DRBC DELAWARE RIVER BIOMONITORING PROGRAM

2006-2007 QUALITY ASSURANCE PROJECT PLAN

FINAL DRAFT: MARCH 7, 2007.

DELAWARE RIVER BASIN COMMISSION

Delaware River Basin Commission
DELAWARE • NEW JERSEY
PENNSYLVANIA • NEW YORK
UNITED STATES OF AMERICA

DRBC Project Officer:	Thomas J. Fikslin	Date
DRBC Quality Assurance Officer:	Edward D. Santoro	Date
DRBC Program Officer	Robert L. Limbeck	Date
USEPA Project Officer		Date

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1. Project Management

1.1 Distribution List

Table 1 is a list of all individuals associated with the Delaware River Biomonitoring program. Each of the following individuals will participate in some aspect of the Delaware River Biomonitoring Program. To ensure the quality of the Delaware River Biomonitoring Program, each of these listed individuals will receive a copy of the signed Quality Assurance Program Plan (QAPP) prior to initiation of the 2006 sampling season. In the case of a revision, each of the participants will receive the revised version electronically in *.pdf* format.

Table 1. Distribution list for the Delaware River Biomonitoring Program

Individual	**Organization**
_____	U.S. Environmental Protection Agency
Thomas Fikslin, PhD.	Delaware River Basin Commission
Robert Limbeck	Delaware River Basin Commission
Aquatic Biologist	*Delaware River Basin Commission*
Edward Santoro	Delaware River Basin Commission
Christopher Dempsey	Delaware River Basin Commission
Elizabeth Fielder	Delaware River Basin Commission
Margaret Passmore	U.S. Environmental Protection Agency
Greg Pond	U.S. Environmental Protection Agency
Lou Reynolds	U.S. Environmental Protection Agency
Patrick Lynch	National Park Service
Don Hamilton	National Park Service (UPDE)
Allan Ambler	National Park Service (DEWA)
Michael Bilger	EcoAnalysts, Inc.
David Velinsky	*ANSP*
Michael Depew	*ANSP*
Roger Thomas	*ANSP*
Algal Taxonomist	*Contract Lab*

1.2 Project/ Task Organization

Figure 1 is a chart describing the organization of the Delaware River Biomonitoring Program. Table 2 lists the individuals that will participate in at least part of the Delaware River Biomonitoring Program and the role that each of the participants will have in the program.

Figure 1. Organizational Chart of the Delaware River Biomonitoring Program

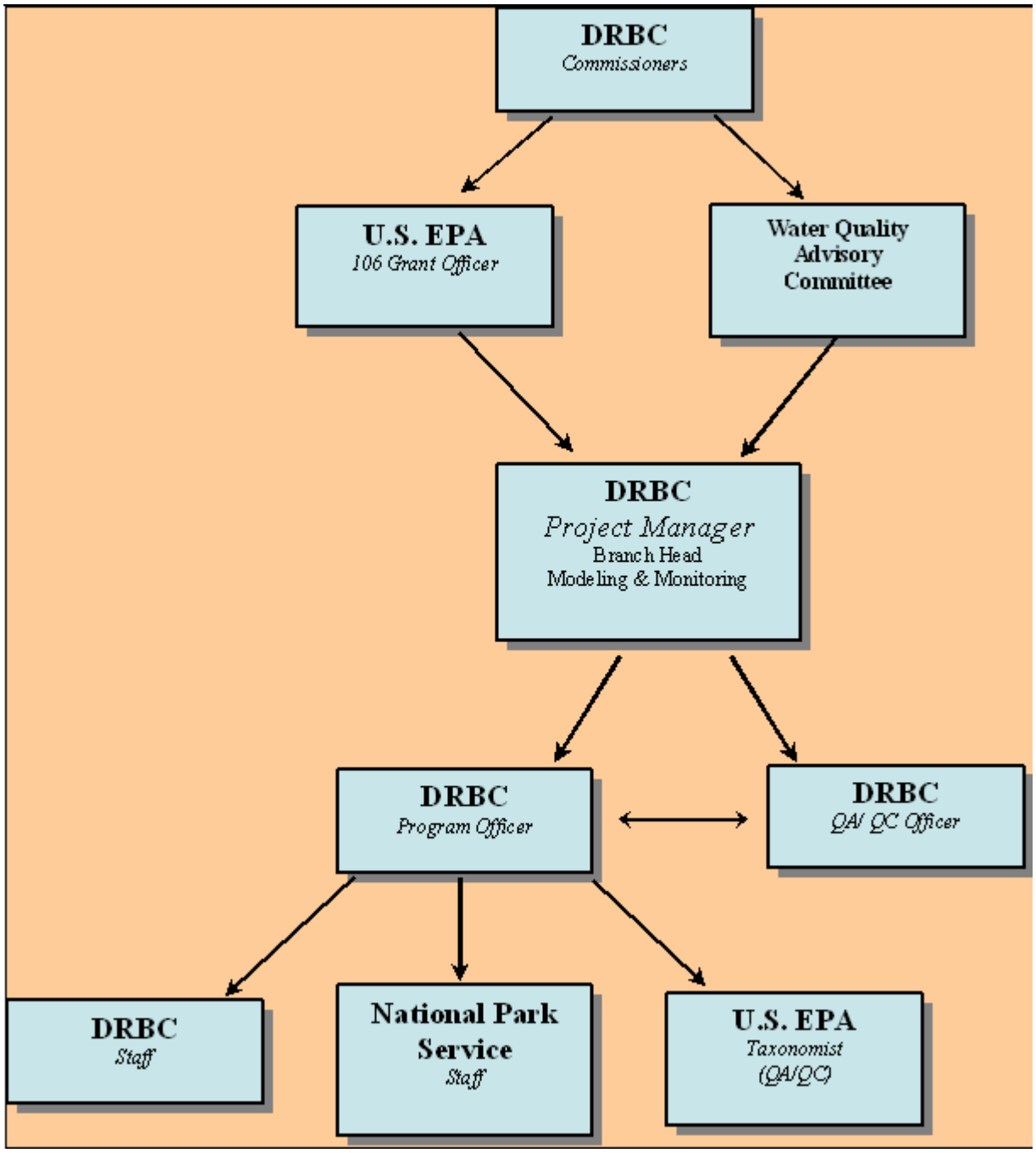

Table 2. Roles and responsibilities of individuals associated with Delaware River Biomonitoring Program

Name	Title	Organization	Role	Responsibility
*********		U.S. EPA	Project Officer	*106 Grant Officer (funding source)
Thomas Fikslin, PhD.	Branch Head, Modeling & Monitoring Branch	DRBC	Project Manager (Monitoring)	*Oversee Monitoring Programs *Review QAPP *Technical Support *Contract Officer
Robert Limbeck	Watershed Scientist	DRBC	Project Officer	*Site Selection *Coordinate Monitoring *QAPP creation *Supervise Personnel *Sample Collection *Criteria development *Data Analyst
Erik Silldorff, PhD.	Aquatic Biologist	DRBC	Project Officer	*Coordinate Monitoring *Site Selection *Macroinvertebrate Taxonomy *Sample Collection *Data Manager *Data Analyst
Michael Depew	Aquatic Biologist	Academy of Natural Sciences	Sample Collection	*Technical Support *Aid in sample collection
Michael Bilger	Benthic Taxonomist	EcoAnalysts, Inc.	Taxonomy Lab	*Macroinvertebrate Taxonomy
David Velinsky	Environmental Geochemist	Academy of Natural Sciences	Chemistry Lab	*Benthic Algal Chemistry Analyses
Contract Laboratory	Algal Taxonomist	RFP Issued 2007	Taxonomy Lab	*Algal Taxonomy
Edward Santoro	Monitoring Coordinator	DRBC	QA/QC Officer	*Ensure project quality
Margaret Passmore	Biologist	U.S. EPA	Taxonomist	*QC of Invertebrate Samples *Technical Support
Karen Reavy	GIS Coordinator	DRBC	GIS Coordinator	*GIS Technical Support
Elizabeth Fielder	Intern	DRBC	GIS and Sampling	*Del. R. Habitat delineation *Habitat ground truthing
Christopher Dempsey	Intern	DRBC	Sample Collection	*Aid in sample collection
Don Hamilton	Natural Resources Specialist	NPS-UPDE	Sample Collection	*Technical Support (UPDE) *Aid in sample collection
Al Ambler	Biologist	NPS-DEWA	Sample Collection	*Technical Support (DEWA) *Aid in sample collection

1.3 Problem Definition/ Background

Historically, the Delaware River Basin Commission (DRBC) has focused resource protection efforts upon traditional chemical water quality monitoring, which proved very effective at reducing impacts created by point sources of pollution. Sewage and industrial waste treatment plants have improved treatment efficiency much over the past 30 years. As a result of inclusion of virtually the entire non-tidal Delaware River in the National Wild and Scenic Rivers system, DRBC created an antidegradation approach to water quality management that defines existing water quality and sets protective limits on chemical constituents for protection of the resource.

In the 1990's the basin states began to use a more holistic approach to address non-point source pollution problems that threaten the high-quality water of the Delaware River. Planning and regulatory efforts of the Commission have expanded in focus to include not only protection of water chemistry, but also sustainable protection of biological integrity.

The DRBC/NPS Scenic Rivers Monitoring Program (SRMP) and the Lower Delaware Monitoring Program (LDMP) combine to monitor water quality of the entire 200-mile non-tidal length of the Delaware River. Similarly, the Delaware River Biomonitoring Program (DRBP) is responsible for biomonitoring and biocriteria development for the non-tidal portion of the Delaware River.

This project plan defines the habitat, benthic macroinvertebrate and periphyton components of DRBC's biological monitoring program. Additional types of biological monitoring are planned for future years as resources allow, including fish, bivalves, plankton, submerged aquatic vegetation, and riparian condition. These activities, in addition to improved physical and chemical data gathering, should provide a well-rounded view of water quality conditions in the Delaware River, and provide sufficient data for management decisions.

DRBC intends to gather sufficient physical, chemical, and biological information to implement biocriteria as part of Special Protection Waters (SPW) regulations for the non-tidal portion of the Delaware River. This project will target the main stem non-tidal Delaware River for the development of biocriteria.

Starting with an intensive macroinvertebrate survey of accessible river sites, targeting the richest habitats (riffles, runs, island margins), a reference baseline of the existing biological community will be developed to quantify ecological integrity for the entire 200-mile non-tidal river. Once the reference baseline is developed (years 2001-2006), further testing of the most sensitive metrics for detecting 'measurable change' will be refined and incorporated into biological criteria useful for protecting long-term ecological integrity of the river. Numerical reference values will be proposed to set an anti-degradation level of protection for the river's aquatic life, and to provide an "existing water quality" biological baseline for assessment of long-term changes. The findings of this project, most importantly the definition of the existing condition of the biological community of the Delaware River, will serve as the backbone for future biomonitoring of tributaries and exploration of specific stressor effects. At the time of this printing, initial reconnaissance has been completed (2001), macroinvertebrate collection and identification has begun (2002, 2003, and 2005), and the biocriteria framework creation is underway. DRBC received a Regionally Applied Research Effort Grant (RARE) with EPA Region 3 Office of Research and Development in 2005 to recommend an assessment methodology for a water body of this size. As a result of the RARE project, DRBC will collect macroinvertebrate samples to define biological communities from two additional habitats of the Delaware River in 2006-2008: pools and runs/glides. Dr. Joseph Flotemersch has submitted a study plan for the RARE project (U.S. EPA 2006, Appendix C).

In addition, DRBC completed a pilot study in 2005 for a periphyton monitoring network (DRBC 2006), finding that eutrophication due to high nutrient concentrations may be problematic in the lower non-tidal portion of the Delaware River. DRBC will conduct annual periphyton community monitoring in richest targeted habitat for the purpose of biocriteria development related to nutrients and eutrophication. After sufficient data has been

collected, biological criteria for the non-tidal portion of the Delaware River will be proposed for use in 305B assessments. DRBC is following recent guidance and publications relating nutrients, eutrophication, urbanization, sedimentation and rapid flow regime changes to algal community indicators (Hill et. al 2000; Kelly et. al 2001; Kentucky DEP 2002; Ponader and Charles 2003; Potapova et. al 2004; Ponader et. al 2005; Potapova and Charles 2005).

1.4 Project Task/ Description

This program requires an annual survey of benthic macroinvertebrates, periphyton and habitat at selected locations along the length of the non-tidal Delaware River. After a sufficient multi-year collection period, the analyzed data will be used to create biological criteria for with the Delaware River Basin Commission Water Quality Regulations.

Macroinvertebrates are collected from Richest Targeted Habitat (RTH) using the Big River Frame Net (BFN) at each of 25 Delaware River sites. Pebble counts, velocity measurements, qualitative RBP habitat assessments and instantaneous water quality samples are collected to characterize habitat and water quality at the time of sampling. Collection occurs during the August to September index period unless conditions are unsuitable. All data collection is done by DRBC and partner agency staff trained in protocols documented here. Macroinvertebrate taxonomy is completed by trained DRBC or contract laboratory staff.

Periphyton samples are collected using the top-rock scrape method from 8 cobbles selected within RTH at the same 25 sites where macroinvertebrates are collected. Ancillary measurements include light (PAR 400-700 nm), canopy cover, nutrient concentrations during the weeks leading up to periphyton sampling, Chlorophyll *a* and Ash-Free Dry Mass, area scraped from each cobble; and depth/velocity profiles of the sampling areas.

Habitat methods are being investigated relative to applicability in free-flowing large rivers. For Delaware River assessment, DRBC has primarily used the RBP habitat method for wadeable streams. Many RBP habitat parameters seem unsuitable for rivers as large as the Delaware, and there seem to be few relationships between habitat parameters and biological metrics. For this reason, DRBC will begin in 2006 to assess habitat conditions using and comparing a variety of methods: the RBP high gradient habitat protocol (Barbour et. al 1999); the EMAP Great Rivers field protocol (Angradi et. al 2004); EMAP habitat protocols for non-wadeable rivers and streams (Lazorchak et. al 2000); and the Qualitative Habitat Evaluation Index (Ohio EPA, Rankin 1989). The RBP presently remains DRBC's primary habitat evaluation method , but eventually DRBC expects to adopt other methods more suitable to rivers similar to the Delaware.

Data produced during this survey are compiled in Ecological Data Application System (EDAS), created by TetraTech, Inc. All metrics are calculated using EDAS, and statistical analyses are done using either Analyze-It, a Microsoft Excel add-on program, or PC-ORD, a multivariate statistical program. Data are stored at DRBC for organizational use as well as uploaded onto EPA's STORET national data base for public usage.

All study participants must read this QAPP prior to sampling. All participants are trained in the study methods as appropriate to their role. The QA officer must be present for at least 10% (n=3) of samples collected during this survey and will produce a memo of program assessment findings. To ensure that samples are similar, quantitative measurements are taken to numerically characterize substrate (must be near gravel/cobble median particle size, about 40 to 70 mm); depth (0.5 to 1.5 feet); and flow (1 to 3 ft/sec) at sampling points to validate samples and rule out the subjectivity of site selection. Samples proven to be dissimilar must undergo further validation prior to their inclusion into the criteria data set.

1.5 Quality Objectives and Criteria for Measurement Data

The purpose of this program is to determine the existing biological quality of the Delaware River for development of baseline biological criteria for water quality regulations consistent with the goals of the Wild and Scenic designation as directed by Congress. No longitudinal surveys of this nature have previously been conducted on the non-tidal Delaware River, leaving few historical and comparable data. Due to the lack of existing data, the data quality standards discussed in this QAPP are mainly used to validate collected data. The USEPA-ORD is assisting DRBC to determine the most useful model for future assessment of aquatic life conditions in the Delaware River.

1.5.1 Bias

The aim of this study is to limit natural variability such that differences observed in biotic conditions are attributable mainly to changes only in water quality. For this reason, we strive to collect samples within a limited seasonal, flow and physical instream habitat window, so that sites can be compared with one another and from year to year. In the field, samples are taken from richest targeted habitat, such as riffles, island margins or shore margins defined by substrate size (D50 between 40 and 70 mm), velocity (1-3 ft.sec), and depth (1-2 ft). This allows for comparability between sites along a longitudinal river mile gradient. Samples are taken within an index period of August 1 to September 30, the low-flow season in the Delaware River. River flow must be less than 10,000 cfs at Trenton, and stable low flow must occur in the weeks leading up to sampling. In the case of flood events large enough to mobilize gravel and cobble sediments, no sampling can be done during a re-colonization time of 4 to 6 weeks after the flood. It is notable that this circumstance can reduce the index period and in some seasons (such as 2003 and 2004) entirely prevent sample collections. All samples are sorted in the laboratory. Laboratory sorting allows for comfortable and controlled lighting and temperature, preventing sorting that may be rushed and biased toward the larger, more easily seen organisms.

1.5.2 Precision

Precision of samples is determined by calculating the relative percent difference (RPD) between duplicate samples at 3 sites per year. Any samples that have a RPD greater than 10% are analyzed further and data disregarded at the discretion of the Project Officer. Best Professional Judgment is used to determine whether variability of this subset of data is due to the natural variability of the system or is truly erroneous data.

1.5.3 Completeness

The completeness of gathered data is dependent on the ability to physically collect samples as well the ability to taxonomically identify samples. Conditions may not allow for collection of samples at all sites during the prescribed sampling year, resulting in an incomplete sample set. In this case, additional samples are collected during the following year's index period. For establishing existing biological condition, an increased number of samples at any one site would not affect results, assuming all samples are collected in the same index period. Of course, such data may not be used to evaluate year-to-year trends, but the increase in N should limit variability of the data set and improve overall performance of metrics. Also, the taxonomist will note if the condition of macroinvertebrates may not allow for taxonomic identification, rendering the sample incomplete if a substantial number of individuals are in poor condition.

1.5.4 Comparability

Comparability of samples is ensured by analyzing substrate and habitat condition by numerical data collected on-site as well as maintaining the same methods and sampling locations throughout the study. Correlation of the physical habitat data between sites and year-to-year proves the comparability of collected samples. All

samples should be taken from similar instream habitat (e.g. particle size and distribution, current velocity, and depth) so that data generated are comparable. The sampling protocol calls for sampling in the Richest Targeted Habitat (Moulton et. al 2002) which is here defined as perennially wetted cobble riffles, island margins or shore margins of the Delaware River with depth 0.5 to 1.5 feet, velocity greater than 1 ft/sec, and substrate median particle size between 40 and 70 mm. Sampling is done by the same method and individuals throughout the course of baseline data collection (about 2001-2008) in all cases. Stations remain the same for each annual survey unless substantial change to conditions arises. Maintenance of the same protocols and habitat conditions for each sample should strengthen site to site, year to year, and within-site comparability for comparable results.

1.6 Special Training / Certification

Sampling is performed by personnel trained in the various sample elements of this study. Only those individuals trained in EPA's Rapid Bioassessment (Barbour et al. 1999) sampling and habitat assessment techniques, and familiar with the BFN will collect macroinvertebrate samples. Other personnel who are trained in gathering flow measurements, conducting Wolman Pebble Counts, and making habitat assessments will perform those duties. Any participants unfamiliar with methods are instructed prior to sample collection.

All participants are trained in canoe/ small vessel safety if they do not already possess such knowledge. Participants also have read and understood the DRBC "Field Safety Manual".

Macroinvertebrate and periphyton taxonomy is conducted by trained taxonomists on the DRBC staff or contract laboratories. Macroinvertebrates are identified and catalogued using ITIS and other taxonomic standards. A sub-set of samples (10%) is sent to an outside contractor as part of the Quality Control requirements for the project. All QA/QC analyses are conducted by staff trained in taxonomy and sorting.

1.7 Documents and Records

The Project Manager is responsible for maintaining and archiving all documents that pertain to this survey. Hard copies of all files sre kept by the Program Manager on file at the Delaware River Basin Commission office. Electronic data specific to this program are stored on digital media both on-site and off-site.

1.7.1 Standard Data Reporting Format

The standard data reporting format is the bench sheet found in Appendix B. Both the DRBC staff and Contract lab record data on these sheets prior to entry by DRBC staff in Ecological Data Application System (EDAS).

2 Measurement/ Data Acquisition

2.1 Sampling Process Design

Macroinvertebrate and periphyton samples are collected at twenty-five stations along the main stem, non-tidal Delaware River and its East and West Branches. The stations are distributed longitudinally over the entire 200 miles of non-tidal Delaware River with segmentation (approximately every 8 miles) as evenly as the geology and hydrology allow. All samples are collected during the August–September critical low flow index period. Table 3 shows the schedule of all tasks that are part of the biomonitoring program. Appendix A shows sampling locations for the Delaware River Biomonitoring Program.

Table 3. Standard schedule for the Delaware River Biomonitoring Program

Tasks	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
QAPP Development												
EPA QAPP Approval												
Sample Collection												
Taxonomy												
Data Analysis												
Reporting												

2.2 Sampling Methods

2.2.1 DRBC Standard Operating Procedure - Macroinvertebrates

Macroinvertebrate sample collection is a modified RBP format. Samples are collected using a Big River Frame Net (BFN) with a substrate frame. The net was designed in 2001 by DRBC and Wildco, Inc. The net is 3'w.x 2'h. with tapered 595µm mesh top and canvas bottom, closely resembling a Slack sampler. A 2'w x 2'l.x 4" h. substrate frame is used to delineate a 4 ft^2 sampling area to provide for semi-quantitative analysis and a large and representative total sample area of 12 ft^2 from a 3-kick composite sample This design limits the amount of sample lost due to escape around net caused by the effects of the flow on the organisms suspended as part of the collection procedure. The large sample area frame was based on recommendations by the National Park Service and Academy of Natural Sciences citing low sample densities and inconsistent patchy distribution of macroinvertebrates (National Park Service, Report Nos. 01-5F, 01-7F).

Site selection focuses upon the richest targeted habitat of the Delaware River, which has been specified as the midstream or margin gravel-cobble riffle microhabitat. The exact location of the sample is chosen after a visual inspection by the principal investigator. The selection of the site is based on the ideal depth, substrate and flow characteristics required for macroinvertebrate colonization as well as representative of the entire riffle to be sampled. The 25 fixed sample locations were chosen in 2001 for accessibility and are representative of similar habitat throughout the non-tidal Delaware River.

Once the sampling location is identified, samples are collected using a modification of the Traveling Kick Method (Barbour et al, 1999). A sampling transect line or arc is chosen, and sampling begins at the

downstream end of 3 stations along the transect. A person stands downstream of the sampling area and secures the net. The frame is placed directly upstream of the net and is held in place by a second individual while the area inside the frame is agitated by foot by the individual holding the net by both hands and a knee wrapped around the metal frame. Once the coarse agitation of the substrate has been completed, the individual holding the frame does a final check to make sure that all of the delineated area has been disturbed, ensuring that the sample effort has been maximized. Any of the area that does not appear to have been disturbed is agitated by hand. An estimate of embeddedness is made by visual observation and difficulty of particle disturbance (easy-medium-hard). The kick area is scanned for live mussels, which are identified, photographed, enumerated, and returned to the river. Last, a survey flag is placed where the kick was completed, to mark the location for quantitative velocity, depth and substrate particle size profiling. This process is repeated at 2 more locations along the chosen transect.

The bulk of the 3-kick sample is composited and rinsed into a large, water-filled container to simplify the cleaning of the net. The macroinvertebrates that were not dislodged by the rinse are picked from the net using forceps and placed in a labeled sample container for preservation. Once the net has been picked, the contents of the larger container are condensed by pouring it through a 500μm sieve, then transferred to the labeled sample container that contains the macroinvertebrates that where picked from the net. After careful inspection of both the net and container for remaining macroinvertebrates, both are rinsed and prepared for the next sample. The macroinvertebrate samples are then preserved in Ethyl Alcohol (>75%) for later identification. The sample contains labels both inside and outside of the container. The sample label accompanies the sample through the entire sort-identify process. A sample label can be found in Appendix B.

2.2.2 DRBC Standard Operating Procedure – Periphyton

The periphyton sample collection method gathers periphyton from Richest Targeted Habitat, just like the macroinvertebrate method used by DRBC. Periphyton are sampled at the same time as macroinvertebrates, at the same locations (upstream and parallel to the macroinvertebrate sampling transect). Collection methods were adapted from Field Sampling Procedures for the New Jersey Algae Indicators Project (ANSP Procedure No. P-13-64, Charles et. al 2000).

After taking macroinvertebrate samples, a transect is established in RTH upstream and parallel to the macroinvertebrate sampling transect. From this transect (approximately 30 m long), three (3) representative cobbles are taken and placed into a white plastic pan for Chlorophyll A and AFDM sampling. Locations where each cobble was taken are flagged. These rocks are photographed with a measurement scale. Using the top-rock scrape method described in the RBP (Barbour et. al 1999), a composite sample is scraped, rinsed and transferred into a pre-weighed and numbered 250 ml plastic bottle. The area of each cobble that was scraped is covered by aluminum foil and cut to shape for later area measurement in the office. The 3 foil cutouts are placed in a Ziploc bag and labeled. The sample is iced, with no preservative, and shipped within 24 hours to the environmental geochemistry laboratory at the Academy of Natural Sciences of Philadelphia, PA. Once received by ANSP, the samples are analyzed under the following standard procedures, and results reported to DRBC:

1. Benthic Algae and Sediment Chlorophyll A Preparation and Analysis (ANSP Procedure No. P-16-117, Velinsky and DeAlteris, 2002)

2. Determination of Dry Weight and Percent Organic Matter for Sediments, Tissues and Benthic Algae (ANSP Procedure No. P-16-113, Kiry et. al. 2000).

An additional five (5) cobbles, preferably without large growths of filamentous algae, yet representative of cobbles found throughout RTH, are collected from the transect and placed in a white plastic pan. Place flags to indicate locations where cobbles were taken. Cobbles are photographed, scraped, and rinsed with river water

into a 500 ml plastic bottle and preserved with buffered formalin (constituting 3 to 5% of total sample volume). The aluminum foil area measurement procedure described above is repeated for each cobble. Samples are labeled and stored for later analysis of diatom taxonomy (by trained DRBC personnel or a contract diatom taxonomy lab). Diatom taxonomy follows the ANSP Standard Procedure:

1. Procedure for Semi-Quantitative Analysis of Soft Algae and Diatoms (ANSP Procedure No. P-13-65, Ponader and Winter, 2002).

Once the samples are taken, additional site measurements are taken and recorded on the Quantitative Targeted Habitat Periphyton Sample Field Data Sheet (Appendix B). Measurements include:

- Particle size class of each cobble sampled (using gravelometer template)
- At each flag, record depth, velocity, shading, percent canopy (densiometer), and macroalgae color/type.
- At upstream end, middle, and downstream end of transect, measure PAR 400-700 nm light intensity at 6 depths: top, 1/5, 2/5, 3/5, 4/5 and bottom depth.
- Also transfer weather, precipitation, water quality, clarity and color characteristics from other sheets.

Upon return to the office, copy a full scale image of each piece of foil to an 8.5x11 sheet and record label information on each sheet. Use a Sharpie to make bold the outline of each piece of foil. Create a pdf document of these 150 sheets, and open the document as full scale images in ARC MAP. Digitize and measure the area of each piece of foil, so that Chlorophyll a, AFDM, and algal densities can be expressed in the data set.

2.2.3 Quantitative Instream Habitat

Pebble counts, depth profiles and flow measurements are conducted to quantitatively characterize the microhabitat of the samples taken to eliminate the subjectivity of the site selection process).

Pebble Count: A 100-particle pebble count is conducted at the each of the sampling sites to numerically characterize the particle size of each of the sampled areas (Wolman, 1954). 100 particles are gathered along the sampled transect and measured using an AL-SCI Field Sieve from Albert Scientific. Particles are placed in the sieve to determine the size class of each particle and the data recorded using a #2 pencil on the brushed aluminum surface of the sieve until data can be transferred to a field sheet. Measurements are analyzed in the field for completeness, and to determine the median particle size (D50) and class of substrate present. These measurements are used to validate the comparability of the benthic community collected with each sample. The median particle size (D_{50}) should fall in the range between 40 and 70 mm. A replicate pebble count should be completed with each replicate macroinvertebrate sample (10% of samples). Outliers are noted in statistical analysis of results. Example of field sheet can be found in Appendix B.

Velocity Measurement: Velocity and depth are measured using a digital Pygmy meter and wading rod at the left, center, and right edge of each of the 2x2 ft kicks sampled for macroinvertebrates (total N=9), and once at each location where cobbles are taken for periphyton (total N=8). The average velocity and depth validates the comparability of samples. The average velocity at each site should fall in the range of 1.0 and 3.0 cfs. Any samples falling outside this range should be noted in statistical analysis. Depth of samples collected should range between 0.5 and 1.5 ft. A replicate set of velocity and depth measurements should be taken with each replicate macroinvertebrate or periphyton sample. Outliers are noted in statistical analysis. Sample field sheet in Appendix B.

2.2.4 Water Quality: Physical

Instantaneous water quality measurements are taken once at each sampling site. The RBP Physical Characterization / Water Quality Field Sheet is completed once per site (see Appendix B). A YSI or Hydrolab multi-parameter meter is used to collect data for the following parameters:

- Dissolved Oxygen (mg/L)
- Temperature (^{o}C)
- Conductivity (mS/cm)
- pH
- Turbidity (NTU)
- TDS (mg/L)

A sample field sheet for water quality parameters is in Appendix B.

Instrumentation is calibrated for all parameters on a daily basis with the exception of Dissolved Percent Saturation (DO %), which is calibrated at each site, and Turbidity, which requires Formazin calibration that is not safe for field calibration and disposal. The calibrations are recorded in a logbook for analysis following completion of sampling. Meter calibration is verified prior to measurements at each site. A sample calibration sheet from the calibration logbook can be found in Appendix B.

2.2.5 Qualitative Habitat Assessment: Rapid Bioassessment Protocol

Habitat conditions are qualitatively assessed using the high-gradient RBP (Barbour et. al 1999) habitat assessment once at each site. This habitat assessment system uses the following parameters to approximate the instream health of the system:

- Epifaunal Subtrate/ Available Cover
- Embeddedness
- Velocity Depth Regime
- Sediment Deposition
- Channel Flow Status
- Channel Alterations
- Frequency of Riffles (or Meanders)
- Bank Stablility
- Vegetative Protection
- Riparian Vegetative Zone Width

These measurements, once analyzed, are used to describe habitat conditions and identify factors attributing to biological changes. Field sheets are in Appendix B.

2.2.6 Location Information

Location information is collected at each site using a hand-held Magellan GPS unit. The positioning information is used for Geographic Information System (GIS) presentation and analysis of data. Location information and notes are reported on a set of DRBC "River Recreational Maps" for navigation on future studies.

Field notes are combined with field sheets for later data entry. Digital photographs are taken in the following order at each site:

- Directly upstream (1)
- Upstream toward right shore (2) and left shore (3)
- Directly toward right shore (4) and left shore (5)
- Downstream toward right shore (6) and left shore (7)
- Directly downstream (8)
- Substrate photo of macroinvertebrate station A (downstream end of transect) (9)
- Substrate photo of macroinvertebrate station B (mid-transect) (10)
- Substrate photo of macroinvertebrate station C (upstream end of transect) (11)
- Photos of white pan containing mussels from A (12), B (13), and C (14)
- Photo of white pan, with measurement scale, containing 3 Chlorophyll a / AFDM cobbles (15)
- Photo of white pan, with measurement scale, containing 5 Diatom Taxonomy cobbles (16)
- Other photos as needed (NOTE in field notes, starting with #17 per site no.)

2.3 Sample Handling and Custody Requirements

Samples are checked immediately upon return to DRBC and split if material fills any jar more than halfway. Samples reside at the DRBC office for a brief period until identified taxonomically by DRBC Staff or transported to a contract taxonomy lab. While samples are in-house, they are periodically checked to ensure that preservative is fresh and at an adequate concentration to prevent sample decay.

All samples are recorded on a sample log as they are collected by DRBC staff. This helps locate each of the samples and ensure that all samples are properly handled and identified. An example of a sheet from the sample log can be found in Appendix B. Also, a log is completed documenting the sorting and taxonomy of all samples (see Appendix B). This information is used for time allocation and budgeting for future studies.

Ten percent (n=3) of samples are sent to U.S. EPA Region 3 Laboratory for Quality Control analysis following DRBC taxonomic identification. At this time, the randomly selected samples are analyzed for sorting efficiency and taxonomic accuracy. The samples are delivered to the laboratory staff in person or by mail, where custody will be relinquished at that time. The U.S. EPA taxonomist is given 120 days for sample analysis and data return to DRBC on bench sheets (Appendix B) following the DRBC format. Appendix B contains a sample chain of custody record for macroinvertebrate samples. No similar process is yet complete for periphyton taxonomy QAQC, but this plan will be updated before preserved periphyton samples are sent to a contract lab.

All identified samples are stored at the DRBC headquarters until completion of the project and criteria are finalized. This allows samples to be pulled and reanalyzed if any questions regarding taxonomy arise. A reference collection is stored onsite to aid in verification of identifications and training aids for taxonomists.

2.4 Analytical Methods

Macroinvertebrate taxonomy is conducted on a 500 organism sub-sample for use in a multi-metric or multivariate analysis. The sub-sample is collected by spreading the sample in a gridded pan and randomly selecting a grid to begin the sort. From this point, a series of randomly selected grids are sorted until a total of

500 organisms has been reached. Once 500 is met (+/- 50), the remainder of that grid is sorted, and all organisms are taxonomically identified. Completely sorting and identifying all organisms from the last randomly selected grid cell prevents the bias introduced by stopping at exactly 500 organisms, and allows quantitative estimates of sample density. Identification of organisms is to genus or lowest achievable taxon. Only those organisms or portions of organisms that contain the head of the organism are identified. All taxonomy is consistent with Integrated Taxonomic Identification System (ITIS) or other taxonomic standard.

At this time, a long list of macroinvertebrate and periphyton community metrics are being reviewed and compared as appropriate for Delaware River bioassessment. A committee of regional experts, including U.S. EPA ORD staff, are assisting DRBC in selection of metrics and biotic index techniques for biocriteria and river assessment.

At present, DRBC has no periphyton taxonomy expertise, nor has DRBC yet selected a contractor. However, the 2005 pilot study periphyton taxonomy (600-frustule count and soft algae identification) was completed by the Academy of Natural Sciences of Philadelphia, Phycology Section. Diatoms were prepared and analyzed using ANSP Procedure for Semi-Quantitative Analysis of Soft Algae and Diatoms (Ponader and Winter, 2002) and the methods are also described in USGS NAWQA protocols for analysis of algal samples (Charles et. al 2002). DRBC may issue an RFP in Fall 2006 for algal taxonomy, and it is expected that ANSP methods will be required by DRBC for 2006 and future periphyton samples.

Instantaneous ambient water quality measurements are collected using a Hydrolab Quanta™ multiparameter meter or two similar YSI meters. Methods used can be found in Table 4:

Table 4: Methods for water quality monitoring using Hydrolab Quanta™

Measurement	Units	Method	Calibration
Dissolved Oxygen (DO mg/L)	mg/L	SM 4500-O.G.	Winkler Titration Method, SM 4500-O.C.
Dissolved Oxygen (DO %)	%	SM 4500-O.G.	Air Calibration (On-Site)
Specific Conductance (SpC)	mS/cm	ISO 7888-1985	Standard Solution (84mS/cm Standard)
Water Temperature	^{o}C	SM 2550	Factory Calibration
pH	pH units	SM 4500-H+	pH Buffer Solution (2 Point)
Total Dissolved Solids (TDS)	g/L	Snoeynick & Jenkins	Standard Solution (84mS/cm Standard)
Turbidity (Turb)	NTU	GLI Method 2 ISO 7027:1999	4000 NTU Formazin Stock Solution (Dilution to 40 NTU) and a "Zero" (DIUF)

2.5 Quality Control

Field QA/QC is obtained by using trained staff for all sampling and field measurements. All are trained in each procedure. Site selection and macroinvertebrate collection is completed by the same personnel at all sites (R. Limbeck and M. Depew) to limit subjective errors. The QA officer oversees 10% of sampling (n=3) to assure that sampling is consistent with the methods described in this QAPP.

Visual inspection of net performance is conducted during collection of each sample. Prior to sampling, the net is visually inspected to ensure that no tears in the mesh are present. During sample collection, the sediment plume created by the sample collection is observed to make certain that the entire plume passes through the net. By doing this, it is safe to assume that no organisms are escaping around or over the net during collection and ensuring that sample collected is complete. Also, during this time, the passage of the water through the net is visually monitored to ensure that no portion of the sample is lost due to back wash caused by a the net becoming clogged by detritus.

Laboratory QA/QC is achieved by having all taxonomy completed by trained staff using taxonomic standards. All taxa will be verified using ITIS, ARGIS, or another taxonomic standard. Upon completion of taxonomy, 10% of samples will be sent to the United States Environmental Protection Agency, Region 3 Field Laboratory for sorting efficiency measurement and taxonomic verification. Sorting efficiency is conducted on only the debris that is actually used for generation of the subsample (sort residue). If more than 50 organisms, or 10% of the subsample, are found in the sort residue, the sample is reconstituted and subsample conducted again. The problem is documented in the sample log, the taxonomy laboratory is notified of sorting deficiency, and an additional 10% of samples are checked to prevent consistent bias in sorting and counting. Persistent sorting efficiency problems may ultimately result in contract termination.

2.6 Instrument / Equipment Testing, Inspection, and Maintenance

Macroinvertebrates are collected using a Big River Frame Net (BFN) developed by DRBC and Wildco. The net is rinsed and inspected for tears prior to each sample collected to prevent sample contamination and sample loss, respectively. If a tear is found, sample collection will be postponed until the net has been repaired.

Pygmy meters undergo careful inspection before each usage and must pass a 60-second spin test prior to usage to insure that data collected is valid. The "cups" for the meter are cleaned, oiled, and stored as recommended by manufacturer after each usage.

The Hydrolab Quanta™ or YSI multi-parameter meter is inspected each day prior to usage. All probes are maintained in compliance with manufacturer's recommendations and are calibrated daily.

2.7 Instrument / Equipment Calibration and Frequency

The multi-parameter meter is calibrated daily for all parameters to be measured, with the exception of Dissolved Oxygen percent saturation (DO %), which is air calibrated at each site. If any values fall outside of expected values, measurement is noted and a calibration is conducted after sampling to validate the measurement. Calibrations are verified prior to measurements at each site and are logged on the field sheet for that site. Calibration procedures can be found in Table 4. All calibrations are logged and used to validate measurements during the data analysis period.

2.8 Data Management

All data generated by this program are managed by the Delaware River Basin Commission. Incoming data is delivered as specified by the Commission prior to collection of data. Data are managed and maintained using the EDAS biological database located in-house by trained staff members familiar with the monitoring program. Data will also reside on STORET national database and on DRBC's website (www.drbc.net).

3 Assessment and Oversight

3.1 Assessment and Response Actions

Assessment and response to problems involving quality of data elements are conducted routinely. The QA/ QC officer and Program Manager are responsible for continuous assessment of sample collection procedures and the resulting data elements to ensure validity of the data reported. Any data that may be in question are noted and the respective data handled in an appropriate manner. These measures ensure data of the highest quality for data reporting, assessment, and criteria development.

3.2 Reporting

Reporting of the QA/ QC assessment is conducted on an "as required" basis. Findings are submitted to the program manager only if the quality of the data is in question. This memo identifies the respective data set, the basis for its identification as invalid, and measures taken as a result of the findings. The report is also included in the preliminary and final reports for the project.

4 Data Validation and Usability

4.1 Data Review, Verification, and Validation

All data that are generated by this project undergo a review process prior to their analysis and subsequent release in report form. There are various levels of review scheduled to ensure that the data are valid for analysis. See Table 5 for list of data validation methods.

Table 5: Data Review and Validation Procedures

Develoment Process

Aspect Under Review	Person(s)	Reason
Collection Methodolgy	QA/ QC Officer Project Officer	To guarantee that the protocol picked best fit the intent of data
Analysis Packages	QA/ QC Officer Project Officer	To guarantee that sample analysis methods will serve the prescribed function of the program

Collection Process

Aspect Under Review	Person(s)	Reason
Sample Collection	Project Officer	Sample collection is consistent with protocol as well as with each other
Calibration Log	QA/ QC Officer Project Officer	To ensure that physical measurements used to validate macroinvertebrate samples are in fact valid themselves

Sample Analysis Process

Aspect Under Review	Person(s)	Reason
Macroinvertebrate Sample	Taxonomist	Determine whether organisms are capable of being identified with confidence to desired taxon
Habitat Data	QA/ QC Officer Project Officer	To both validate the actual habitat data itself as well as the reproducability of macroinvertebrate samples collected
Macroinvertebrate Taxonomy	Head Taxonomist QA/QC Officer Project Officer	To ensure that macroinvertebrate data reported is valid prior to analysis

Data Analysis Process

Aspect Under Review	Person(s)	Reason
Data Entry	Project Officer	To ensure that data was correctly input into analysis package
Data Analysis	Project Officer	To ensure that methods used for analysis are valid prior to reporting
Data Storage/ Reporting	Project Officer	To ensure that data that is being received has not been altered during any step of the entry or analysis process, rendering it invalid

4.2 Reconciliation with Data Quality Objectives

Data gathered by this project are used for the development of biological criteria for inclusion into The Delaware River Basin Water Quality Regulations as well as possible index development for the non-tidal Delaware River. Once valid macroinvertebrate data are gathered and analyzed, the findings will be used to expand the data set for the determination of existing water quality (EWQ) of the Delaware River and for the development of water quality criteria to prevent the degradation of the EWQ

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Appendix A

Map of sampling locations for Delaware River Biomonitoring Program

Table 1: Sampling sites and locations

Site Name	Site Number	River Mile	Latitude	Longitude
West Branch Delaware River	DRBC3310W	331.0	41.95250	-75.29121
East Branch Delaware River	DRBC3310E	331.0	41.95199	-75.28016
Buckingham Access	DRBC3250	325.0	41.86627	-75.26293
Long Eddy (Down's Residence)	DRBC3150	315.0	41.84669	-75.13317
Callicoon Bridge	DRBC3040	304.0	41.76508	-75.06120
Castillo del Rio	DRBC2935	293.5	41.64772	-75.04939
Ascalona Campground	DRBC2790	279.0	41.49817	-74.98205
Pond Eddy (Landers Base)	DRBC2690	269.0	41.44466	-74.86242
Port Jervis	DRBC 2550	255.0	41.37229	-74.69813
Kittatinny Access	DRBC 2499	249.9	41.34134	-74.75964
Cadoo Rd. (NPS Property)	DRBC 2475	247.5	41.32364	-74.78502
Spackman's Island	DRBC 2336	233.6	41.17032	-74.89400
Bushkill Access	DRBC 2285	228.5	41.10439	-74.98422
Worthington	DRBC 2150	215.0	41.00448	-75.10609
Arrow Island	DRBC 2108	210.8	40.96275	-75.11989
Portland	DRBC 2073	207.3	40.89449	-75.07563
Capush Island	DRBC 1949	194.9	40.79190	-75.10891
Getter's Island	DRBC 1843	184.3	40.69973	-75.20121
Forks of the Delaware	DRBC 1833	183.3	40.68362	-75.19946
Whippoorwill Island	DRBC 1798	179.8	40.65406	-75.19819
Upper Black Eddy	DRBC 1666	166.6	40.55148	-75.08178
Treasure Island	DRBC 1608	160.8	40.47566	-75.06330
Paunacussing Bar	DRBC 1556	155.6	40.40936	-75.04072
Washingtons Crossing	DRBC 1418	141.8	40.29657	-74.86853
Rotary Island	DRBC 1369	136.9	40.23963	-74.81852

Appendix B

Macroinvertebrate Sample Label

Site Number: _____
Site Name: _____

Date: _____
Time: _____

Type of Sample: _____
Preservative: _____
Method: _____
Collectors: _____

Container _____ of _____

Delaware River Biomonitoring Program

Instream Habitat Assessment

Instantaneous Water Quality and Flow Velocity Measurements

Station Name:

Station Number:

Date (YYYY/MM/DD) and **Time** (Military) :

Dissolved Oxygen	Method: Hydrolab Quanta		mg/l
Air Temperature	Method: Hydrolab Quanta		°C
Water Temperature	Method: Hydrolab Quanta		°C
Specific Conductance	Method: Hydrolab Quanta		µmhos/cm
pH	Method: Hydrolab Quanta		pH units
Turbidity (*in situ*)	Method: Hydrolab Quanta		NTU
Total Dissolve Solids	Method: Hydrolab Quanta		g/L

Collectors:

Instrument: Spin Test seconds

	Depth	Revolutions	Time	Velocity
Left				
Center				
Right				
Average				

	Depth	Revolutions	Time	Velocity
Left				
Center				
Right				
Average				

	Depth	Revolutions	Time	Velocity
Left				
Center				
Right				
Average				

Comments:

100-Particle Pebble Count From Benthic Sampling Transect

Class Name	Particle Size Class (mm)	Tally	Count	Cumulative Count
Sand	<2			
VF Gravel	2 - 2.8			
VF Gravel	2.8 - 4			
Fine Gravel	4 - 5.6			
Fine Gravel	5.6 - 8			
Med. Gravel	8 - 11.3			
Med. Gravel	11.3 - 16			
Coarse Gravel	16 - 22.6			
Coarse Gravel	22.6 - 32			
VC Gravel	32 - 45.3			
VC Gravel	45.3 - 64			
Sm. Cobble	64 - 90.5			
Sm. Cobble	90.5 - 128			
Lg. Cobble	128 - 181			
Lg. Cobble	181 - 256			
Sm. Boulder	256 - 362			
Sm. Boulder	362 - 512			
Med. Boulder	512 - 1024			
Lg. Boulder	1024 - 2048			
VL Boulder	2048 - 4096			
Bedrock	>4096			
	Totals			

HABITAT ASSESSMENT FIELD DATA SHEET—HIGH GRADIENT STREAMS (FRONT)

STREAM NAME	LOCATION	
STATION #_____ RIVERMILE_____	STREAM CLASS	
LAT _____ LONG _____	RIVER BASIN	
STORET #	AGENCY	
INVESTIGATORS		
FORM COMPLETED BY	DATE _____ TIME_____ AM PM	REASON FOR SURVEY

Parameters to be evaluated in sampling reach	Habitat Parameter	Condition Category			
		Optimal	**Suboptimal**	**Marginal**	**Poor**
	1. Epifaunal Substrate/ Available Cover	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are <u>not</u> new fall and <u>not</u> transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
	SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
	2. Embeddedness	Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment. Layering of cobble provides diversity of niche space.	Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment.	Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment.
	SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
	3. Velocity/Depth Regime	All four velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow). (Slow is < 0.3 m/s, deep is > 0.5 m.)	Only 3 of the 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes).	Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score low).	Dominated by 1 velocity/ depth regime (usually slow-deep).
	SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
	4. Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
	SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
	5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
	SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

HABITAT ASSESSMENT FIELD DATA SHEET—HIGH GRADIENT STREAMS (BACK)

Parameters to be evaluated broader than sampling reach	Habitat Parameter	Condition Category			
		Optimal	**Suboptimal**	**Marginal**	**Poor**
	6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
	SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
	7. Frequency of Riffles (or bends)	Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream <7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important.	Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is between 7 to 15.	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25.	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ratio of >25.
	SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
	8. Bank Stability (score each bank) Note: determine left or right side by facing downstream.	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
	SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
	SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
	9. Vegetative Protection (score each bank)	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
	SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
	SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
	10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
	SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
	SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

Total Score_____

PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA (FRONT)

STREAM NAME	LOCATION	
STATION #_____ RIVERMILE_____	STREAM CLASS	
LAT _____ LONG _____	RIVER BASIN	
STORET #	AGENCY	
INVESTIGATORS		
FORM COMPLETED BY	DATE _____ TIME _____ AM PM	REASON FOR SURVEY

WEATHER CONDITIONS

Now		**Past 24 hours**
❑	storm (heavy rain)	❑
❑	rain (steady rain)	❑
❑	showers (intermittent)	❑
____%❑	%cloud cover	❑____%
❑	clear/sunny	❑

Has there been a heavy rain in the last 7 days? ❑ Yes ❑ No

Air Temperature_____ ^{0} C

Other_____

SITE LOCATION/MAP

Draw a map of the site and indicate the areas sampled (or attach a photograph)

STREAM CHARACTERIZATION

Stream Subsystem
❑ Perennial ❑ Intermittent ❑ Tidal

Stream Type
❑ Coldwater ❑ Warmwater

Stream Origin
❑ Glacial ❑ Spring-fed
❑ Non-glacial montane ❑ Mixture of origins
❑ Swamp and bog ❑ Other_____

Catchment Area_____km^2

PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA (BACK)

WATERSHED FEATURES	**Predominant Surrounding Landuse** ❑ Forest ❑ Commercial ❑ Field/Pasture ❑ Industrial ❑ Agricultural ❑ Other _____ ❑ Residential **Local Watershed NPS Pollution** ❑ No evidence ❑ Some potential sources ❑ Obvious sources **Local Watershed Erosion** ❑ None ❑ Moderate ❑ Heavy
RIPARIAN VEGETATION (18 meter buffer)	**Indicate the dominant type and record the dominant species present** ❑ Trees ❑ Shrubs ❑ Grasses ❑ Herbaceous **dominant species present** _____
INSTREAM FEATURES	**Estimated Reach Length** _____m **Estimated Stream Width** _____m **Sampling Reach Area** _____m^2 **Area in km^2 (m^2x1000)** _____km^2 **Estimated Stream Depth** _____m **Surface Velocity (at thalweg)** _____m/sec **Canopy Cover** ❑ Partly open ❑ Partly shaded ❑ Shaded **High Water Mark** _____m **Proportion of Reach Represented by Stream Morphology Types** ❑ Riffle_____% ❑ Run_____% ❑ Pool_____% **Channelized** ❑ Yes ❑ No **Dam Present** ❑ Yes ❑ No
LARGE WOODY DEBRIS	**LWD** _____m^2 **Density of LWD** _____m^2/km^2 **(LWD/ reach area)**
AQUATIC VEGETATION	**Indicate the dominant type and record the dominant species present** ❑ Rooted emergent ❑ Rooted submergent ❑ Rooted floating ❑ Free floating ❑ Floating Algae ❑ Attached Algae **dominant species present** _____ **Portion of the reach with aquatic vegetation** _____%
WATER QUALITY	**Temperature**_____^{0} C **Specific Conductance**_____ **Dissolved Oxygen** _____ **pH** _____ **Turbidity** _____ **WQ Instrument Used** _____ **Water Odors** ❑ Normal/None ❑ Sewage ❑ Petroleum ❑ Chemical ❑ Fishy ❑ Other_____ **Water Surface Oils** ❑ Slick ❑ Sheen ❑ Globs ❑ Flecks ❑ None ❑ Other_____ **Turbidity (if not measured)** ❑ Clear ❑ Slightly turbid ❑ Turbid ❑ Opaque ❑ Stained ❑ Other_____
SEDIMENT/ SUBSTRATE	**Odors** ❑ Normal ❑ Sewage ❑ Petroleum ❑ Chemical ❑ Anaerobic ❑ None ❑ Other_____ **Oils** ❑ Absent ❑ Slight ❑ Moderate ❑ Profuse **Deposits** ❑ Sludge ❑ Sawdust ❑ Paper fiber ❑ Sand ❑ Relict shells ❑ Other_____ **Looking at stones which are not deeply embedded, are the undersides black in color?** ❑ Yes ❑ No

INORGANIC SUBSTRATE COMPONENTS (should add up to 100%)			**ORGANIC SUBSTRATE COMPONENTS (does not necessarily add up to 100%)**		
Substrate Type	**Diameter**	**% Composition in Sampling Reach**	**Substrate Type**	**Characteristic**	**%Composition n Sampling Area**
Bedrock			Detritus	Sticks, wood, coarse plant materials (CPOM)	
Boulder	> 256 mm (10")				
Cobble	64-256 mm (2.5"-10")		Muck-Mud	Black, very fine organic (FPOM)	
Gravel	2-64 mm (0.1"-2.5")				
Sand	0.06-2mm (gritty)		Marl	Grey, shell fragments	
Silt	0.004-0.06 mm				
Clay	< 0.004 mm (slick)				

Delaware River Biological Monitoring

Benthic Invertebrate Sample Log

Site Number	Date	Time	Collector	Site Description	# of Jars	Analysis	Sample Type
Collectors:							
Sent to Lab:							

Delaware River Biological Monitoring

Benthic Invertebrate Lab Matrix

Return To:	Robert Limbeck, DRBC, PO Box 7360, 25 State Police Drive, West Trenton, NJ 08628 (Robert.Limbeck@drbc.state.nj.us)						
Site Number	**Date Collected**	**Site Description**	**# of Jars**	**Date Floated**	**Date Identified**	**Squares Picked**	**No. Counted**
			0	jars			

DELAWARE RIVER BIOMONITORING PROGRAM

CHAIN-OF-CUSTODY RECORD

Project Manager:		Robert L. Limbeck		Agency: Delaware River Basin Commission			
Address & Phone:		PO Box 7360, W. Trenton NJ 08628 609-883-9500 x 230		Project: Delaware River Biomonitoring			
Date Collected (YYYYMMDD)	Time Collected (Mil. HHMM)	Site No. Location	# jars	Sample Type (see below)	Preserv-ation (see below)	Collect. Method (Grab / Composite)	Log Number (Seq+)

Sampled by (signature):					
Received by (signature):		Date		Time	
Received by (signature):		Date		Time	
Received by (signature):		Date		Time	

Instructions/Notes: Each Sample Bag Contains:

Instructions:

Record all information concerning samples.

Check log numbers against containers to assure all samples are present, then sign in appropriate spaces.

Keep original Chain-of-Custody Record with samples.

Person relinguishing samples should receive a photocopy of this form.

Notify Project Manager immediately of any damaged or missing samples.

Delaware River Biomonitoring Program
Bench Tally Sheet

Site Name: _____ **Date:** _____

Site Number: _____ **Time:** _____

Collectors: _____ **Method:** _____

Taxonomist: _____ **Grids:** ___ of _____

Taxa	No.		Taxa	No.
1.			26.	
2.			27.	
3.			28.	
4.			29.	
5.			30.	
6.			31.	
7.			32.	
8.			33.	
9.			34.	
10.			35.	
11.			36.	
12.			37.	
13.			38.	
14.			39.	
15.			40.	
16.			41.	
17.			42.	
18.			43.	
19.			44.	
20.			45.	
21.			46.	
22.			47.	
23.			48.	
24.			49.	
25.			50.	

* Resized to fit page

Hydrolab Quanta Calibration Sheet

Date: _____ **Time:** _____

DO Percentage

**Air Calibration*

	Initial Value	Calibration	Final Value	Initials
Air Temperature:		Y or N		

DO Concentration (mg/L)

	Initial Value	Calibration	Final Value	Initials
Water Temperature:				
DO (mg/L):		Y or N		

Winkler Titrations

1. _____
2. _____
3. _____

Comments: _____

pH Calibration (2pt)

	Initial Value	Calibration	Final Value	Initials
7.0 Buffer:		Y or N		
4.0 Buffer:		Y or N		

**anticipated values less than 7.0*

7.0 Buffer:		Y or N		
10.0 Buffer:		Y or N		

**anticipated values greater than 7.0*

Comments: _____

Specific Conductance (84 µS/cm Standard)

	Initial Value	Calibration	Final Value	Initials
Specific Conductivity:		Y or N		
Temperature:				

Comments: _____

Turbidity (2pt, 4000 NTU Stock)

**dilution created using 1mL stock and 99mL water*

	Intial Value	Calibration	Final Value	Initials
Zero (DI water):		Y or N		
40 NTU Standard:		Y or N		

Comments: _____

Delaware River Biomonitoring Program

Quantitative Richest Targeted Habitat Periphyton Sample Field Data Sheet

Sample Number:	DRBC - _____ - _____ - _____ River Mile Date Time					
Station Name:						
River Mile:			**Reach Length (M):**			
Date YYYYMMDD			**Military Time:**			
GPS Coordinates (NAD83 dd)						
Collectors/Roles:						
Related Sampling:	WQUAL DISCH HABITAT INVERT FISH					
Clouds %	**Wind:** CALM LIGHT MODERATE GUSTY					
Precipitation	NONE RAIN SLEET SNOW					
Precipitation Intensity	N/A LIGHT MODERATE HEAVY					
Water Quality	**Water Temperature (C)**		**Air Temperature (C)**		**pH**	
	Dissolved Oxygen (mg/l)		**Specific Conductance (µmhos/cm)**		**Turbidity (NTU)**	
Discharge (cfs)		**USGS Gage/Time**				
Riparian Shading	SHADED PARTIAL FULL SUN					
Water Clarity	CLEAR SLIGHTLY TURBID TURBID VERY TURBID					
Water Color	BLACK BROWN CLEAR DK GREEN LT GREEN YELLOW					
Photographs:						
Comments:						

Delaware River Biomonitoring Program

Periphyton Sample Field Data Sheet

Sample Number:	DRBC - _____ - _____ - _____ River Mile Date Time					
Bottles:	Chlorophyll A + AFDM (250 ml, iced, no preservative) Algal Taxonomy (500 ml, buffered formalin preservative)					
Sampling Information:	PRIMARY SAMPLE REPLICATE SAMPLE					
Sample Type:	RICHEST TARGETED HABITAT DEPOSITIONAL HABITAT					
Periphyton Habitat Sampled:	EPILITHIC EPIDENDRIC EPIPHYTIC EPISAMMIC EPIPELIC					
Periphyton Method:	TOP-ROCK SCRAPE CYLINDER GRAVEL SAMPLER PETRI DISH					
CHLA/AFDM ROCKS (3)	DIAM1: cm2	DIAM2: cm2	DIAM3: cm2			
Taxonomy Rocks (6) Diam cm2:	1:	2:	3:	4:	5:	6:

Sample Location No.	**Depth (ft)**	**Velocity (ft/sec)**	**Shading** **S=Shaded** **P=Partial** **F=Full Sun**	**Densiometer (face S, % open)**	**Type and Color of Macroalgae**
CHLA 1					
CHLA 2					
CHLA 3					
TAXONOMY 1					
TAXONOMY 2					
TAXONOMY 3					
TAXONOMY 4					
TAXONOMY 5					
TAXONOMY 6					

Light Measurements in Transect		**Light Intensity Reading (PAR 400-700nm)**		
Reading No.	**From Surface**	**Location 1 (end)**	**Location 2 (mid)**	**Location 3 (end)**
		depth:	depth:	depth:
1	top			
2	1/5			
3	2/5			
4	3/5			
5	4/5			
6	bottom			

DRBC ALGAE SAMPLE				
Sample Number:	**DRBC** - _____ - _____ - _____ **River Mile** **Date** **Time**			
Station Name				
Date		**Time (Mil)**		
Collectors				
Sample Type	RTH	**Component**	Microalgae	
Subsample	**DIATOM ID** **CHLA** **AFDM** **SOFT ALGAE**			
Sample Volume		**Subsample Volume**		
Preservative	Buffered Formaldehyde	**Preservative Volume**		
BOTTLE_____of _____				

DRBC ALGAE SAMPLE				
Sample Number:	**DRBC** - _____ - _____ - _____ **River Mile** **Date** **Time**			
Station Name				
Date		**Time (Mil)**		
Collectors				
Sample Type	RTH	**Component**	Microalgae	
Subsample	**DIATOM ID** **CHLA** **AFDM** **SOFT ALGAE**			
Sample Volume		**Subsample Volume**		
Preservative	Buffered Formaldehyde	**Preservative Volume**		
BOTTLE_____of _____				

Appendix C

EPA-ORD RARE GRANT STUDY PLAN 2006
Joseph Flotemersch, Ph.D.

Received by DRBC
24 July 2006

Assessment Techniques and Biological Criteria for Free Flowing Large Rivers:

Special Emphasis on Non-tidal Sections of the Delaware River Basin

2006 Project Research Plan
Version 3.6
24 July 2006

1.0 Introduction

1.1 Background

In 2004, EPA-ORD-NERL-ERB and EPA Region 3 scientists began discussions with the Delaware River Basin Commission (DRBC) to determine the type of assistance that could be provided in the development of biocriteria for the non-tidal portion of the Delaware River. A USEPA Regionally Applied Research Effort (RARE) grant was awarded in 2005 to support the development of stressor response relationships for the river and its large tributaries. This activity would provide indicators of biological condition in response to specific types of stressors which are of concern for this river system. Field work associated with this grant has been delayed by hurricanes and other unforeseen circumstances, but associated activities have continued.

1.2 Proposed Study

Currently, the DRBC samples 25 riffles distributed throughout the 200-mile extent of the non-tidal Delaware River (Figure 1; Table 1). The goal of this project is to produce a final assessment strategy that includes other habitats yet is approximately equivalent to DRBC's current field effort of sampling 25 sites per year and laboratory effort of processing 25 samples to 500 organisms.

An analysis of existing DRBC data has been completed. The goal of the analysis was to identify any natural groupings of sites based on biology and the abiotic factors that contribute to those divisions. Two or possibly three natural groups of sites were identified from macroinvertebrate data, and these corresponded roughly to broad sections of the river (upper, middle, and lower). Among the available parameters, conductivity and substrate size were identified as key factors that explained the separation of sites into groups.

One of the key objectives of the project has been the development, testing, and implementation of methods for sampling (i.e., benthic macroinvertebrates, physical habitat) throughout the Delaware River. Currently, only

riffle habitats are being sampled, but it has been recognized that impairments in the river may be most evident in pool areas. To meet this objective, sampling protocols for non-riffle habitats will be developed collaboratively by scientists from EPA-ORD, EPA-Region 3, and the DRBC. The target sampling period for this study is August 15 to October 15.

2.0 Site distribution, selection, and sampling order

2.1 River segments

The river has been divided into three sections; the upper (river miles 330.7-254), middle (river miles 254-209.5), and lower Delaware (river miles 209.5-133.3). The top and bottom boundaries of the upper and middle Delaware sections roughly correspond to the boundaries of the upper Delaware (http://www.nps.gov/upde/) and Delaware River Gap National Parks (http://www.nps.gov/dewa/). This will function to facilitate future collaboration with the Eastern Rivers and Mountains Network (http://www.nature.nps.gov/im/units/ermn/index.htm), National Park Service and also reflects clustering of benthic communities observed during analysis of existing DRBC data.

2.2 Sites per segment

For this study, the goal is to sample 25 sites in each of the three sections of river (n=75). Within each section, sites were randomly selected from a pool of candidate sites spaced at 1/16 mile intervals throughout the 200 mile section of the river that the DRBC is concerned with. This provided a pool of approximately 3200 sites throughout the river. In each section of river, an oversample of 200% (a total of 75 sites per section) were drawn at random as candidate sample sites. The first 25 will be the targeted sites (Figures 2-4). The oversample allows for replacement sites in the event that some sites are not sampleable or are determined to be non-target.

Of the targeted 75 sites, Region 3 scientists will be sampling approximately 18 sites. This value may change depending on logistics scheduling conflicts, weather, number of crew members, and field logistics. The remaining sites will be targeted by USEPA on-site contractor field crews.

2.3 Target / Non-Target Sites

The DRBC has historically sampled riffle habitat. The average mean flow values at these sites have been 2.13 ft/sec (0.65 m/sec), with a minimum mean of 1.14 ft/sec (0.35 m/sec). Sampling for this study will target non-riffle habitats. For this study, a riffle will be defined as; **a stretch of choppy water caused by a rocky shoal or sandbar lying just below the surface of a waterway.** Flow criteria cannot be used because some riffles have areas with slow moving water and some deep non-riffle areas have velocities exceeding those previously sampled in riffles. The final decision as to whether a site is *Target* or *Non-Target* will have to be made by the field crew. **When there is a doubt, sample the site**. The sample time is minimal compared to the travel time between sites. *Non-target* also includes sites that cannot be safely accessed or sampled, where owner permission may be required (this is not expected to be an issue on the Delaware), and that are extremely logistically

Non-Target Sites Include those:

- that are riffles
- that cannot be safely accessed
- that cannot be safely sampled
- lacking owner permission
- that are unrealistically time consuming to access

cumbersome or too time-consuming (exceeds daylight hours) to access. If a site is deemed non-target, the next site on the list of alternate sites for that section of river will become a candidate site for sampling. Be sure to note on the data sheets why a site was deemed non-target.

3.0 Methods

3.1 Documentation of the Sample Site

The first duty upon arriving at a site will be to fully document the site. Location information will be collected at each site using a hand-held GPS unit. The positioning information will be used for Geographic Information System (GIS) presentation and analysis of data. Location information and notes will also be recorded on a set of DRBC "River Recreational Maps" for navigation on future studies. A sample data sheet for recording site location is provided as Figure 5.

3.1 Benthic macroinvertebrate sample collection methods by flow criteria

Sampling for the DRBC RARE project will use two different sample collection protocols. The first method (the DRBC method) will be used at sites where the flow is sufficient to flush dislodged benthic organisms from the substrate into the net. The second method (the modified Pennsylvania anti-degradation method [m-PAD]) is used in locations where movement of the net will be required to collect and capture dislodged benthic organisms. As an initial guide, at sites where the flow is above 1 ft/sec (0.3 m/sec), the protocol use the DRBC method will like be used. At sites were the flow is < 1 ft/sec (0.3 m/sec), the m-PAD method will likely be used. Again, these flow criteria are a guide to be used by the field crews. If a site is encountered by the field crew where the flow is > 1 ft/sec but the field crew finds use of the DRBC protocol unfeasible, the decision can be made to use the m-PAD method. However, it is important to document the justification for the deviation from the guidance so that what has been learned by the field crew can be incorporated into future guidance.

3.1.1 Sample zone

All sampling will be based on a 100 m sample reach. All sampling to be conducted by the USEPA on-site contractor and USEPA-Region 3 scientists will occur in non-riffle habitats (see the narrative definition of riffle in section 2.3). The latitude and longitude used to locate the site will serve as the mid-point of the reach that will extend 50 m upstream and downstream of that point. Before finalizing the extent of the reach, be sure that the reach has a dominant habitat type. If the reach is not dominated by a single habitat, the reach can be slid upstream or downstream to the extent that it still includes the original target coordinance. As an example, if the reach is half riffle and half glide, since the study is targeting non-riffle habitat, slide the reach so that the glide habitat dominates the reach. As another example, if the reach is half glide and half pool, slide the reach so that one of the habitats dominates the sample reach.

3.1.2 The DRBC Protocol

The DRBC protocol has historically been used only in riffle habitat. This study will expand its use to other habitats where the flow is sufficient to flush dislodged benthic organisms into the net. For this protocol, samples are collected using a Big Frame Net (BFN) with a substrate frame. The nets for this study were constructed by Superstitches, Youngstown, OH using specification provide by the DRBC staff. The net is 24 in x 36 in (60.96 cm x 91.44 cm) with a 595 µm mesh (closely resembling a slack sampler). In front of the net, a 2ft x 2ft (60.96cm x 60.96cm) substrate frame is used to delineate a 4 ft^2 (0.3716 m^2) sampling area for a more quantitative analysis than a standard D-frame kick net or slack sampler and also for an increased sample area.

The net is 12 in (30.48 cm) wider than the substrate frame to limit the amount of sample lost around net caused by the effects of the flow on the organisms suspended as part of the collection procedure. The increased sample area was based on recommendations made by the National Park Service and Academy of Natural Sciences citing low densities and inconsistent distributions of macroinvertebrate communities in the Upper Delaware River (National Park Service, Report Nos. 01-5F, 01-7F).

At each site, 3 samples will be collected using the BFN (total area: 12 ft^2 [1.1148 m^2]) and combined into a single composite sample for the site. The location of each of the 3 samples is chosen after a visual inspection by the field crew lead. The selection of the site and specific sample collection locations are based on the **ideal substrate and flow characteristics required for macroinvertebrate colonization** as well as representative of the entire reach. In riffle areas, this will likely be the head of the riffle. Varying in response to the geomorphology of the site, the point where the 3 samples are collected may be parallel, perpendicular, or diagonal to the flow. A flag (or other suitable marker) should be placed at each point where a sample will be collected. The distance between the flags is not set, but when selecting the sampling locations, it should be kept in mind that a 100-count Wolman Pebble Count (Section 4.1.1) will be conducted that covers the extent of the placement of the sampling points (flags). Flagged points must be oriented to facilitate the Wolman Pebble Count, and therefore should generally be in a straight line or arc.

Once each sampling point is identified, samples are collected using a modification of the Traveling Kick Method (Barbour et al, 1999). A person stands down stream of the sampling area and is responsible for securing the net. The sampling frame is placed directly upstream of the net and held in place by a second individual while the area inside the frame is agitated by foot. Once the coarse agitation of the substrate is complete, the individual holding the frame does final check to make sure that all of the delineated area has been disturbed, ensuring that the sample effort is maximized. Any of the area that does not appear to have been disturbed is agitated by hand. If upon inspection of dislodged rocks (and other substrate materials) a high number of organisms appear to still be clinging to the substrate, brushing/rubbing of the substrate by hand to further dislodge attached organisms is permissible.

3.1.2 The m-PAD Protocol

At sample locations where the flow is insufficient to flush dislodged organisms into the sample net, a modified version of the Pennsylvania anti-degradation method (m-PAD) will be used for collection of benthic organisms. The method is modified from the original method in that the modified protocol samples an area upstream of the net equal to 0.15 m^2 rather than the 1 m^2 area prescribed by the original. As with the DRBC method, each site will consist of a 100 m reach from which the sample can be collected. Samples will be collected using a D-frame net (595 µm mesh; ~30 cm wide).

At each site, 6 samples will be collected within the 100 m reach and combined into a single composite sample for the site. Each of the six kicks will cover 0.15 m^2 of substrate (net width of 0.3 m x 0.5 m length of pass) for a total area sampled of 0.9 m^2, a surface area slightly less than that sampled by the DRBC BFN at riffle sites. The 6 samples should be collected from the dominant "kickable" habitat. This excludes sampling habitats such as undercut banks, root wads, and woody debris that are likewise unsampled by the DRBC riffle method.

In "glide-like" reaches, the targeted habitat may be the richest and most productive habitat present in the reach. However, in more pool-like areas, the dominant kickable habitat may not be the richest and most productive habitat. None-the-less, the dominant kickable habitat is what should be sampled. Varying in response to the geomorphology of the site, the point where the 6 samples are collected may be parallel, perpendicular, or diagonal to the flow. A flag (or other suitable marker) should be placed at each point where a sample will be collected. The distance between the flags is not set, but when selecting the sampling locations, it should be kept

in mind that a 100-count Wolman Pebble Count (Section 4.1.1) will be conducted that covers the extent of the placement of the sampling points (flags). Flagged points must be oriented to facilitate the Wolman Pebble Count, and therefore should generally be in a straight line or arc.

At each of the six sampling points, an area the width of the net and extending 0.5 m in front of the net is sampled. The technique used to make the collection at each sampling point will vary by the composition of the substrate, but likely similar within a site. At some points, the sample area may need to be first disturbed by foot, followed by sweeping the collection net multiple times through the disturbed and suspended material to net specimens dislodged by the sampling effort. At other points, the most effective sampling technique may be to jab the substrate, followed by sweeping the net through the disturbed and suspended materials. Regardless of the technique, the process may be repeated multiple times at each point until the sampler concludes that area has been adequately sampled. As with the DRBC protocol, if upon inspection of dislodged rocks (and other substrate materials) a high number of organisms appear to still be clinging to the substrate, brushing/rubbing of the substrate by hand to further dislodge attached organisms is permissible.

3.2 Field processing of benthic samples

After removal of any large rocks or other debris, the bulk of the sample is rinsed into a large, water-filled container to simplify the cleaning of the net. The macroinvertebrates not dislodged by the rinse are then picked from the net using forceps and placed in a labeled sample container for preservation. Once the net has been picked, the contents of the larger container is condensed by pouring it through a 595 µm mesh sieve (or the D-frame net), and then transferred to the labeled sample container that contains the macroinvertebrates picked from the net. After careful inspection of both the net and container for remaining macroinvertebrates, both are rinsed and preserved in Ethyl Alcohol (>75%) for later identification.

The sample container will receive both an external and internal label (Figure 6). The sample label accompanies the sample through the entire sort-identify process.

3.1 Duplicates of benthic macroinvertebrate samples

Currently, the plan is to sample 25 sites in each of the three sections of the river for a total of 75 sites. A rate of 10% duplicates results in 7.5 sites. Practically applying this to the present study, we will collect 9 duplicate samples; 3 randomly selected from the 25 sites selected in each of the upper, middle, and lower sections. The sample variability that the duplicates are targeted to document is that associated with the method. For this reason, duplicate samples for a site will be collected in the same day. If a site selected for collection of a duplicate sample is deemed non-target, then a duplicate sample should be collected at the next site sampled in that section of the river. If two sites targeted for duplicates are in close proximity to each other, it is permissible that they be sampled in the same day.

3.2 Order that sites are sampled:

The strongest statistical design would be one where the order that sites are sampled is selected completely at random to minimize the potential for seasonal effects and to maximize the likelihood of coverage from top to bottom. The most efficient field design would be one where sites were sampled in order from top to bottom or vice versa (serial sampling order). As a compromise, after the 25 sites in each of the three sections of river have been selected, sites that cluster can be sampled in the same day. Clusters of sites sampled in the same day will like range in size from 3-5 sites, but this will vary by crew and logistics of the sites.

As an example, study site number 1 is located in the lower Delaware section of the river. Within 2 miles are sites 25 and 47 (which is a duplicate site). Therefore, the crew that samples site 1 may also sample site 25 and 47 (3 sites) which would result in a total of 4 benthic samples since site 47 was a duplicate. The following day they would proceed to study site number 2 which is in the upper Delaware. Sites 31 and 47 are within 2 miles, and sites 24 and 49 (a duplicate site) are within 5 miles. However, site 73 is to the North and isolated by itself, the crew may choose to sample it in lieu of sampling sites 24 and 49 which have additional sites that they could be clustered with downstream.

When multiple crews are in the field, sampling will have to be closely coordinated with a central contact to ensure that multiple crews do not sample the same site.

3.3 Laboratory processing of samples: 300

Samples will be processed in a lab to obtain approximately 300 macroinvertebrates. Samples will be spread out in a Caton subsampling tray (25 or 50 square tray depending on the amount of material) and rinsed. A square will be randomly selected and the material from that square will be transferred to a tray for picking. All macroinvertebrates will be picked from this transferred material. If the process yields at least 300 organisms, the subsampling stops. Otherwise, additional squares will be picked until at least 300 organisms are selected. Once a square is removed, all macroinvertebrates must be picked from it (even if the total passes 300).

If all sites are sampled and duplicates collected (n=75+9), it will result in 84 benthic macroinvertebrate samples. Of these, Region 3 scientists have agreed to sort and identify 43 samples. The remaining samples will be sorted and identified by the USEPA on-site contractor benthic macroinvertebrate laboratory.

Note: Since two laboratories will be processing samples, the protocol the labs will be following should include information such as whether pupae will be identified, minimum number of squares that should be picked during the sorting process, acceptable picking error, the level of taxonomic identification targeted for different groups of organisms (e.g., family, genus, species), etc.

4.0 Physical Assessment and Physicochemical Parameters

The assessment of physical habitat for this study will be focused on describing the in-stream habitat from which the sample is collected. This includes the description of the substrate (e.g., Wolman Pebble Count) and characterization of the water conditions (e.g., flow measurements, depth, temperature, conductivity, turbidity, dissolved oxygen). These measurements will be used to explain differences observed among benthic macroinvertebrate collections from the system, and then to develop habitat categories that will be the basis for future sampling efforts.

4.1 In-stream Habitat

Pebble counts and flow measurements are two in-stream measures that are conducted to quantitatively characterize the habitat from which benthic macroinvertebrate samples are collected.

4.1.1 Pebble Count

A Wolman pebble count will be conducted at each sampling site to numerically characterize the particle size of each of the sampled areas (Wolman, 1954). The count will occur along a straight or arced transect that spans the flagged (or other suitable marker) points where benthic macroinvertebrates were collected (Sections 3.1.2 &

3.1.3). One hundred particles gathered along the sampled transect will be measured using an ALSCI Field Sieve from Albert Scientific (or other suitable supplier). These particles will be placed in the sieve to determine the size class of each particle and recorded on the data sheet. As a time saving measure, the size class of particles can be recorded as tick marks on the sieve and later transferred to a field sheet. Measurements will be analyzed to determine average size and class of substrate present. These measurements will be used to validate the comparability of the benthic community collected with each sample. See Figure 5 for a sample data sheet.

4.1.2 Velocity and Depth Measurement

At sites where the DRBC protocol (BFN net) is used, velocity measurements will be taken using a digital Pygmy meter (or suitable substitute to be approved by the scientific lead) at the left, center, and right edge of each of the areas sampled for macroinvertebrates. Depth measurements will also be recorded at the collection point of each sample. At sites with low water velocities where the benthic macroinvertebrate sample is collected using the m-PAD (D-frame net) protocol, velocity and flow will be collected at a single point for each of the six D-frame net samples. The net should not be in-place when the flow measurements are collected as to not interfere with the flow velocity measurement. This information will be used to characterize the habitat where samples were collected. Depth of samples collected will likely range between 0.5 and 1.5 ft, with some approaching 3 ft. See Figure 7 for a sample data sheet on which velocity and depth measurements are recorded.

4.2 Water Quality: Physical

Instantaneous measurements of the physical properties of the water will be conducted at each of the sampling sites using a Hydrolab Quanta™ multi-parameter sonde (or suitable substitute to be approved by the scientific lead).
Data will be collected for Dissolved Oxygen (mg/L), Temperature (^{o}C), Conductivity (mS/cm), pH, Turbidity (NTU), and TDS (mg/L). Water chemistry parameters will be recorded on the same data sheet as velocity (Figure 8).

Instrumentation will be calibrated for all parameters in the field on a daily basis with the exception of Dissolved Oxygen Percent Saturation (DO %). The calibrations will be recorded in a logbook for analysis following completion of sampling. An example of the calibration form is provided in Figure 9. Special care will be taken to ensure that all instruments are operating correctly.

4.3 Qualitative Habitat Assessment

Other in-stream conditions will be assessed qualitatively as part of the RBP habitat assessment that will be conducted at each site. This habitat assessment uses the following parameters to approximate the in-stream health of the system.

- Epifaunal Substrate/Available Cover
- Embeddedness
- Velocity-Depth Regime
- Sediment Deposition
- Channel Flow Status
- Channel Alteration
- Frequency of Riffles (or Bends)

These measurements will be used as possible explanations for deficiencies found in the macroinvertebrate community. Example field sheets for these data are provided in Figure 10.

A riparian habitat assessment will be conducted at each site consistent with the RBP habitat assessment protocol. Documentation will be made of any non-aquatic factors that may have influences on the health of the benthic community. The following parameters will be used in approximating the health of the riparian area.

- Bank Stability
- Vegetative Protection
- Riparian Vegetative Zone Width

These will be analyzed as part of the survey to explain differences observed in macroinvertebrate data. Examples of the field sheets where these data are recorded are provided as part of Figure 11.

Table 1: Sampling sites and locations

Site Name	Site Number	River Mile	Latitude	Longitude
West Branch Delaware River	DRBC3310W	331.0	41.95250	-75.29121
East Branch Delaware River	DRBC3310E	331.0	41.95199	-75.28016
Buckingham Access	DRBC3250	325.0	41.86627	-75.26293
Long Eddy (Down's Residence)	DRBC3150	315.0	41.84669	-75.13317
Callicoon Bridge	DRBC3040	304.0	41.76508	-75.06120
Castillo del Rio	DRBC2935	293.5	41.64772	-75.04939
Ascalona Campground	DRBC2790	279.0	41.49817	-74.98205
Pond Eddy (Landers Base)	DRBC2690	269.0	41.44466	-74.86242
Port Jervis	DRBC 2550	255.0	41.37229	-74.69813
Kittatinny Access	DRBC 2499	249.9	41.34134	-74.75964
Cadoo Rd. (NPS Property)	DRBC 2475	247.5	41.32364	-74.78502
Spackman's Island	DRBC 2336	233.6	41.17032	-74.89400
Bushkill Access	DRBC 2285	228.5	41.10439	-74.98422
Worthington	DRBC 2150	215.0	41.00448	-75.10609
Arrow Island	DRBC 2108	210.8	40.96275	-75.11989
Portland	DRBC 2073	207.3	40.89449	-75.07563
Capush Island	DRBC 1949	194.9	40.79190	-75.10891
Getter's Island	DRBC 1843	184.3	40.69973	-75.20121
Forks of the Delaware	DRBC 1833	183.3	40.68362	-75.19946
Whippoorwill Island	DRBC 1798	179.8	40.65406	-75.19819
Upper Black Eddy	DRBC 1666	166.6	40.55148	-75.08178
Treasure Island	DRBC 1608	160.8	40.47566	-75.06330
Paunacussing Bar	DRBC 1556	155.6	40.40936	-75.04072
Washingtons Crossing	DRBC 1418	141.8	40.29657	-74.86853
Rotary Island	DRBC 1369	136.9	40.23963	-74.81852

Figure 1: Sampling locations for Delaware River Biomonitoring Program

Figure 2: Juxtapositions of the target sample sites in the upper Delaware River.

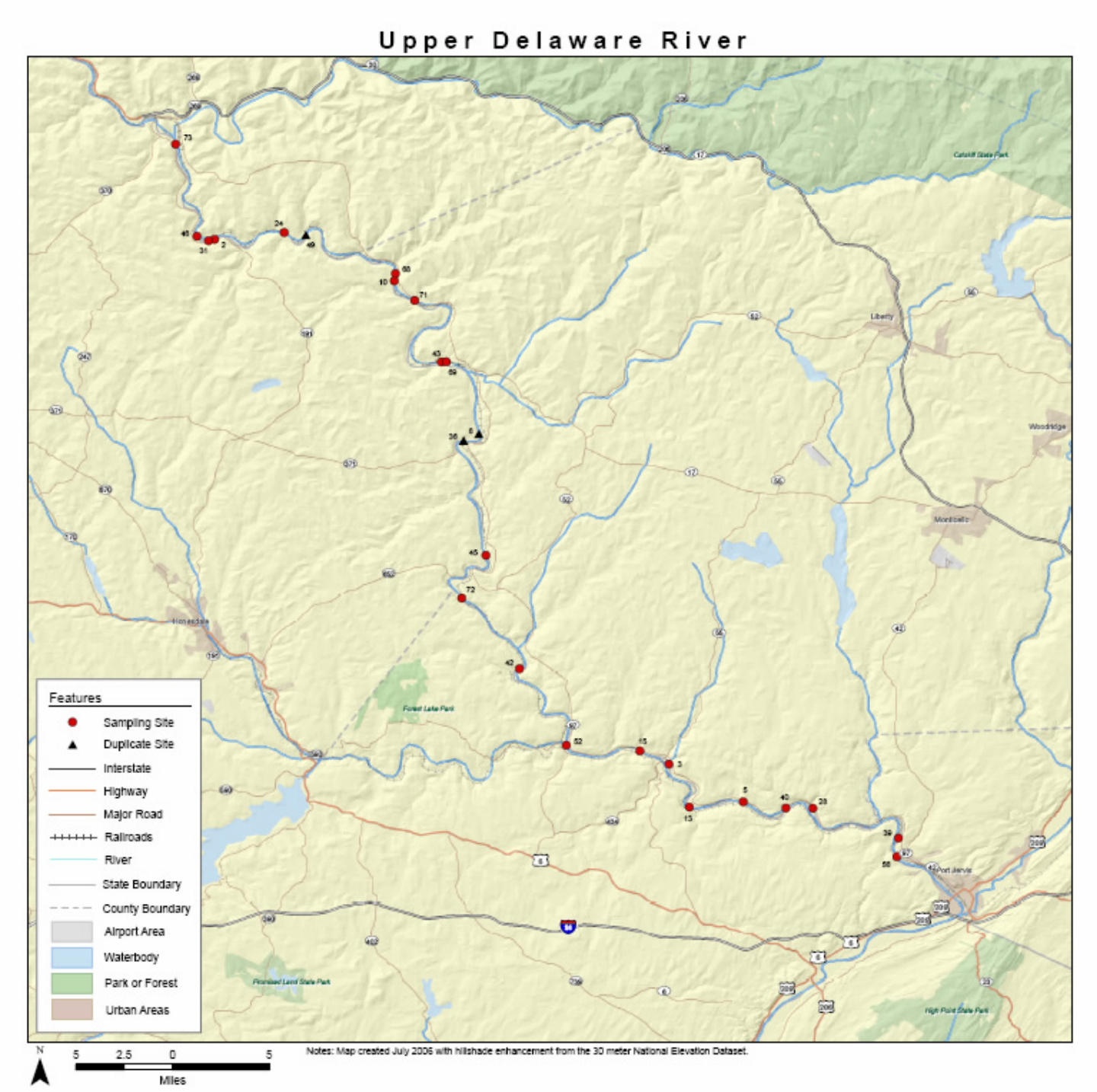


Figure 3: Juxtapositions of the target sample sites in the middle Delaware River.

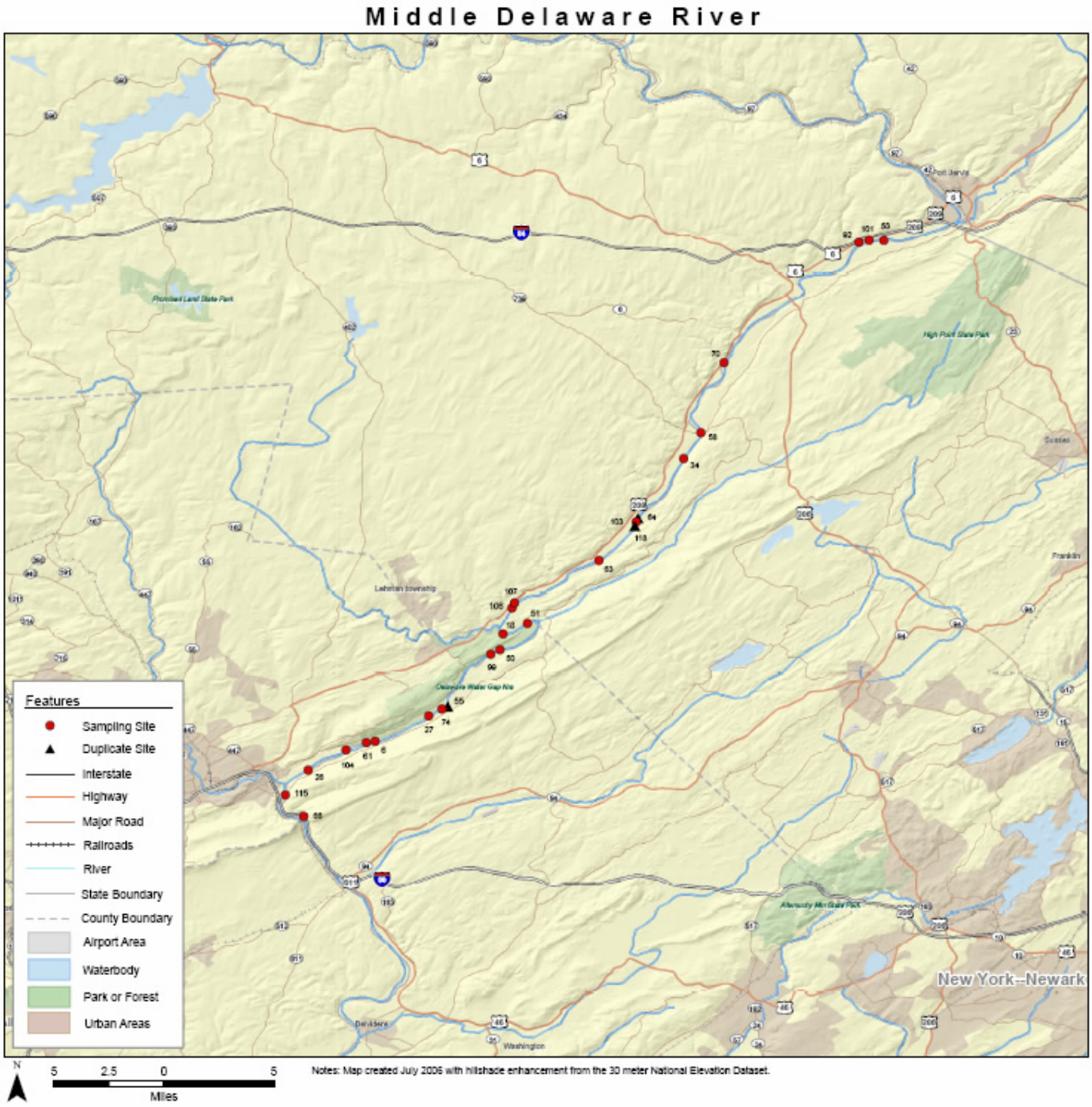
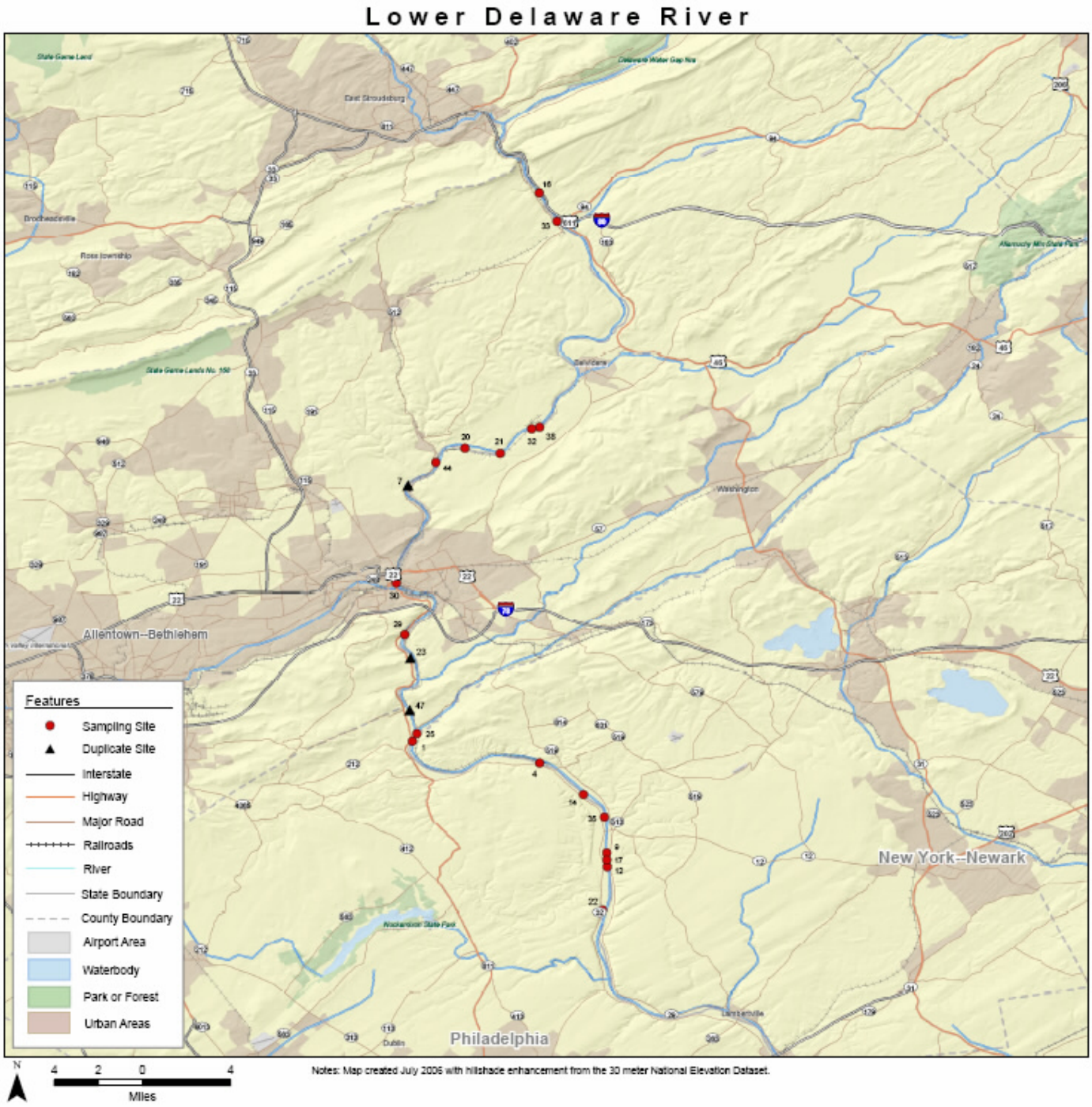


Figure 4: Juxtapositions of the target sample sites in the lower Delaware River.



(FIGURES 5-11 NOT SHOWN: SAME AS DATA SHEETS FOR DRBC, APPENDIX A)