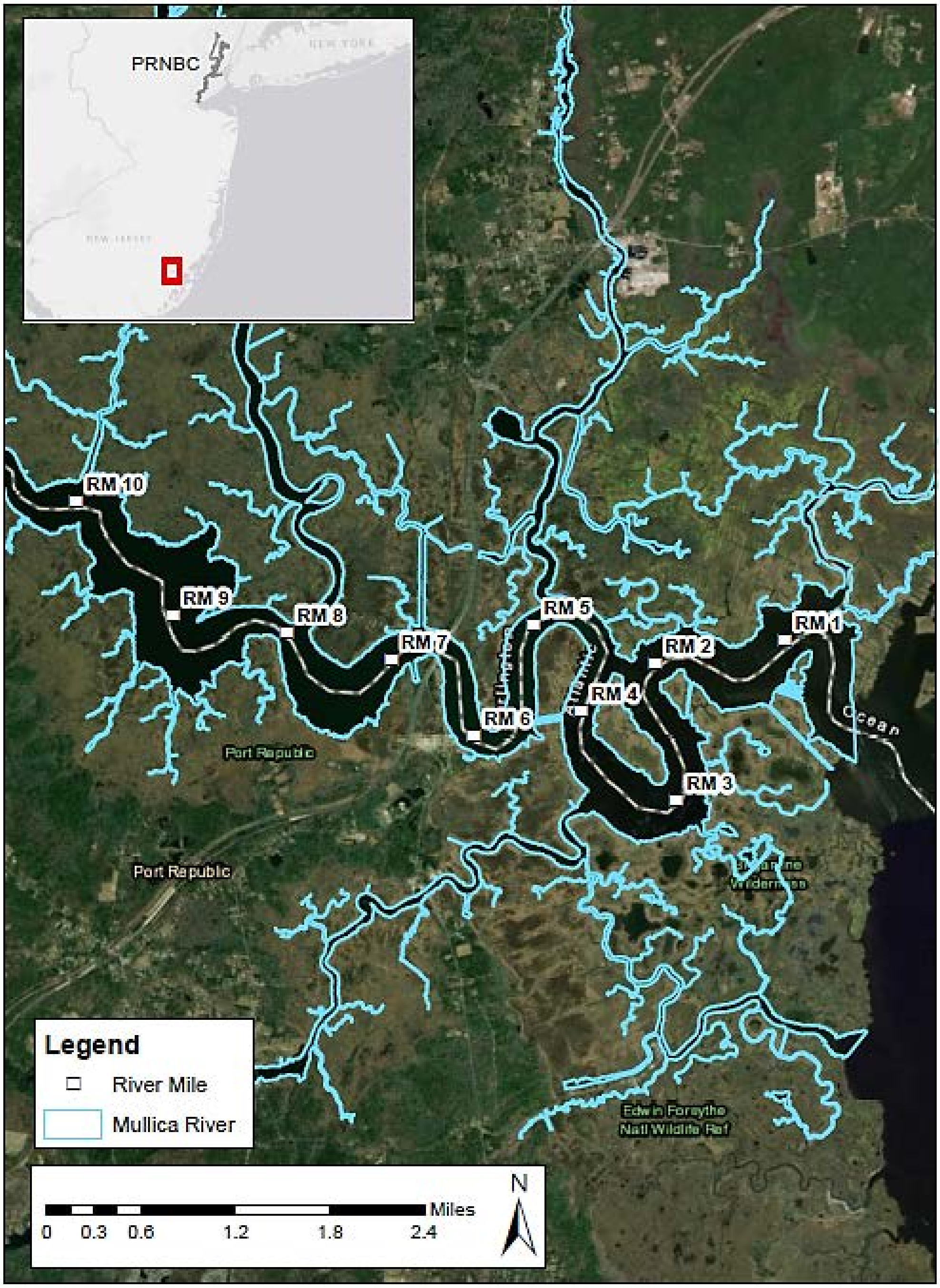
The field component of this study will be implemented during spring spawn. Both surface sediment (MR) and white perch (MR, LPR) will be sampled and transported to the NOAA laboratory. This section describes the available information for sediment and fish in the LPR and the MR (Exhibit 2-1 and Exhibit 2-2). Based on this contaminant and habitat information, white perch was selected as the target species and general sampling locations were identified.

EXHIBIT 2-1 LOWER PASSAIC RIVER



Sediment type data ends at approximately RM 16. Based on general knowledge of the river, it is anticipated that coarse-grained material is present between RM 16 and Dundee Dam.

EXHIBIT 2-2 MULLICA RIVER

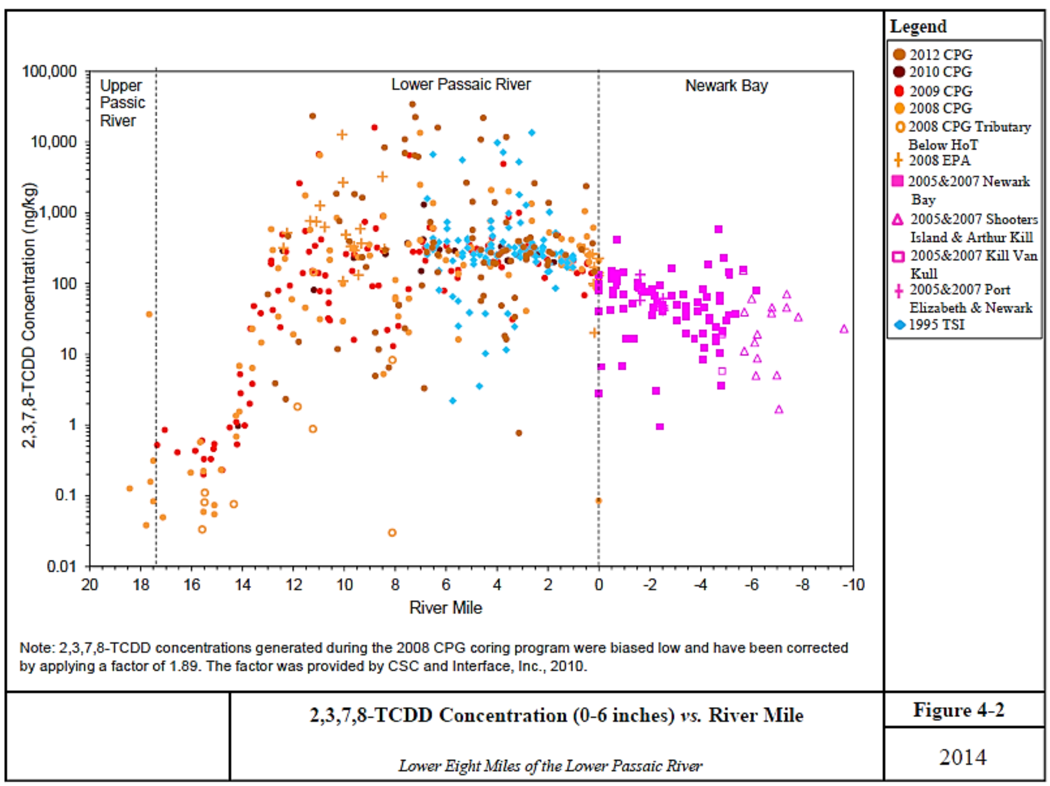


2.2.1 SUMMARY OF EXISTING SEDIMENT INFORMATION

The LPR includes the former Diamond Alkali facility and is known to be a highly impacted waterway. The Diamond Alkali Superfund Site, including the LPR, is subject of an USEPA-led Remedial Investigation and Feasibility Study (USEPA 2014, CPG 2019b) that included extensive surface sediment contaminant characterization along spatial and temporal scales. Sediment chemistry performed in 2009 and 2010 detected the presence of metals, PCBs, and dioxins/furans, in surface sediment samples collected in the LPR.

For example, Exhibit 2-3 presents TCDD concentrations from surface sediment samples collected between 2005 and 2012 from the LPR, the Upper Passaic River (UPR) (upstream of Dundee Dam), and Newark Bay (USEPA 2014). The data are plotted on a logarithmic scale as a function of river mile; these concentrations are several orders of magnitude higher within the LPR than in the UPR. Additionally, there are extremely high values, greater than 10,000 ng/kg, scattered throughout the LPR. In the lowest eight miles of the LPR, where the former Diamond Alkali facility was located, the concentration ranges from 0.09 to 34,100 ng/kg with many samples close to the median of 280 ng/kg (USEPA 2014).

EXHIBIT 2-3 TCDD SURFACE SEDIMENT CONCENTRATIONS (FIGURE 4-2 FROM USEPA 2014)



2.2.2 SUMMARY OF EXISTING FISH INFORMATION

As stated, white perch was selected as the focus of this study. Data from USEPA's 2009 and 2010 fish sampling events were reviewed (CPG 2010, 2011) as part of the decision process. These data comprise the most recent information available on the fish community in the LPR and therefore are most appropriate for determining which species are likely to be present in the LPR in sufficient numbers for the purposes of this study.

Because this study further aims to understand the effects of LPR-related contamination bioaccumulating through the food chain, upper trophic level finfish were considered as potential study species for this study.[2] Further, species that spend a substantial portion of their lives in the same general area (i.e., do not migrate long distances but have relatively high site fidelity) will best demonstrate body burdens and adverse effects resulting from LPR-related contamination. Finally, euryhaline species, or those with a broad salinity range, are more likely to be found throughout the LPR, which includes both freshwater and saltwater reaches. White perch, common carp (*Cyprinus carpio*), and pumpkinseed (*Lepomis gibbosus*) are the only abundant upper trophic level species captured in the LPR during USEPA's 2009 and 2010 sampling with relatively high salinity tolerance and site fidelity.[3] White perch was the most abundant of these species and was selected for the study.

Dioxins and other contaminants likely cause injury to white perch in the LPR. Tissue chemistry performed in 2009 and 2010 as part of USEPA's BERA work detected the presence of DDx, metals, PCBs, PAHs, and dioxins/furans in the tissue of white perch collected in the LPR. Further, the dioxin levels are orders of magnitude higher in the LPR compared to fish tissues collected above the Dundee Dam (CPG 2010, 2011, 2019a). These contaminants have been associated with endocrine disruption, poor hatching success, increased mortality, and deformities in fish (Myers et al. 1991, Walker and Peterson 1991, Walker et al. 1996, Davis 1997, Sfakianakis et al. 2015). Monosson et al. (1994) showed that injecting female white perch with 3,3′,4,4′-tetrachlorobiphenyl (TCB or PCB 77), a coplanar PCB with dioxin-like effects, impaired ovarian development and increased offspring mortality. These detrimental effects could propagate to the population level in the form of reduced recruitment, stunted growth, and reproductive impairment (Lawrence and Hemmingway 2003).

2.2.3 SAMPLING PROCESS AND LOCATIONS

Fish will be collected from multiple locations in the expected spawning region within the LPR. Sites will be identified based on preferred white perch spawning habitats (salinities less five parts per thousand and gravel-like substrates; Exhibit 2-1). Sampling efforts will begin in late February/early March 2021 and may continue throughout the spring spawning, which varies based on water temperature and other climatic conditions. Collection efforts will begin near RM 14 due to accessibility by boat and continue

[2] The Trustees are conducting additional studies in order to understand the impact of LPR contamination on lower trophic levels (e.g., forage fish) (USFWS 2020).

[3] Based on a review of ecological information from the online repositories FishBase.org (Froese and Pauly 2019) and the International Union for Conservation of Nature's Red List of Threatened Species (IUCN 2020) and targeted literature review.

downstream until gravid or advanced ripening white perch migrating upstream to spawn are encountered. All final sample collection sites will be noted in field data sheets (see Section 2.2.4).[4]

The MR, New Jersey will provide a "non-urbanized," clean reference sediment location and a reference white perch population for comparison. The MR has been used as a reference area in investigations to support the remediation of the Passaic River (e.g., Ludwig and Iannuzzi 2005 and Iannuzzi et al. 2005). Adult white perch in or near spawning condition will be collected from areas of low salinity within the MR and used as a chemically naïve, reference population. Past studies have reported aggregations of white perch near Lower Bank Bridge (river mile 9) of the MR. Sediment for use as a diluting agent will also be collected from the reference area.

Gravid fish (maximum of 50 per collection) will be transported live to the Sandy Hook facility. Preserved tissues from additional gravid adults (maximum of 20 per collection) will be transported to Sandy Hook for further histopathology and assessment. Further information on the study design is in Section 2.1.

2.2.4 DATA COLLECTION

Field notebooks will document key field sampling information, such as where, when, how, and from whom any vital project information is obtained. Entries will be complete and accurate enough to permit reconstruction of field activities. A separate notebook entry will be maintained for each sampling day, including comprehensive documentation of sampling locations and fish collection methods. The field sampling plan will include protocols for data collection and retention. A standardized suite of information will be recorded during the collection of samples (e.g., sample location, date and time, sample-specific measurements). The final study plan for this effort will include field forms showing the suite of collected information. Subsequent to field collection, sediment and tissue will undergo chemical analysis to understand the relationship between contaminant concentrations and biological effects (see Section 2.3).

2.3 LABORATORY COMPONENT STUDY DESIGN DETAILS

The laboratory component of this work will assess adult status from the LPR and MR populations (Objective 1) and quantify performance of offspring from both source populations in response to the conditions provided in the factorial experimental design (Objectives 2 and 3). Adult metrics and ELS responses of offspring may be used to quantify the impacts of sediment contamination to mortality, health, and reproductive capability consistent with 43 C.F.R. § 11.60 (*et seq.*). Examples of potential metrics for adult and ELS individuals include but are not limited to the following:

- Pathohistological examination of liver, gonad, spleen, and gill for indications of disease and developmental abnormalities in wild-caught adults.

[4] This study design is not intended to provide a population survey or evaluation of specific spawning locations for white perch. Fish community information is being collected under another Trustee study (USFWS 2020).

- Gene expression and hormone profiles indicating disruption of normal reproductive development and cycles in wild-caught adults.
- Egg quality and fertilization rate.
- Proportion of embryos surviving to hatching, duration of embryonic period, size and condition of larvae at hatching, and developmental abnormalities of embryos and hatched larvae (e.g., yolk-sac and cardiac edema, spinal curvature).
- Persistence of larvae in a food-free environment (median day at death) as an index of yolk assimilation efficiency.
- Physiological response and gene expression metrics that have been demonstrated to shorten lifespan and reduce fecundity with a focus on well-established endpoints identified in controlled laboratory studies that resulted from exposure to TCDD and other contaminants known to be present in the LPR.

The specific methods and procedures for quantifying these adverse effects in the laboratory follow standard scientific protocols used in other studies at our laboratory (e.g., Chambers et al. 2012; Chambers et al. 2014). Once at the laboratory, ripened females will receive an intramuscular hormone injection to induce final egg production by the following day. Males and females will then be strip-spawned by source population. The viability of each individual cross will be assessed within several minutes after mixing gametes and the eggs from viable crosses will be mixed. Sets of eggs will be drawn from the egg pool to populate the experimental units (replicates of different sediment dilutions, see study design in Section 2.1). The units are glass cylinders with mesh-bottoms onto which eggs will settle. The mesh will be gently lowered into a dish containing one of the sediment mixtures. Eggs will be monitored twice daily for mortalities and hatching larvae. Mortality rates as well as morphometric, developmental, and physiological and growth responses will be measured as metrics of impairment and health. In parallel with the collection of responses by the ELS, adult tissues and stomach contents will be analyzed to quantify the concentrations of DDx, metals, PCBs, PAHs, and dioxins/furans. The analytical requirements for this work will be developed in collaboration with an appropriate contract analytical laboratory and will be consistent with the Quality Assurance Management requirements of the final DAP (see Appendix A of Federal Trustees 2020 and Chapter 3 of this draft study plan).

2.4 ADAPTIVE MANAGEMENT

Certain aspects of the study may be modified during the implementation phase to maximize data collection towards achieving the objectives of this study. The Program Managers will work collaboratively with subcontractors and the Trustees to discuss the status of the project's sampling and analysis (see Section 3.1). Any modifications from or adjustments to the currently envisioned study will be discussed with and approved by the Trustees through NOAA's designated representatives. For example, additional field samples may be collected in order to characterize unique communities, geographic features, and presumed impacts, as appropriate. Also, final sampling locations are expected to be determined *in situ* by the field sampling team with oversight from the Trustees through NOAA's designated representatives, with consideration given to sampling timing and feasibility relative to the stated objectives of the study. Modifications to laboratory protocols may also occur (e.g., in response to increased or decreased sample sizes), but any procedural changes will be consistent with general scientific practice. Further, any modifications or corrective actions will be documented in field data sheets and the final study report, post-implementation (Section 2.1.1).

2.5 DATA ANALYSIS

A robust statistical analysis of the laboratory toxicity results and quantified metrics (e.g., degree of impact, percent occurrence) will be conducted. The sensitivity of white perch to hazardous substances, as well as the uptake of such substances from sediment, can be assessed by spawning chemically naïve fish on contaminated LPR sediment. Further, contrasting these results with the performance of LPR and MR white perch when maintained over reference sediment will allow for the testing of maternally transmitted toxicity to offspring or genetic impairment of offspring.

2.6 INJURY ASSESSMENT

Chapter 3 of the final DAP describes the NRDA process and the role of the Trustees in this process (Federal Trustees 2020). This study plan represents one component of the implementation of the final DAP. Consistent with the final DAP, the Trustees are assessing potential biological injuries to fish with a focus on ELS evaluation, following the DOI NRDA regulations (see Exhibit 4-3 of Federal Trustees 2020). The Trustees will measure potential adverse effects of increased mortality and decreased reproduction (and the accompanying loss of resource services as characterized by white perch) attributed to exposure to hazardous substances in the LPR. The results of this study are expected to inform the determination and quantification of potential injuries to fish in future analyses through the use of appropriate models and habitat or resource equivalency analysis, as described in Federal Trustees 2020. Additional studies for other natural resources will be implemented in accordance with the final DAP as the NRDA proceeds.

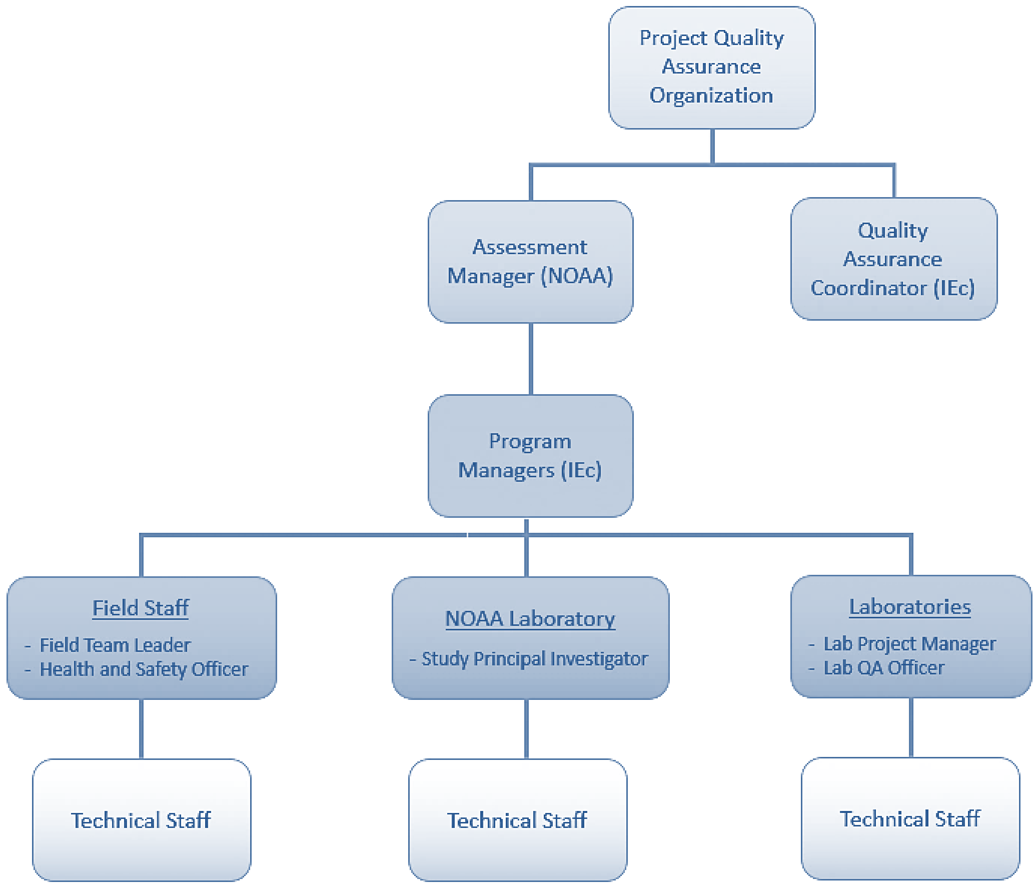
This chapter provides an overview of the Quality Assurance Project Plan (QAPP), which will cover all aspects of quality control (QC) (i.e., not just topics related to the analytical laboratory). A full QAPP is being developed and reviewed as part of the more detailed sampling and analysis plan (SAP) for this study.[5] The QAPP will be consistent with the project management, data generation and acquisition, assessment and oversight, and data validation and usability objectives defined in Appendix A of the final DAP (Federal Trustees 2020).

3.1 PROJECT MANAGEMENT

NOAA is managing this study on behalf of the Trustees. The project management organization for this draft study plan is consistent with that presented in Appendix A of the final DAP (see Exhibit A-1, Federal Trustees 2020). In addition to the roles identified in the final DAP (Exhibit A-1), Program Managers at Industrial Economics, Incorporated (IEc) will report directly to the Assessment Manager at NOAA (Exhibit 3-1). The NOAA laboratory Principal Investigator (PI), the Analytical Laboratory Project Manager, and the Field Team Leader will report directly to the Program Managers. The Quality Assurance (QA) Coordinator at IEc will oversee the implementation of the study, including whether specified QC procedures are followed as described. The QA Coordinator will discuss any identified issues with the Project and Program Managers as the need arises. Key personnel will review and sign the final SAP prior to project implementation.

[5] A detailed SAP and QAPP are required for the field contractor and contracted analytical laboratory to implement the study and will be developed in collaboration with them. Further, a health and safety plan will be developed that will include appropriate COVID-19 protocols.

EXHIBIT 3-1 PROJECT ORGANIZATION (MODIFIED FROM FEDERAL TRUSTEES 2020)



3.2 DATA GENERATION AND ACQUISITION

It is important ensure that data of sufficient and known quality are generated through the implementation of this study. The NOAA laboratory as well as the contracted analytical laboratory and field contractor will submit written Standard Operating Procedures (SOPs) detailing their respective methods and QC procedures. The Assessment and Program Managers will review and approve the SOPs, and the QA coordinator will review aspects related to QC. For analytical chemistry, standard USEPA and American Society for Testing and Materials (ASTM) methods will be used to determine the concentrations of DDx, metals, PCBs, PAHs, and dioxins/furans in field-collected (LPR and MR) sediment and fish tissue. For sediment samples, conventional measurements such as total organic carbon, sediment grain size, and percent solids will also be taken. For tissue samples, percent moisture and percent lipids will be analyzed.

The approved SOPs will be kept on file. Following the adaptive management approach outlined in Section 2.4, modifications to the approved SOPs will be documented in the final study report describing the field collection activities and laboratory results. Minor modifications will be made at the discretion of the Field Team Leader, Principal Investigator, or Analytical Laboratory Project Manager. For more significant modifications, the Program Manager or their designee will be consulted before modifications are implemented.

The Trustees intend to develop procedures and schedules for sharing data, split samples, and results of analyses, when requested, with any identified potentially responsible party. Information on any such decisions and procedures will be shared with the public.

3.2.1 DATA QUALITY OBJECTIVES

The Data Quality Objectives (DQO) Process (USEPA 2006) is a series of logical steps that guides planning for resource-effective acquisition of environmental data. It is both flexible and iterative. DQOs are useful in establishing performance or acceptance criteria, that serve as the basis for designing a plan for collecting data of sufficient quality and quantity to achieve a study's goals. For this study, the objectives and methods have been developed to achieve the DQOs quickly, safely, and cost-effectively (Exhibit 3-2).

EXHIBIT 3-2 DQOS FOR FIELD, ANALYTICAL CHEMISTRY, AND TOXICITY TESTING DATA

STEP	DESCRIPTION
Step 1: State the Problem	Contaminants from upland industrial facilities (e.g., Diamond Alkali chemical manufacturing plant) have been released to the PRNBC. Potential injuries to upper trophic level fish resulting from these releases have not been quantified.
Step 2: Identify the Decision(s)	Additional investigation is proposed to quantify the impact to white perch of contaminants currently in the LPR in advance of scheduled remedial dredging of the lower eight miles of the LPR.
Step 3: Identify the Inputs to the Decisions	Data on the effect of LPR contamination on white perch reproductive success (including fitness of offspring) will be collected via analysis of adult white perch condition and toxicity testing of fertilized eggs from LPR-collected adult fish. Field-collected sediment and fish tissue samples will be analyzed for contaminant chemistry (i.e., concentrations of DDx, metals, PCBs, PAHs, and dioxins/furans).
Step 4: Define Study Boundaries	The Lower Passaic River is the study area and the Mullica River is the reference area for the purposes of this draft study plan.
Step 5: Develop Decision Rules	Collect and analyze biological and analytical chemistry data to identify and, as appropriate, quantify potential injury in white perch in the LPR compared to the MR.
Step 6: Specify Tolerable Limits on Errors	Appropriate sampling techniques and supporting analyses will be utilized to obtain an optimum sample quantity and to identify sampling locations that will meet study objectives. Data review will be performed by the QA coordinator. Full data packages will be preserved for future review as needed.
Step 7: Optimize Sampling Design	Locations and numbers of samples will be based on a review of existing data combined with professional judgement and will be sampled using an adaptive management approach (Section 2.4).

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