

STUDY PLAN FOR FRESHWATER MUSSEL INJURY DETERMINATION

POPULATION ASSESSMENT AND POTENTIAL FUNCTIONAL ROLES OF NATIVE MUSSELS IN MULTIPLE SECTIONS OF THE UPPER HUDSON RIVER: 2014 REMEDIAL INJURY STUDY

HUDSON RIVER NATURAL RESOURCE DAMAGE ASSESSMENT

HUDSON RIVER NATURAL RESOURCE TRUSTEES

STATE OF NEW YORK

U.S. DEPARTMENT OF COMMERCE

U.S. DEPARTMENT OF THE INTERIOR

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EXECUTIVE SUMMARY

Natural resources of the Hudson River have been contaminated through past and ongoing discharges of polychlorinated biphenyls (PCBs). The Hudson River Natural Resource Trustees – New York State, the U.S. Department of Commerce, and the U.S. Department of the Interior – are conducting a natural resource damage assessment (NRDA) to assess and restore those natural resources injured by PCBs.

The Hudson River PCBs Superfund Site (the “Site”) extends about 200 miles between Hudson Falls and the Battery in New York City. A 40-mile stretch of the freshwater non-tidal Upper Hudson River, from Fort Edward to Troy, NY, is the site of an extensive PCB federal Superfund remediation project being conducted by General Electric Corporation pursuant to the Record of Decision issued by EPA in 2002. Dredging to remove PCBs, followed by capping or backfilling of dredged areas began in 2009 and is ongoing. The Hudson River Natural Resource Trustees have been assessing PCB contamination and injuries to natural resources in the Hudson River and have decided to survey native mussel populations to assess potential injuries to these resources.

Based on the results of preliminary investigations conducted by the Trustees in 2013, and goals of the NRDA, the Trustees have determined that it is appropriate to conduct further investigations focused on freshwater mussels, to be initiated in the year 2014. Pursuant to the Hudson River NRDA Plan, the Trustees have developed this Final Study Plan for a freshwater mussel injury determination effort. A Draft Study Plan for this work was peer reviewed and made available to the public for review and comment. All comments received on the Draft Study Plan, as part of the peer and public review process, have been considered. The Trustees evaluated peer and public comments and, where warranted, incorporated these comments in the Draft Study Plan to produce the Final Study Plan. A Responsiveness Summary, responding to public comments on the Draft Study Plan, will be provided by the Trustees in the near future. In the future, the Trustees may propose additional work to supplement this effort.

These surveys are designed to meet the following objectives:

1. Quantify freshwater mussel assemblages in areas that are targeted for dredging (“to be remediated”) to estimate the potential loss of freshwater mussels and some of the potential services provided by these mussels in areas that will be dredged.
2. Quantify freshwater mussel assemblages in areas not targeted for dredging (“unremediated”) to provide context for mussel assemblages in areas targeted for dredging.
3. Quantify freshwater mussel assemblages in areas following remediation (“remediated”) to estimate recovery potential.
4. Characterize the mussel community in a relatively un-PCB contaminated, unremediated reference reach (“reference”).

The purpose of this work is to inform the Trustees regarding injury to freshwater mussels resulting from the dredging of the Hudson River, as defined in regulations written by the U.S. Department of the Interior contained in Title 43 of the Code of Federal Regulations Part 11, Natural Resource Damage Assessment. This work will also be used to help determine whether future studies will be performed, and if so, to help in their design.

Pursuant to the Hudson River NRDA Plan, the results of the work conducted pursuant to this Study Plan will be peer reviewed upon completion of the study, and the results then released to the public.

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1.0 BACKGROUND

Freshwater pearly mussels are among the most imperiled groups of animals in North America (Strayer et al. 2004). Almost 300 species of freshwater mussels have been described as endemic to North America, representing the greatest diversity of these mussels in the world. Of these species, 13% are listed as extinct and 66% of the remaining species are ranked as vulnerable, imperiled, or critically imperiled (Master et al. 2000). Historically, 51 species of mussels have been described in the state of New York. Currently, 38 species are listed by the New York State Department of Environmental Conservation (NYSDEC) as extinct, threatened, or endangered, or are designated as Species of Greatest Conservation Need (<http://www.dec.ny.gov/animals/9406.html>). Because mussel populations in many rivers and lakes in the State of NY have never been surveyed and recorded, important populations of mussel species may exist, but have yet to be characterized or described. Such is the case for the Upper Hudson River (north of Troy, NY) where there is knowledge that abundant populations of mussels exist, but documentation of population sizes and species diversity is limited. Strayer (2012) noted that there could be 19 species of mussels present in the Hudson River between Corinth and Troy, NY.

The diversity and abundance of freshwater fauna provide critical functions and services in these ecosystems. An important group of organisms for the function of freshwater systems is the native pearly mussels (Bivalvia: Unionidae). Mussels can be the most abundant benthic organisms in terms of biomass in some systems, often occurring in high-density beds of multiple species (Strayer et al. 1999; Raikow and Hamilton 2001). Freshwater mussels serve as couplers of nutrient and energy flows between pelagic and benthic communities (Welker and Walz 1998; Raikow and Hamilton 2001; Nalepa et al. 1991; Vaughn and Hakenkamp 2001), particularly in moving water where materials would otherwise be transported downstream. In addition, mussel shells provide habitat for other benthic organisms (Sephton et al. 1980; Beckett et al. 1996) and epiphyton (Vaughn and Hakenkamp 2001; Gutiérrez et al. 2003) and a potential source of food for consumers (Owen et al. 2011).

These services are important for the preservation of clean freshwater ecosystems that provide drinking water and recreational opportunities for residents and visitors to New York. Changes to the diversity, long-term viability, and abundance of the native mussel community may alter the function and services that these communities perform. In the Upper Hudson River, where over 2.2 million cubic yards (cy) of sediment (along with the associated mussel community) have been removed since the dredging project began in 2009, large areas of the native mussel community have presumably already been altered. The remediation will ultimately remove approximately 2.65 million cy of sediment from River Sections 1, 2 and 3 (USEPA 2002) (Figure 1- See Appendix A).

2.0 INTRODUCTION

Based on the results of preliminary investigations conducted by the Trustees, and goals of the NRDA, the Trustees have determined that it is appropriate to conduct further investigations on freshwater mussels, to be initiated in the year 2014.

Pursuant to the Hudson River NRDA Plan, the Trustees developed a Draft Study Plan (Hudson River Natural Resource Trustees, 2014) for a mussel injury determination effort. As this investigation evaluates injury endpoints, the Trustees performed a peer review of that Draft Study Plan, and made it available to the public for review and comment.

In accordance with the Hudson River NRDA Plan, the Trustees are now issuing this Final Study Plan for a mussel injury determination effort. Changes made as a result of the peer review process have been incorporated into the Final Study Plan. A Responsiveness Summary responding to public comments on the Draft Study Plan will also be released. After the study is completed, the results will be peer reviewed and released to the public.

When ready, that information will be available on the following Trustee websites:

<http://www.fws.gov/contaminants/restorationplans/HudsonRiver/index.html>;

<http://www.dec.ny.gov/lands/25609.html>; and,

<http://www.darrp.noaa.gov/northeast/ HUDSON/>

3.0 PURPOSE AND OBJECTIVE

In 2013, a freshwater mussel pilot study was conducted within the Fort Miller and Stillwater pools in areas targeted for remediation and in areas that would not be dredged.

(http://www.dec.ny.gov/docs/fish_marine_pdf/nrdmussel.pdf). Proposed surveys in 2014 will quantitatively survey and characterize the species composition, population size, relative abundance, and population structure (in terms of age and length) of mussels within each surveyed section of river. From these data, we will estimate some of the potential ecological services (i.e., filtration capacity and production), provided by the existing mussel community in up to four pools of the river (including remediated and unremediated areas within 2 pools, to be remediated and unremediated areas in 1 pool, and a reference pool(s)). This information will be used to estimate species composition, relative abundance, population size, population structure and ecological services of mussel communities in the Upper Hudson River prior to and after remedial actions. This information, combined with 2013 study results, will provide an estimate of the mussels lost as a result of the remedial action and an initial estimate of recovery post-remediation. It will also provide a baseline for future restoration activities of remediated areas to address loss of ecological structure and function. They may also provide information about the changes in mussel communities in PCB contaminated areas relative to the upstream reference areas and available PCB literature. Thus, the 2014 surveys are designed to meet the following objectives:

1. Quantify freshwater mussel assemblages in areas that are targeted for dredging (“to be remediated”) to estimate the potential loss of freshwater mussels and some of the potential services provided by these mussels in areas that will be dredged.
2. Quantify freshwater mussel assemblages in areas not targeted for dredging (“unremediated”) to provide context for mussel assemblages in areas targeted for dredging.
3. Quantify freshwater mussel assemblages in areas following remediation (“remediated”).
4. Characterize the mussel community in a relatively un-PCB contaminated, unremediated reference reach (“reference”).

4.0 METHODS

On behalf of the Trustees, beginning in 2014, Principal Investigators (PIs) will conduct a study to quantitatively survey and characterize the species composition, population size, relative abundance, and population structure (in terms of age and length) of mussels within each surveyed section of the Hudson River. This information will be used to estimate species composition, relative abundance, population size, population structure and ecological services of mussel communities in the Upper Hudson River prior to

and after remedial actions. This information, combined with 2013 study results, will provide an estimate of the mussels lost as a result of the remedial action and an initial estimate of recovery post-remediation.

This study will be conducted pursuant to a work plan entitled "Population Assessment and Potential Functional Roles of Native Mussels in Multiple Sections of the Upper Hudson River: 2014 Remedial Injury Study Plan" contained in Appendix A.

This study will enable the Trustees to assess the following injuries: loss of freshwater mussels (and associated ecological services) as a result of the remedial action.

5.0 QUALITY ASSURANCE/QUALITY CONTROL

This study is being conducted in accordance with the Quality Assurance Management Plan for the Trustees' Hudson River NRDA (Hudson River Natural Resources Trustees 2002). The NYSDEC Hudson River NRDA Case Manager, working under the direction of the Hudson River Trustee Council, has overall project oversight responsibility. The Study Plan and Standard Operating Procedures for this study were developed to provide detailed and explicit instruction for the Field Teams to follow when collecting study data. Data developed in this study must meet standards of precision, accuracy, completeness, representativeness, comparability, and sensitivity, and be consistent with sound scientific methodology appropriate to the data quality objectives.

Strict chain-of-custody procedures will be used throughout the study. All samples collected under this Study Plan will be maintained under chain-of-custody upon collection, and through processing, storage and shipment to the testing laboratory, analytical laboratory or archive facility. Analysis will be by appropriate methods approved by the Trustees. Quality assurance and quality control are described in greater detail in Appendix A.

6.0 SPECIAL PROVISIONS

Permission will be required to enter private lands or lands under the jurisdiction of State agencies or authorities other than New York State Department of Environmental Conservation to access certain locations on the Hudson River.

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APPENDIX A

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ABSTRACT

The Hudson River PCBs Superfund Site (the “Site”) extends about 200 miles between Hudson Falls and the Battery in New York City. A 40-mile stretch of the freshwater non-tidal Upper Hudson River, from Fort Edward to Troy, NY, is the site of an extensive PCB (polychlorinated biphenyls) federal Superfund remediation project being conducted by General Electric Corporation pursuant to the Record of Decision issued by EPA in 2002. Dredging to remove PCBs followed by capping or backfilling of dredged areas began in 2009 and is ongoing. The Hudson River Natural Resource Trustees (HRNRT) have been assessing PCB contamination and injuries to natural resources in the Hudson River (HRNRT 2013) and have requested a proposal to survey native mussel populations.

These surveys are designed to meet the following objectives:

1. Quantify freshwater mussel assemblages in areas that are targeted for dredging (“to be remediated”) to estimate the potential loss of freshwater mussels and some of the potential services provided by these mussels in areas that will be dredged.
2. Quantify freshwater mussel assemblages in areas not targeted for dredging (“unremediated”) to provide context for mussel assemblages in areas targeted for dredging.
3. Quantify freshwater mussel assemblages in areas following remediation (“remediated”) to estimate recovery potential.
4. Characterize the mussel community in a relatively un-PCB contaminated, unremediated reference reach (“reference”).

Surveys will occur in areas targeted for remediation and not targeted for remediation in the Lower Mechanicville Pool (River Section 3) (i.e., prior to remedial activities), in both remediated and unremediated areas of Thompson Island Pool (River Section 1) and Northumberland Pool (River Section 2); and in a reference location upstream of the PCB contamination. The priority will be to first survey the Mechanicville Pool as remediation has not occurred in the lower pool to date. The final scope will depend on the amount of work that can be conducted during the 2014 field season while avoiding river pools under active remediation.

This proposal continues work begun in 2013 (Fort Miller Pool in River Section 2, Stillwater Pool in River Section 3) and describes an effort to estimate the species composition, relative abundance, population size, and potential ecological services of freshwater mussels in unremediated areas, areas targeted for remediation but not yet dredged, remediated areas, and reference areas. Surveys of unremediated areas and areas targeted for remediation prior to remedy implementation provide an assessment of mussels and their habitat in areas with a long history of PCB exposure. Selected reference pool(s) in the Upper Hudson provide an assessment of mussels and their habitat in areas upstream of the Hudson River PCB Superfund site, with generally much lower PCB concentrations. Baseline conditions for remedial injury are the mussel assemblages and the ecological services they provide prior to remediation (unremediated and to be remediated areas). Baseline represents what likely will be lost due to remedial actions at the Hudson River PCB Superfund Site. Surveys of remediated areas in the year or years following dredging and subsequent capping or backfilling could document the status of the mussel assemblages after the remedial action, shedding light on how mussel communities responded to the altered environment following dredging and subsequent backfill or capping. By assessing mussel communities in the relatively uncontaminated reference section, the study may also shed light on how mussel communities may have changed in response to the presence of PCBs within the PCB Superfund site.

PROBLEM STATEMENT

The native freshwater mussel populations of the Upper Hudson River have not been quantitatively surveyed or thoroughly characterized. A 40-mile stretch of the freshwater non-tidal Upper Hudson River, from Fort Edward to Troy, NY, is the site of an extensive PCB federal Superfund remediation project being conducted by General Electric Corporation pursuant to the Record of Decision issued by EPA in 2002. Dredging to remove PCBs, followed by capping or backfilling of dredged areas began in 2009 and is ongoing. Dredging will remove about 490 acres of PCB-contaminated sediment and freshwater mussels that reside in those sediments will be removed along with the sediment. Subsequent backfilling or capping should bury any mussels in the dredge area that might have escaped removal. In areas of the river where dredging/capping/backfilling activities (i.e., PCB remediation) have already been completed, surveys in adjacent unremediated areas and in other pools surveyed prior to remediation offer the best option to characterize mussel populations that were removed in the remediation process and/or impacted by contamination. A reference stretch upstream of the Hudson River PCB Superfund Site offers the best opportunity to characterize mussel populations in a large river system not likely impacted by PCB contamination.

In this proposal, the lead investigators and staff aim to conduct mussel population surveys in multiple reaches of the Upper Hudson River. These surveys, along with the surveys conducted in 2013, will provide the HRNRT with mussel population information. Potential ecological services (i.e., filtration capacity and production) provided by these mussels could assist the HRNRT in making decisions about potential restoration priorities following PCB remediation activities in the Upper Hudson River. Surveys will target unremediated areas, to be remediated areas, remediated areas, and upstream reference areas.

BACKGROUND

Freshwater pearly mussels are among the most imperiled groups of animals in North America (Strayer et al. 2004). Almost 300 species of freshwater mussels have been described as endemic to North America, representing the greatest diversity of these mussels in the world. Of these species, 13% are listed as extinct and 66% of the remaining species are ranked as vulnerable, imperiled, or critically imperiled (Master et al. 2000). Historically, 51 species of mussels have been described in the state of New York. Currently, 38 species are listed by the New York State Department of Environmental Conservation (NYSDEC) as extinct, threatened, or endangered, or are designated as Species of Greatest Conservation Need (<http://www.dec.ny.gov/animals/9406.html>). Because mussel populations in many rivers and lakes in the State of NY have never been surveyed and recorded, important populations of mussel species may exist, but have yet to be characterized or described. Such is the case for the Upper Hudson River (north of Troy, NY) where there is knowledge that abundant populations of mussels exist, but documentation of population sizes and species diversity is limited. Strayer (2012) noted that there could be 19 species of mussels present in the Hudson River between Corinth and Troy, NY.

The diversity and abundance of freshwater fauna provide critical functions and services in these ecosystems. An important group of organisms for the function of freshwater systems is the native pearly mussels (Bivalvia: Unionidae). Mussels can be the most abundant benthic organisms in terms of biomass in some systems, often occurring in high-density beds of multiple species (Strayer et al. 1999; Raikow and Hamilton 2001). Freshwater mussels serve as couplers of nutrient and energy flows between pelagic and benthic communities (Welker and Walz 1998; Raikow and Hamilton 2001; Nalepa et al. 1991; Vaughn and Hakenkamp 2001), particularly in moving water where materials would otherwise be transported downstream. In addition, mussel shells provide habitat for other benthic organisms (Sephton et al. 1980; Beckett et al. 1996) and epiphyton (Vaughn and Hakenkamp 2001; Gutiérrez et al. 2003) and a potential source of food for consumers (Owen et al. 2011).

These services are important for the preservation of clean freshwater ecosystems that provide drinking water and recreational opportunities for residents and visitors to New York. Changes to the diversity, long-term viability, and abundance of the native mussel community may alter the function and services that these communities perform. In the Upper Hudson River, where over 2.2 million cubic yards (cy) of sediment (along with the associated mussel community) have been removed since the dredging project began in 2009, large areas of the native mussel community have presumably already been altered. The remediation will ultimately remove approximately 2.7 million cy of sediment from River Sections 1, 2 and 3 (USEPA 2002) (Figure 1).

In 2013, a freshwater mussel pilot study was conducted within the Fort Miller and Stillwater pools in areas targeted for remediation and in areas that would not be dredged. (http://www.dec.ny.gov/docs/fish_marine_pdf/nrdmussel.pdf). Proposed surveys in 2014 will quantitatively survey and characterize the species composition, population size, relative abundance, and population structure (in terms of age and length) of mussels within each surveyed section of river. From these data, we will estimate some of the potential ecological services (i.e., filtration capacity and production), provided by the existing mussel community in up to four pools of the river (including remediated and unremediated areas within 2 pools, to be remediated and unremediated areas in 1 pool, and a reference pool(s)). This information will be used to estimate species composition, relative abundance, population size, population structure and ecological services of mussel communities in the Upper Hudson River prior to and after remedial actions. This information, combined with 2013 study results, will provide an estimate of the mussels lost as a result of the remedial action and an initial estimate of recovery post-remediation. It will also provide a baseline for future restoration activities of remediated areas to address loss of ecological structure and function. They may also provide information about the changes in mussel communities in PCB contaminated areas relative to the upstream reference areas and available PCB literature. Thus, the 2014 surveys are designed to meet the following objectives:

5. Quantify freshwater mussel assemblages in areas that are targeted for dredging (“to be remediated”) to estimate the potential loss of freshwater mussels and some of the potential services provided by these mussels in areas that will be dredged.
6. Quantify freshwater mussel assemblages in areas not targeted for dredging (“unremediated”) to provide context for mussel assemblages in areas targeted for dredging.
7. Quantify freshwater mussel assemblages in areas following remediation (“remediated”).
8. Characterize the mussel community in a relatively un-PCB contaminated, unremediated reference reach (“reference”).

METHODS

The purpose of the 2014 study is to quantitatively assess populations of freshwater mussels in up to four pools of the Upper Hudson River not sampled in 2013 by gathering data on species composition (number of species), relative abundance (number of mussels per square meter), population estimate (number of mussels in a given pool and/or stratum (to be remediated, unremediated and remediated areas, reference)), and population structure (age and length) of freshwater mussels and estimate two potential ecological services, filtration capacity and production, provided by the mussel communities. These results, in conjunction with 2013 data will help inform injury determination and restoration planning of mussels impacted by the remedy.

1. Lower Mechanicville Pool (River Section 3) in unremediated and to be remediated areas. The lower pool has not yet been dredged and sampling the unremediated and to be remediated locations will provide data on species composition, relative abundance, population estimate, population structure, and ecological services of mussels prior to dredging.
2. Thompson Island Pool (River Section 1) in unremediated and remediated areas. Surveys in remediated (dredged/capped/backfilled) areas and unremediated areas will provide data on species composition, relative abundance, population estimate, population structure, and ecological services of mussels undisturbed by dredging and in areas that have been remediated in 2009, 2011-2013.
3. Northumberland Pool (River Section 2) in unremediated and remediated areas. Surveys in remediated (dredged/capped/backfilled) areas and unremediated areas will provide data on species composition, relative abundance, population estimate, population structure, and ecological services of mussel populations undisturbed by dredging and in areas that have been remediated in 2013.
4. Upstream Reference Stretch in a relatively uncontaminated pool or pools between the South Glens Falls Dam and Corinth, NY where dredging (remedial or otherwise) has not occurred. Surveys in the reference stretch will provide data on species composition, relative abundance, population estimate, population structure, and ecological services of mussels undisturbed by dredging and subsequent capping or backfilling and exposed to relatively low PCB contamination compared to the 40-mile stretch of the Upper Hudson requiring remediation under the 2002 Record of Decision.

Definition of the reference reach

The potential reference reach consists of one or more pools between the South Glens Falls Dam and Corinth, NY upstream of the PCB-remediation project. This river stretch consists of four pools formed by a sequence of dams (Route 9 Dam in South Glens Falls; Feeder Dam; Sherman Island Dam; Spier Falls Dam; Corinth Dam). The reference stretch supports a warm water fishery (Fiorentino 2014). Since most species of freshwater mussels rely on fish to complete their reproductive cycle (i.e., mussel larvae parasitize the gills of fish), the diversity of fish species may influence mussel diversity. Based on personal communication and direct field observations, the reference area offers a suite of potential fish host species, the ecology and morphology of a large river system, and like the downstream reaches, a series of dams divide the river into flat pools.

Specific reaches within the reference stretch will be selected that appear to be similar in ecology and hydrology to the remediated stretches of the river downstream of Fort Edward while excluding known contaminated areas. The Feeder Pool, the pool downstream of the Sherman Island Dam, has been used in past studies by NYSDEC, USEPA, and General Electric as a reference stretch (USEPA 1997) and will be the primary reference pool sampled for mussels during 2014. Further observations of the overall topography, substrate type, vegetation, water depth, safety concerns, or other factors during on-site assessments of other pools within the reference reach may require adjustments to the inclusion of specific areas in the overall reference stretch, and these determining factors will be recorded in detail.

Mussel sampling and design

In this survey, a study site is defined by a 0.25 x 0.25 meter quadrat sampler placed adjacent to a marker anchor on the river bottom. Study sites will be selected using a stratified random sampling design in pools where remediation is planned or completed (i.e., strata are unremediated, to be remediated and remediated areas), and a simple random sampling design in the unremediated reference stretch. Such probabilistic sampling designs provide unbiased estimates of the mean and variance. Such designs are sometimes enhanced by using spatial data on known mussel beds or appropriate correlative habitat

variables (e.g., substrate type), but those data do not exist in sufficient quantity to permit the use of such designs in the Upper Hudson River.

The sampling design will identify sites within each surveyed pool, which could include the reference stretch, and the Thompson Island, Northumberland, and Lower Mechanicville Pool. The sampling grid will exclude the navigation channel and 30.5 meters upstream and downstream of dams prior to sample selection because of known safety concerns.

Sites will be selected from Geographical Information System (GIS) coverage provided by NOAA and will utilize a 10 meter by 10 meter grid. The grid will be reduced to a 5 meter by 5 meter grid when selection probability with a 10 meter by 10 meter grid is >10%. The timing of sampling and the number of pools sampled during the 2014 season will be determined based on the initiation date of field work and the 2014 remediation schedule (i.e., survey work within Mechanicville Pool will only occur prior to commencement of dredging in a given pool). The total number of locations investigated per pool and per strata may be modified in the field for the safety of field personnel (e.g., avoidance of working close to dams, in dense beds of water chestnut (*Trapa natans*), around boat traffic, strong currents, water depths greater than 9 meters) but is anticipated to be around 100 per strata per pool. These criteria are consistent with the approach taken during 2013 field season.

Pools Targeted for Surveying (allowing exclusion of sites/pools when in the field):

Feeder Dam Pool (Feeder Dam to Sherman Island Dam (~6.5 miles)):

Reference 100 to 120 sites

Unidentified Pool between South Glens Falls Dam and Corinth (if similar to River Sections 1-3 of the Hudson River PCB Superfund Site and time permitting)

Reference 100 to 120 sites

Thompson Island Pool (~6.1 miles):

Unremediated Areas - 100 to 120 sites

Remediated Areas by year completed- 30 to 40 sites/year (total of 100 to 120 sites)

Northumberland Pool (~2.9 miles):

Unremediated Areas - 100 to 120 sites

Remediated Areas - 100 to 120 sites

Lower Mechanicville Pool (~2.4 miles)

To Be Remediated Areas- 100 to 120 sites

Unremediated Areas- 100 to 120 sites

Investigators will make efforts to reduce sampling bias over space and through time by assigning sampling locations to blocks that represent a day of sampling (approximately 30 sites per day). The sequence for sampling of these blocks will be random, thus minimizing the potential for bias from sampling point locations in an ordered fashion. Additionally, the design will provide for an unbiased sample if not all sampling locations could be visited in the allotted study period; missing data will be at random (Rogala et al. 2007). Site selection approach is consistent with the method employed in the 2013 pilot survey. The sampling approach is consistent with the method employed in the 2013 pilot survey,

except where noted.

Predetermined sites (comma-delimited file with site coordinates) shall be located in the field using a GPS (Geographical Positioning System). A marker buoy labeled with the site identification number set at the site, and coordinates for the sampled site will be recorded on the datasheet (Appendix 1 –Site Coordinates Data Sheet). At each location, there will be two boats, one deploying sampling buoys, the other supporting the diver.

The diver shall excavate substrate within two 0.0625 m² quadrats (one excavation on each side of the marker anchor) into a 6-mm mesh bag attached to the sampling frame (Figure 2). The same diver who conducted the surveys in 2013 will survey mussels in 2014. The quadrat sampler will be modified slightly with a ca. 2-mm mesh bag for post-remediation sampling within areas remediated between 2009 and 2013. The ca. 2-mm mesh bag allows for the potential collection of newly transformed juvenile mussels which can be as small as 3-mm in length. The samples from the two quadrats will be combined to form one sample per site. The total area of each surveyed sample site will be 0.125 m².

The sampling depth within each quadrat will be 15 cm. Researchers have found that *Elliptio complanata* are rarely found deeper than 20 cm into soft sediment (Amyot and Downing 1991). Because adult mussels usually burrow <10 cm into the substrate (Balfour & Smock, 1985; Schwalb & Pusch, 2007; Haag, 2012), scientists often excavate samples down to a substrate depth of 15 cm (Newton et al. 2011). Juvenile *Elliptio* are not typically found at the sediment surface. They burrow into the sediment but the majority have been found up to 15 cm depth, similar to adult *Elliptio* (Schwalb and Pusch 2007).

Excavated material will be rinsed through the mesh bag and the contents transferred into a bucket labeled with the site number in the boat. On land, the collected samples will be transferred to trays and labeled with the site number to facilitate removal of all mussels. The unremediated, to be remediated and reference area material, sampled with ca. 6 mm mesh quadrat, will be passed through a series of graduated sieves with a minimum size less than 6 mm (i.e., 5.6 mm). The remediated areas, sampled with ca. -2 mm mesh quadrat, will be passed through a series of graduated sieves with a minimum size less than 3 mm (i.e., 2.8 mm). The graduated sieves used on the remediated area material will include the 5.6 mm sieve size, allowing for comparability with the unremediated, to be remediated, and reference areas sampled with the 6 mm mesh. The 2.8 mm sieve will provide additional information on newly transformed mussels in the remediated area as an assessment of recovery potential within the top 15 cm of sediment.

All live mussels will be identified to species, counted, aged (via external annuli count, if visible), and measured for shell length (to the nearest mm using the posterior/anterior axis). For consistency, the aging of mussels by counting external annuli and other mussel observations will be conducted by the same technician as in the 2013 surveys. Since external aging of mussels tends to be more accurate for young mussels, the external aging will provide us with an indication of recruitment of young mussels into the population. The age of older mussels will be determined at a later date by counting growth rings of shell thin-sections. The thin-sectioning of shells will be performed by a yet-to-be-determined contract facility that specializes in this type of work and the effort will be described in a separate document. The number



Figure 2: 0.0625 m² (0.25 m x 0.25 m) quadrat sampler with 6 mm mesh bag attached placed adjacent to the marker anchor on the river bottom. Sediment is excavated to a depth of ca. 15 cm at two sites (one on each side of the anchor) within the quadrat site for a total sampled area of 0.125 m².

and species of fresh dead mussels (with soft tissue and/or clean, shiny nacre) will also be counted as an index of recent mortality. The number and species of weathered, dead mussel shells (Appendix 2 - Mussel Data Sheet) will similarly be recorded and may provide additional information on historical species composition. However, only live specimens will be used for population measures.

At each site, investigators will record the water depth in the center of each quadrat to the nearest 0.1 m, qualitatively estimate substrate type, substrate penetration resistance, and the presence and type of aquatic vegetation. Substrate type will be determined by tactile/visual methods and be recorded as an approximate percentage of cobble, gravel, sand, silt, bedrock, boulder, detritus, and/or clay (Appendix 3 - Dive Boat Data Sheet) according to Cummins (1962).

Substrate penetration resistance (in kg/cm^2), a metric not recorded in 2013, will be measured within each of the two quadrats per sampling site by pushing the tip of a hand-held pocket penetrometer (Humboldt, or similar) into the stream bed to a depth of 6 mm and the resulting resistance will be read in kg/cm^2 (Geist and Auerswald 2007). A 2.5-cm adapter foot will be attached for measurements in areas of soft sediment to increase sensitivity and the readings divided by 16 to calculate actual resistance. A minimum value of $0.001 \text{ kg}/\text{cm}^2$ will be assigned to areas with extremely soft mud, where even with the adapter foot the penetrometer does not produce any detectable reading (Geist and Auerswald 2007).

A subsample of live mussels from each river reach (approximately 20 to 40 individuals of each abundant species), representing a range of size classes, will be used for estimation of wet and dry tissue and shell mass. To ensure representation of various size classes in the length-weight regression, mussels from 10-mm size class divisions will be randomly selected from across the survey region (i.e., from multiple sites) until 3 to 5 mussels from each size class (i.e., 11-20 mm, 21-30 mm, 31-40 mm, etc.) have been designated for the regression analysis. In addition, the smallest and largest individuals will be included to capture the lower and upper ends of the regression, respectively. The number of individuals selected within each size class for this analysis will be tracked by the mussel processing team on a separate data sheet. Mussel species will be validated by two members of the field team and representative shell or whole specimens of each species will be retained for species confirmation by colleagues who have expertise in the identification of mussel species in the Northeastern U.S.

A subsample (up to 50 from each river section, pool, or stratum) of older individuals of each abundant species (*Elliptio complanata* length ca. 85-110 mm) from each river section (including mussels from pools sampled in 2013) will be sent to a contract facility for thin sectioning and aging of shells by counting the internal growth rings (Neves and Moyer 1988; Haag and Commens-Carson 2008) as a separately funded portion of the project. All other mussels will be returned to the approximate location where they were sampled or retained and frozen for future analyses. For mussels that are returned to the river, particularly in already remediated areas, to ensure non-destructive sampling, mussels will be held in trays labeled with site identification until they can be returned to their original location. Retained mussel samples will be placed in ziplock bags labeled with the collection date, site number, and purpose of the sample (i.e., dry weight, aging, or PCB), and packed in coolers with ice for transport. They will be stored at -20°C until they can be processed. Investigators will document and track each sample on chain of custody sheets. If investigators encounter a species that is State or federally listed as threatened or endangered, this specimen will be appropriately cared for and will not be collected or destroyed. Photographic evidence of such specimens will be retained.

Frozen mussels will be processed by experienced technicians. Each mussel shell, whole tissue, and DNA foot tissue sample will be assigned and labeled with a unique identification number and preserved for future studies. Both shells of each bivalve mussel will be labeled with permanent marker, length recorded, and then stored in labeled boxes. Groups of the same species, collected at the same site on the same date will be assigned a lot number (for example, Unionid-0001), but each individual mussel (shells and tissues) will retain its unique ID (for example, 00010). When processing the mussels, all soft

parts will be removed and a small slice of foot tissue will be preserved in 95% ethanol. This foot tissue sample will be stored at -20°C to preserve DNA for extraction in potential future studies. The remaining soft mass will be weighed (g wet weight) and packaged in a small zip-lock plastic bag and initially frozen (-20°C) for potential future analysis of PCB concentrations. Archived tissues will be held at -80°C. Upon processing, the data associated with each mussel (e.g., ID, length, tissue weight, collection site and date) will be recorded on a datasheet and maintained in a digital spreadsheet. While in the possession of lead investigator and staff, the digital data file will serve as the chain of custody form for the mussel samples. If any samples are to leave the possession of lead investigator and staff, separate chain of custody forms will be created for those samples.

To estimate some of the potential ecological services, scientists will estimate filtration capacity and production provided by the mussel community within each sampled river reach. Investigators will develop length-mass regressions from a subsample of the abundant mussel species within each river pool. For each abundant species, the mean tissue mass across all sampled individuals will be multiplied by the mean abundance to obtain an estimate of the biomass of mussels per m² in the unremediated, to be remediated, and reference stretches as in Newton et al. (2011). Confidence limits will be approximated by multiplying the mean tissue mass by the lower and upper confidence limits around the density. To estimate the filtering capacity of the community, a filtration rate of 0.5 L per hour will be multiplied by the pool- or stratum-wide (i.e., remediated, to be remediated and unremediated areas, reference) mean biomass. Although, the amount of water an individual mussel can filter varies with abiotic and biotic factors (e.g., water temperature, species, mussel size) and experimental procedures, several studies have produced similar volume estimates. In a recent review paper, maximum filtration has been estimated at ~0.5 to 1 L/h (Vaughn et al. 2008 and references therein) over a range of species. Carbon content of mussels (grams per m³) will be estimated as one half of the mean dry tissue mass (Strayer and Smith 2001). Mean production (grams of carbon per m² per year), a measure of the energetic importance of native mussels in the Hudson River ecosystem, will be estimated from biomass using a total annual production to biomass (P/B) ratio of 0.2 (Nalepa and Gauvin 1988). For reference, Strayer et al. (1994) observed mean mussel abundance and filtration rates in the Lower Hudson River at approximately 8 mussels/m² and 0.14 m³/m² per day, respectively, prior to zebra mussel invasion. In that study, Strayer et al. (1994) observed much higher mussel densities (30-60 mussels/m²) in the upper estuary (River kilometer (RKM) 213 to 248) nearest to the Troy dam compared to mussel densities downstream to Newburgh (RKM 99). The data produced from the 2013 and 2014 surveys will allow us to compare the densities and filtration rates between Upper Hudson River pools (River Sections 1-3) subjected to PCB contamination relative to the upstream reference pool(s) and to similar data from the lower freshwater tidal Hudson River (as in Strayer et al. 1994).

Data analysis

Data on population estimates and relative abundance will be analyzed with survey sampling statistical software (Survey means procedure, SAS 2003). Data on size structure and potential ecological services will be analyzed as in Newton et al. (2011) and the analysis of age structure will be supplemented by the analysis of internal annuli. Data tables will be created presenting mean and 95% confidence limits for mussel community attributes (e.g. relative abundance (number/m²), weight (wet and dry in g), biomass (g dry mass/m² and g C/m²), age (external and internal ring counts), population estimate (total number), ecological services (filtration capacity (m³/m²/d) and tissue production (g dry mass/m²/yr and g C/m²/yr) and penetration depth (kg/cm²) in unremediated, to be remediated, remediated and reference areas in the pools sampled. Investigators will present data tables on species composition, population structure (age frequency) and length. Investigators will estimate biomass, production and filtering rates of each abundant species and present graphs of age frequency distributions.

The habitat data collected as part of the 2014 survey are not intended to be quantitative, but rather descriptive observations of the substrates from which each sample is taken. Thus, we do not intend to

correlate mussel metrics and qualitative habitat metrics using statistical analyses, but may assess the general trends of substrate types, penetration resistance, and mussel assemblages associated within river pools and remediated, unremediated, and to be remediated areas. These data will likely be presented as a series of graphs depicting the relative occurrence of various substrate types, penetration depths and mussel assemblages within each river pool and stratum.

Results from 2014 will be combined with those from the 2013 pilot study. Predictive estimates of mussel densities and ecological services will be prepared for remediated areas within Thompson Island and Northumberland Pools that were not surveyed prior to remediation and for unsampled pools in River Section 3. The results from the two years of data will be combined in the final report to present (1) an overall picture of the mussel populations in the Upper Hudson River (unremediated, to be remediated, remediated, reference), (2) the potential ecological services these mussel assemblages provide and (3) the potential loss of mussel assemblages and ecological services due to remedial activities within the upper 40 miles of the Hudson River PCBs Site.

QUALITY ASSURANCE/QUALITY CONTROL

Project Management

This study is being conducted in accordance with the Quality Assurance Management Plan for the Trustees' Hudson River NRDA (Hudson River Natural Resources Trustees 2002). The study team is organized based on tasks and levels of responsibility to ensure good communication between all personnel. The NYSDEC Hudson River NRDA Case Manager, working under the direction of the Hudson River Trustee Council, has overall project oversight responsibility. The Quality Assurance Coordinator manages communications from the QAC with the project team, especially the Principal Investigators (PIs). The NYSDEC Case Manager is responsible for ensuring that adequate coordination and communication occurs amongst the Trustees, the Quality Assurance Coordinator, the Principal Investigators, and the NYSDEC Project Coordinator. The Principal Investigators are responsible for the project's design, statistical analysis, reporting to the Trustees, providing guidance and technical expertise as needed to the Field Teams, and working with the NYSDEC Project Coordinator and Quality Assurance Coordinator to ensure that the study is consistent with the overall QA objectives of the NRDA. The NYSDEC Project Coordinator also supports implementation of the study plan developed by the PIs, facilitating the acquisition of access to NYSDEC facilities and support staff, and helping oversee the actions of the Field Teams.

The Study Plan and Standard Operating Procedures for this study were developed to provide detailed and explicit instruction for the Field Teams to follow when collecting study data. The plan will be reviewed, commented on, and approved by key parties to the study before the beginning of formal identification of study sites. Reliance on a detailed, explicit, and fully reviewed study plan ensures that:

- Study objectives, methods, procedures, and details are reviewed thoroughly before sampling. Data will be collected in a systematic and consistent way throughout the study.
- Every member of the study team adheres to the requirements of the plan. Each field team member is required to sign a statement (Appendix 9) that they have read the Study Plan and associated Standard Operating Procedures and understand them.

Events can arise during field data collections that require changes to the procedures being used. In these circumstances, deviations from the plan will be conducted only after consultation with the PIs or designee. Deviations from the work plan will be carefully documented, as will a detailed explanation as to why the deviations were necessary.

Data Generation and Acquisition

Data developed in this study must meet standards of precision, accuracy, completeness, representativeness, comparability, and sensitivity, and be consistent with sound scientific methodology appropriate to the data quality objectives.

Precision is defined as the level of agreement of repeated independent measurements of the same characteristic. Field personnel will be trained by the Field Lead or the NYSDEC Field Coordinator in the operation of GPS units, data collection, and the transfer of data to computers prior to the study. Data forms will be filled out in the field on-site and electronically transferred daily after the field work. Electronic records, including files for photographic data, will be kept up to date (i.e., daily) and backup electronic or paper copies created. A multi-stage visual and physical process of sieving sediments to identify mussels was designed to ensure a precise measure of mussels in each sediment sample. Multiple size gradients of sieves separate the entire sample (of mussels, rocks, sediments, etc.) so mussels can be visually identified. Individuals tasked with this identification are well trained in this process. The field lead will spot-check the work of the mussel processing team to ensure their adherence to SOPs.

Sample sites are identified precisely with GPS coordinates. Field technicians will be trained by the field lead in the operation of GPS units. Multiple factors, such as human error, boat movement, or suitability of site could potentially affect the actual location of each targeted sample site, but the actual location sampled will be recorded with the GPS unit. The GPS data from this study will be downloaded and saved for future reference, and the actual location of each sample site will be noted on a data sheet to ensure precise locational information exists. The creation of SOPs for many elements of this study also provides assurances of precise data collection.

To ensure that data from written data sheets are precisely transcribed into electronic data files, all entered data will be reviewed from the original data sheet by a two-person quality assurance team. The field lead will keep a field notebook, which contains information collected from the field and mussel processing teams, and will review data sheets daily to ensure field information is precisely reflected in data sheets.

Each of the pools, sites, lots, and individual mussels will be provided a unique number, which contributes to the precision of this study and facilitates chain of custody procedures. Each pool to be surveyed will be given a series of consecutive numbers, which will be assigned randomly to the sampling locations. (For example, a pool with 150 sampling locations might use the numbers 100 to 250. These numbers would be randomly assigned to the sampling locations in this pool). Sampling location numbers for 2014 will start with the last number used in 2013 and then will be assigned consecutively. Numbers will not be re-used in subsequent pools.

Mussel specimens that are retained as part of the study for eventual incorporation into the NY State Museum's collection will be assigned a mussel number. This numbering system is intended to track mussel shells and tissues in the Museum's collection and was not designed specifically for the Hudson River project. A 5-digit number will be assigned when the specimen is processed based on the Museum's mussel log and the number will be written on the inside of each shell with permanent marker (fine-tipped Sharpie), on the specimen bag if tissues for PCB analysis are preserved, and on the vial of tissue if DNA is preserved. A consecutive lot # (all specimens collected at the same site on the same date/time) will also be assigned based on the Museum's mussel collection log spreadsheet starting with the next available number.

Accuracy is defined as the agreement of a measurement with its true value. For the parameters related to this freshwater mussel survey, accuracy means that the identified animal has the agreed-upon characteristics that uniquely distinguish the species from other species, and its age can be determined either by shell size, external ring counts, or laboratory procedure of counting internal annuli. Each team

member will use the same reference sources and agreed upon characteristics for the identification of freshwater mussel species. The mussel processing team's procedure for measuring the length of mussels will be reviewed by the field lead to ensure precise measurement and that the location of the measurement is correct. The mussel processing team will follow the SOP for their work.

Completeness is defined as the percentage of the planned monitoring activity actually completed. The study design calls for the identification of more sampling locations than will actually be used, thereby allowing investigators to not sample some locations and still meet the study design requirements. Variables such as water depth, current, or submerged woody debris may create hazards that make some locations unsuitable for sampling. Investigators do not expect to sample in each of the locations identified. Investigators will make efforts to reduce sampling bias over space and through time by assigning sampling locations to blocks that represent a day of sampling (approximately 30 sites per day). The sequence for sampling of these blocks will be random, thus minimizing the potential for bias from omitting sampling points in an ordered fashion. Additionally, the design will provide for an unbiased sample if not all sampling locations could be visited in the allotted study period; missing data will be at random (Rogala et al. 2007). Site selection approach is consistent with the method employed in the 2013 pilot survey. The sampling approach is consistent with the method employed in the 2013 pilot survey, except where noted. Data forms will be filled out each day correctly and completely and 100% will be checked daily by the Field Lead or the NYSDEC Project Coordinator. Data forms will be legible and accurate.

Sensitivity is defined as the ability of a measurement technique or instrument to operate at a level sufficient to measure the parameter of interest. Instruments used for field measurements (GPS, temperature, penetration resistance, etc.) will have a level of resolution necessary to meet the degree of precision needed for each measurement. In this study, the parameter of interest being measured can be defined as the population of freshwater mussels in the sampled pools of the Hudson River. Therefore, the sufficiency of the number of samples taken per pool provides assurance that the sensitivity of this measure is sufficient to measure this population (Newton et al. 2011).

Representativeness is defined as the degree to which the data accurately reflect the true population. Study sites will be selected using a stratified random sampling design in pools where remediation is planned or completed (i.e., strata are unremediated, to be remediated, and remediated areas), and a simple random sampling design in the unremediated reference stretch. Such probabilistic sampling designs provide unbiased estimates of the mean and variance. Such designs are sometimes enhanced by using spatial data on known mussel beds or appropriate correlative habitat variables (e.g., substrate type), but those data do not exist in sufficient quantity to permit the use of such designs in the Upper Hudson River.

Comparability is defined as the measure of confidence with which results from this study may be compared to another similar data set. Because of the nature of the study, there cannot be a duplication of effort in the same area at the same time. However, the same sampling protocol will be employed in multiple pools of the Hudson River, ensuring that these data are internally comparable. Additionally, the data collected in 2014 will use the same methodology, documentation, and personnel as the surveys in 2013, making the data from these two years comparable as well. Thorough documentation of methodology used in this study will permit similar methodology to be employed in future studies, thus ensuring more comparability of this study with future work.

Field and laboratory audits will help assure that the project is conducted in the manner consistent with this work plan. A large number of factors may impinge on the samples being collected, their handling, and the conduct of analyses. It is not possible to anticipate all the factors that may potentially affect the conduct of the project, nor all the corrective actions, if necessary, that may need to be conducted. The general description for conduct of audits is included below.

An on-site field audit will be conducted by the Hudson River Quality Assurance Coordinator, or the Coordinator's designee, to assure compliance with good field practices and to assure proper collection, handling and measurement of specimens. The findings of the audit will be documented in writing and shall include observations on compliance with or deviations from the quality assurance project plan. Where deviations occur, and those deviations do not adversely impact the project, a rationale for the judgment shall be included. Where deviations require corrective actions, those recommendations shall be recorded and follow-up to assure compliance with recommended actions is required. If any deviations will substantially affect the quality of the data or the findings of the study, those opinions and rationale shall be recorded. In the latter event, the principal investigator shall consider the audit findings and take appropriate actions during the evaluation and reporting of data.

A third-party review of approximately 10% of field entries will be conducted by the Hudson River Quality Assurance Coordinator, or the Coordinator's designee, to provide an assessment of the precision of data entry. The findings of the audit will be documented in writing and shall include observations on completeness of data entry and compliance with the quality assurance project plan.

Study Documentation

All study activities will be documented in field notebooks, data forms, or personal digital assistants (PDAs) as appropriate. Electronic files will be downloaded and hardcopies printed. All hardcopies will be placed into three- ring binders. To the extent possible, information will be recorded on preformatted data sheets on rite-in-the-rain paper. The use of preformatted data sheets is a quality assurance/quality control measure designed to:

- Ensure that all necessary and relevant information is recorded for each sample and each sampling activity,
- Serve as a checklist for the field teams to help ensure completeness of the data collection effort,
- Assist the field teams by making data recording more efficient, and
- Minimize the problem of illegible field notebook entries.

Each field team will have a single field data recorder responsible for recording information in field notebooks or on data forms. Assigning this responsibility to a single person will help ensure that documentation is complete and consistent throughout the sampling event. The field data recorder is also responsible for the care, custody, and disposition of the field notebook and data forms and for downloading electronic files and providing hardcopies.

Field notebook and data sheet entries will be made in ink. Corrections will be made with a single line through the error accompanied by the correction date and corrector's initials. Each completed data sheet will be reviewed, corrected (if necessary), and initialed by the field data recorder. Following completion of the study, field notebooks, data sheets, and electronic-file originals including files for photographic data will be stored at the NYS DEC Hale Creek Field Station.

Assessment and Oversight

The QC management plan specifies that studies that generate data will be audited to ensure that the project-specific plans are being properly implemented. Several mechanisms for internal audits of the data generation process will be used. These mechanisms include:

- A project management structure that defines clear lines of responsibility and ensures communication between field teams and the PI or designee. Clear responsibilities and communication can serve as a means of providing internal audits of monitoring data.

- A requirement that field notebooks and data forms be reviewed by the PI or designee, or the NYSDEC Project Coordinator.
- The use of pre-formatted data sheets that serve as a checklist for monitoring procedures, thereby helping to ensure that data collection is complete.

The in-river sampling phase of the study will not begin until this Work Plan has been approved by the Quality Assurance Coordinator or the QAC's designee. The QAC or designee will conduct a field audit of procedures and documentation of the study.

Data Validation and Usability

This study employs standard, repeatable methods based on the scientific literature for collecting data. The study plan has been extensively reviewed for the adequacy of the study design and methods. The original field notebooks will be maintained by NYS DEC and archived at the Hale Creek Field Station. All materials related to the study will be archived until approval for any disposal is approved in writing by the Trustees. Final reports can be reviewed against original records to ensure that the data present in the reports represent complete and accurate information. Data analysis will be performed using commercially available statistical software.

The PI or designee will validate that biologists and technicians are collecting data as described in the study plan, and are completing data forms properly, by performing periodic checks during the study. Additionally, the PI, PI's Designee, or the DEC Project Coordinator will verify 100% of the manual transcriptions from the field forms to the electronic data sheet.

Chain of Custody Procedures

Strict Chain of Custody (COC) procedures will be used throughout the study. The purpose of the COC is to assure the integrity of each data file and mussel sample, and clearly identify who was responsible for these records. The COC form will be used to maintain records of sample transfer between personnel other than immediate team members. A completed COC form will accompany any transfer of mussel shells. The COC form will contain the following information:

- Project name
- Unique identification for each shell
- Name and signature of individual relinquishing custody
- Name and signature of individual accepting custody
- Shipping date and mode of shipment

Other information such as monitoring date and location may be on the COC form or on accompanying documentation. Each shipping container containing mussel shells will be accompanied by an original COC form for the items in the container. All sections of the COC form will be completed. All items included in the catalog will be clearly listed. Indication of the number of containers per shipment (*e.g.*, 1 of 3) will be listed on the form if more than one container is shipped. Once the form is completely filled out, it will be placed securely inside the container. Field personnel will maintain a copy of the COC to keep with shipping invoices. The container will be sealed with custody seals. Custody seals are used to detect unauthorized tampering with the contents until the time of receipt. Signed and dated gummed paper seals may be used for this purpose. The seals will be attached so that they must be broken to open the shipping container. Each container will be sealed with strapping or other tape. All mussel shells will be kept in a locked or otherwise secure location, or with custody seals at all times until shipped.

An air bill, Federal Express shipping label, etc. can be used to document the transfer of mussel shells from the field team to an intermediate storage location or archive. Containers with mussel shells will be opened only by a person authorized to receive these records. The containers will first be inspected for integrity of the chain of custody seals or other signs of tampering. The receipt of each record will be verified on the COC forms. The signed COC form will be photocopied, and the photocopy will be mailed to the sending party.

Staff

The study team is organized based on tasks and levels of responsibility to ensure good communication between all personnel. The NYSDEC Hudson River NRDA Case Manager, working under the direction of the Hudson River Trustee Council, has overall project oversight responsibility. The Quality Assurance Coordinator manages communications from the QAC with the project team. The NYSDEC Case Manager also provides direction to the Principal Investigators (PIs). The NYSDEC Case Manager is responsible for ensuring that adequate coordination and communication occurs amongst the Trustees, the Quality Assurance Coordinator, the Principal Investigators, and the NYSDEC Project Coordinator. The Principal Investigators are responsible for the project's design, the statistical analysis, and the formal reporting back to the Trustees. The Principal Investigators provide guidance and technical expertise, as needed to the Field Teams, acting as the Field Lead. The Field Lead guides the field study, working with the NYSDEC Project Coordinator and the Quality Assurance Coordinator to ensure that the study is consistent with the overall QA objectives of the NRDA. The NYSDEC Project Coordinator also supports implementation of the study plan developed by the PIs, facilitating the acquisition of access to NYSDEC facilities and support staff, and helping oversee the actions of the Field Teams. The NYSDEC Project Coordinator should be included in consultations that require deviations from the work plan. The PIs have primary responsibility for project design, data interpretation (including statistical analyses), final report preparation and scientific publication resulting from the investigation.

The NYSDEC Project Coordinator has the primary responsibility of coordinating field activities and data transfer between the Field Teams and NYSDEC. This may include the supervision of supplemental field teams composed of NYSDEC staff if additional field teams are deemed necessary for the study. The NYSDEC Project Coordinator will also assist in verifying accuracy of data transferred from field forms to electronic data sheets.

Technicians designated by the NYSDEC will support field work efforts by assessing locations for river access, driving boats, deploying buoys at sampling locations, and transporting buckets of sampled sediments back to the mussel processing team.

Facilities

NYS DEC facilities are available for construction and storage of field apparatus, storage of field apparatus, storage of supplies, and archival storage of any data sheets.

NYS DEC Hale Creek Field Station

182 Steele Ave. Ext.

Gloversville, NY 12078

Phone 518 773 7318

Fax 518 773 7319

Expected Products

Activity updates are to be provided to the Trustees monthly. The investigators will provide databases and data reports that include methods, metadata, and an initial summary of field data upon the conclusion of the project. A final report that includes data from 2013 and 2014 surveys will be prepared for the study. Reports will be forwarded to the U.S. Fish and Wildlife Service Northeast Regional Office,

300 Westgate Center Rd. Hadley, MA 01035 to the attention of Ms. Margaret Byrne; where possible, electronic copies of the reports will also be provide to the Trustees (Margaret_Byrne@fws.gov). Monthly activity updates are to be provided to the same address (e-mail preferable).

Results of this study may be published in one or more peer-reviewed scientific journal articles, subject to review and approval by the Trustees.

Using data to inform recovery efforts

The purpose of this study is to assess the remedial injury to freshwater mussels due to dredging and subsequent capping/backfilling being conducted between Fort Edward and Troy, New York as part of the Hudson River PCB Superfund Site remediation, and to use the results to guide mussel restoration planning efforts following remedial actions at the site. This work may also inform the potential for adverse effects from PCB-contamination from the site on native mussels. The final report will summarize data from the 2014 surveys and compare these to data from the 2013 surveys. The combined data set will provide the HRNRT a more complete picture of the mussel community across surveyed pools (Thompson Island, Fort Miller, Northumberland, Stillwater, and Lower Mechanicville Pool) in River Sections 1, 2, and 3, including remediated, to- be- remediated, and unremediated areas within the geographic scope of the Hudson River PCB Superfund Site remedy, and in an upstream reference stretch of the Hudson River. Results from surveyed pools will be used to provide estimates for unsampled pools; e.g., Waterford Pool, Troy Pool and for sections of pools remediated prior to surveying (e.g., Thompson Island, Northumberland).

These survey data can be used to inform future restoration activities because they provide resource managers a reasonable benchmark of what the mussel assemblage in select reaches consisted of before dredging and subsequent capping/backfilling (i.e., unremediated and to be remediated areas surveyed in 2013 and 2014) and prior to PCB contamination (i.e., the reference pool(s)). These benchmarks can be used as targets for future restoration activities. For example, the proposed work will identify the ranges in population size, relative abundance, size structure, and potential ecosystem services in unremediated, to be remediated, remediated, and reference areas of the Upper Hudson River. Results from surveyed areas can be extrapolated to the unsurveyed areas within the remediation project area and to areas that were only surveyed after remediation to estimate the mussel assemblage prior to dredging and the extent of injury to the mussel community and associated ecosystem processes due to remedial actions and possibly to PCB contamination. Further details on how the proposed work can inform the evaluation of injury and potential restoration activities will be developed in coordination with the Trustees.

APPENDICES IN FINAL REPORT

The report appendices will include all field notes, raw data sheets, chain of custody forms, maps, photos of voucher specimens, documentation verifying identify of voucher specimens, location and list of archived samples, SAS runs, etc. Calculations used to generate final values in report should be transparent.

REPORTING REQUIREMENTS

Electronic draft and final reports and associated files will be provided to representatives of each HRNRT agency. Shape files with populated attributed tables and Excel or Access spreadsheets used to generate tables, figures or results will be provided electronically as a component of the report. All original documents will be saved by the PIs. All archived tissue will be saved by the PIs. A written request will be

made to the HRNRT in the advent that there is an interest in disposing of archived tissue. All mussel shells will be archived with the NYS Museum.

SCHEDULE

The general period of performance is August 15th, 2014 to September 30, 2014, but the schedule is subject to the timing of funding and river water levels. If sampling cannot be completed in the fall of 2014, work under this plan may continue in the summer of 2015. Such a delay would also delay report creation until the completion of sampling activities and data analysis.

- June-August 2014: Draft scope of work, create datasheets, seek peer review and public comment on draft, establish sampling sites
- August 2014: Issue final study plan and responsiveness summary
- August-September 2014: Time permitting, sample Lower Mechanicville Pool, Northumberland Pool, Thompson Island Pool and Reference pool(s).
- October 2014: Process mussels for length-dry weight regression analysis
- November 2014-January 2015: enter and proof data and estimate relative abundance and population size; process and archive mussel shells and tissues; send mussel shells to contract laboratory for internal growth ring analysis; provide trustees update on 2014 study results
- February-May 2015: estimate potential ecological services and begin report preparation; continued processing and archiving of mussel shells and tissues
- June 2015: draft final report to Trustees
- September 2015: final report to Trustees

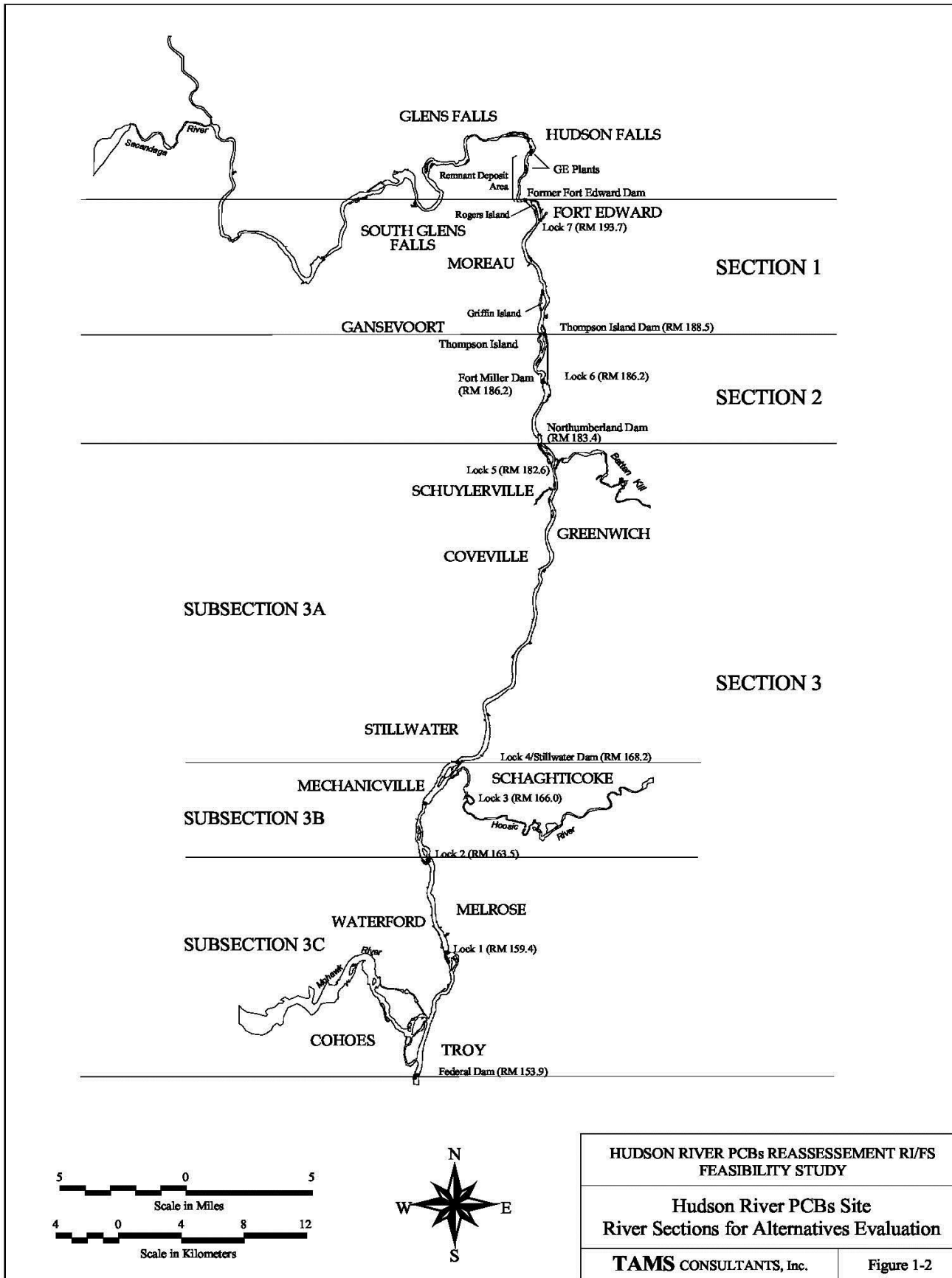


Figure 1: Hudson River PCB Site River Sections

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APPENDICES

Appendix 1: Site Coordinates Data Sheet

Site Coordinates Data Sheet

Personnel: _____

Upper Hudson River - Location:

SITE ID	Target Easting	Target Northing	Actual Easting	Actual Northing	Date sampled	Notes
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						

Date entered: _____ ()
Date QC Checked: _____ (/)

Appendix 2: Mussel Data Sheet

Page ____ of ____

Personnel: _____

Location: _____

Upper Hudson River

Collection Date:

Site #	Fresh dead (FD)	Snails
	Weathered dead (WD)	
	Zebra Mussel (ZM)	Corbicula
Species	Length (mm)	Age (years)
	-	
NOTES:		

Date entered: _____ ()

Date QC Checked: _____ (/)

Appendix 3: Dive Boat Data Sheet

Dive Boat Data Sheet

Upper Hudson River

Page ____ of ____

Personnel: _____

Diver ID: _____

Collection Date: _____

Quad #		H ₂ O depth (m):
Substrate %		Veg present in quad?
Clay	-	No Yes
Silt		Type:
Sand		
Gravel		Penetrometer:
Cobble		<input type="checkbox"/> foot adapter
Boulder		#1
Bedrock		#2
Vegetation		Notes:
Detritus		
Logs		
Shells		

Date entered: _____ ()

Date QC Checked: _____ (/)

Appendix 4: Mussel Size Class for Length-Weight Regression Data Sheet

Mussel Size Class for Length-Weight Regression Data Sheet

Upper Hudson River

Location: _____

Species: _____

Size Class	Record Date collected and site #					Notes:
1-10 mm						
11-20 mm						
21-30 mm						
31-40 mm						
41-50 mm						
51-60 mm						
61-70 mm						
71-80 mm						
81-90 mm						
91-100 mm						
> 100 mm						

Date entered: _____ ()

Date QC checked: _____ (/)

Appendix 5 - Health and Safety Plan

Hudson River Mussel Surveys 2014 SOP: Health and Safety Plan

The success of any field sampling program is a direct result of careful and complete planning and organization. The safety of all field personnel is the most important factor to consider in planning all aspects of a study. This document describes the roles that each team member plays in completing a safe and productive field season.

- Each employee shall report to work in an alert, agile and capable condition.
- Each team leader is responsible for basic health and contact information records to be on site for each of their staff. This includes a complete list of staff, health concerns (allergies, medications, etc.), and contact information.
- A first aid kit will be available at the launching site (mussel processing station) and each member of the crew will be shown its location and contents at the beginning of the season.
- Daily Work Plan: The work plan for the day will be discussed with the entire crew at the beginning of each work day. Items to be discussed include:
 - Sites to be sampled and where to begin sampling.
 - Assessment of potential hazards, weather, tides, current, etc.
 - Check two-way radios for batteries and that all radios (3) are powered up.
 - Presentation of appropriate data sheets and maps to each crew.
 - The site marking crew (NYS-DEC boat and crew) will evaluate maps, data sheets, and daily site plan.
 - The dive boat survey crew will assess safety equipment on the boat (dive flag, anchor), data sheets, maps, and site plan.
 - The mussel assessment crew will set up tables and equipment in a safe location, prepare appropriate data sheets, and keep the shore site organized.
- Personal flotation devices will be provided, appropriately adjusted, and worn by personnel while in sampling watercraft.
- Diving Safety: Since the freshwater mussel surveys require underwater sampling, only certified SCUBA divers will be performing dives. Shallow, wadable sites may be sampled by non-SCUBA-certified staff (depths less than 1 m).
 - Site marking boat (NYS-DEC boat) staff:
 - Do not approach the dive boat when the diver is under water, but will wait until the diver surfaces and is holding on to the dive boat.
 - Alert dive boat staff to potential hazards ahead including water depth, current, fallen trees, etc.
 - Dive boat staff: There will be 3 personnel in the dive boat, including one diver and 2 boat staff. Each staff member in the dive boat will receive training prior to actual field sampling to ensure that the boat is operated in a safe manner and that the dive tender(s) is knowledgeable and prepared.

- Once the diver is in the water, a dive safety flag will be presented and visible on the boat or in the water at all times until the diver out of water.
- Both members of the boat crew will remain alert and aware of the diver's location while underwater. Keeping distractions away from the boat. Someone's eyes should ALWAYS be on the site marker and air bubbles. Record data only when the diver has surfaced.
- Diver:
 - All diving equipment must be in excellent operating condition and have undergone annual servicing. The diver must be SCUBA certified and in good physical condition. If in doubt at any point during the day, don't dive.
 - Perform performance and safety checks of all equipment at the start of each day and periodically throughout the day.
 - Do not allow the air tank to go below 500 psi. For a full day of surveys, change out the air tank at lunchtime.
 - Special safety precautions will be followed when diving each site:
 - The system we are using to locate and mark sites provides a good system for diver safety. When descending at a site, the marker line will serve as a guide to the marker anchor where the grid quadrat will be placed. The marker line will be kept between the diver's arms as a life-line to the surface. At any point, a sharp tug on the line will alert the dive tender in the boat and the diver will be retrieved with the marker line.
 - While slowly descending, the diver will maintain a horizontal position and be scanning the area for potential hazards.
 - Diving depths will generally be 2 to 6 m, and rarely will depths greater than 8 m be encountered. Sites will be excluded from sampling if their depth is not safe for solo, tended, diving. These relatively shallow sampling depths are safe for repetitive diving.
 - Each diver will maintain a daily diving log indicating the number of dives, time in the water, water temperature, and maximum depth.
 - These dive logs will be maintained in a log book with emergency contact information and equipment servicing records.

DIVER CHECKS:

- Inspect the Cylinder(s) for cracks, dents, gouges, or defective valves. Check O-ring.
- Verify current hydrostatic test and visual inspection, on all cylinders to be used.
- Gauge Cylinder (s) Charge if necessary. (Reserve UP) Check for leaks. Shut cylinder valve.
- Inspect regulator assembly. Attach to cylinder. Open cylinder valve. Verify operation by breathing regulator.
- Inspect Face mask
- Inspect BC.
- Inspect all other equipment. Ensure all rubber in good condition.
- Knife is sharp.
- Adequate weight.
- Lay out all equipment ready for use

Appendix 6: Mussel Sampling and Processing SOP

Protocol for Sampling Native Mussels in Upper Hudson River

Population estimates:

Download UTM coordinates into GPS. Discuss the sampling plan for the day and record the date and team member names on top of appropriate data sheets.

GPS Boat Team:

- Materials List: Clipboard with data sheets, map of sites, pre-written labels of targeted site numbers, waterproof pen, permanent marker (Sharpie), 2-way radio, cell phone, GPS with loaded way-points, extra batteries, marker buoys with attached weights and lines, personal floatation devices (PFD) for all crew, emergency contact information.
- Navigate boat (or wade) to predicted GPS coordinates
- Record actual GPS coordinates on data sheet
- Place labeled yellow marker at site, taking up as much slack in the line as practical.

Dive Boat Team:

- Materials List: Clipboard with data sheets, map of sites, pre-written labels of targeted site numbers, waterproof pen, permanent marker (Sharpie), 2-way radio, cell phone, buckets, 0.0625 quadrats with 2 mm or 6 mm mesh bag, penetrometers (2), anchor and line, plumb-bob with marked line for depth measurement to 0.1 m, SCUBA gear, dive flag, sample bags, PFDs for all crew, emergency contact information.
- Approach the marker location and place boat anchor
- Shut off motor so diver can descend along the marker rope to the anchor.
- Place the 0.0625 m² quad on the river bottom next to the marker anchor location.
- Measure substrate penetrability by inserting the tip of one penetrometer 6 mm into the sediment within the quad sampler. Repeat after placing quad in second location with second penetrometer. When assessing penetration in soft sediment, attach a 2.5 cm adaptor foot to the penetrometer to control sampling depth.
- Where a 2.5-cm adaptor foot will be attached for measurements in areas of soft sediment, record actual reading. Upon entry into the spreadsheet, if the adaptor foot was used, the recorded value will be divided by 16 to calculate actual resistance.
- Diver takes visual/tactile assessment of the substrate in the quadrat and excavates the substrate within the quadrat to a depth of 15 cm and places it into the attached ca. - 6 mm mesh bag for unremediated, to be remediated and reference areas. Use a ca. - 2 mm mesh bag for remediated areas. Repeat excavating a second quadrat area into the same sample bag for a total of 0.125 m² sample area.
- The boat team records on data sheet the quadrat number, water depth to the nearest 0.1 m, substrate type, penetrometer readings, and presence and type of submerged or emergent vegetation and invasive species present at each location before moving on to next quadrat.
- Raise the sample bag up and down in the water to remove fine sediments before emptying contents into a bucket. Place the quadrat number label on the bucket and remove the quadrat number label from the yellow marker and place in the bucket.
- Hand off buckets to GPS boat to transfer to the Mussel Processing Team.

Mussel Processing Team:

- Materials List: Clipboard with data sheets, waterproof pen, permanent markers (Sharpie), 2-way radio, trays, taxonomic keys of freshwater mussels, caliper, paper towels, graduated stack of sieves (openings 16.0 mm, 5.6 mm, and 2.8 mm), hip boots, folding tables, chain of custody sheets,

coolers with ice for samples, sample bags, water cooler for drinking water, emergency contact information, cell phone.

- Remove all freshwater mussels from the bag and sort into alive, fresh dead (fresh dead mussels will contain soft tissue and/or a clean/shiny nacre) or weathered dead (no soft tissue, non-shiny nacre).
- Record the number of live, fresh dead (FD), and weathered dead (WD) individuals of each species and presence of invasive molluscs (zebra mussels or *Corbicula*) and/or snails; record on data sheet.
- Using calipers, measure shell length as the greatest anterior-posterior distance that is perpendicular to the hinge line (make sure not to crush the new periostracum that has not calcified); record on data sheet.
- Count the number of external annuli for each; record on data sheet. If the periostracum is badly weathered such that annuli cannot be easily visualized, do not age the individual, but make a note in the comments section why this mussel was not aged.
- Voucher representative specimens of each species for independent verification at a later date and package all mussels in labeled zip-lock bags placed in a cooler with ice for transport back to the NYSM Field Research Laboratory where they will be frozen (-20°C).

Length-mass regression:

While sampling for population estimates (above), retain a total of about 50 individuals of each abundant species from multiple sites within each pool or river stretch. Place mussels into an ice-filled cooler in labeled ziplock and transport back to the laboratory. In the laboratory, estimate wet and dry tissue and shell mass following AHPA et al. (1995). The mussels may be frozen (-20°C) and processed for length-mass ratio at a later date.

Archival of mussels and processing for PCB analyses and aging by thin-sectioning of shells:

While sampling for population estimates (above), retain individuals of each abundant species from multiple sites. Place mussels in labeled ziplock bags and place in an ice-filled cooler for transport back to the laboratory to be placed into the chest freezer (-20°C).

Processing mussels:

- Remove bag of mussels from the freezer and thaw just enough to loosen tissues from the shells.
- Record the mussel ID number, site location, pool,
- Insert a knife into the shell opening and slice the adductor muscles to open shell.
- Place entire tissue mass in a pre-tared weigh boat.
- Label both shells with their unique mussel ID number using permanent marker.
- Remove a small (ca. 3 mm) slice of foot tissue and place in a labeled cryovial containing 95% ethanol.
- Record weight (g) of tissue mass and place in labeled ziplock bag and place that bag inside a labeled whirlpack bag.
- Place all tissue samples in freezer at -80°C for long-term storage.
- Place shells in labeled boxes and store in dry location.
- Shells ca. >85 mm in length will be sent to an external laboratory for thin-section aging of shells.
- Record all of the data associated with each mussel (ID, length, tissue weight, collection site and date) on a datasheet and enter into the digital spreadsheet. While in the possession of lead investigator, the digital data file will serve as the chain of custody form for the mussel samples. If any samples are to leave the possession of the lead investigator, separate chain of custody forms will be created for those samples.

Appendix 7 - Sample Chain of Custody

Hudson River Mussel Survey 2014: Chain of Custody
SAMPLE RECORD OF FIELD COLLECTED SAMPLES

Field Collection Date:
Collection Location and Land and Boat Personnel:

Quad Site #	Description

Quad Site #	Description

Transfer		Initials		Method of Storage (Ice or freezer & Temperature)
Date	Time	Given By	Taken By	

Appendix 8 – Signature Page for Principal Investigators and Quality Assurance Coordinator

**Population Assessment and Potential Functional Roles of Native Mussels in
Multiple Sections of the Upper Hudson River:
2014 Remedial Injury Study Plan**

Hudson Natural Resource Damage Assessment

Hudson River Natural Resource Trustees

State of New York

Department of Commerce

Department of the Interior

August 2014

Principal Investigator _____

Principal Investigator _____

Quality Assurance Coordinator _____

Appendix 9 – Signature Page for Investigation Team

Investigation Team Acknowledgement of Work Plan Review and Compliance

By my signature, I acknowledge that I have read this Work Plan and understand it, and will comply with it in performing this work.

Name (printed): _____ Name (printed): _____

Signature: _____ Signature: _____

Initials: _____ Initials: _____

Date: _____ Date: _____

Title: _____ Title: _____

Name (printed): _____ Name (printed): _____

Signature: _____ Signature: _____

Initials: _____ Initials: _____

Date: _____ Date: _____

Title: _____ Title: _____