QUALITY ASSURANCE/WORK PLAN

WATER QUALITY AND BIOLOGICAL SURVEY OF THE LARGE RIVERS OF THE SUSQUEHANNA RIVER BASIN

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I. PROJECT NAME

Water Quality and Biological Survey of the Large Rivers of the Susquehanna River Basin

II. PROJECT OFFICER

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III. QUALITY ASSURANCE OFFICER

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IV. DATE OF PROJECT INITIATION

June 2005

V. PROJECT DESCRIPTION

A. Objective and Scope

Little recent information exists regarding the biological integrity of the Susquehanna River and its major tributaries: the Chemung, Juniata, and West Branch Susquehanna Rivers. The Susquehanna River Basin Commission (Commission) initiated a pilot project in 2002 to determine proper methods of assessing the biological conditions of these large rivers (Hoffman, 2003). This proposal is based on the results of the aforementioned pilot project.

Benthic macroinvertebrates will be used to assess biological conditions for several reasons. Benthic macroinvertebrates are sensitive to a wide range of stressors, have a wide range of documented pollution tolerances, and are found in a wide variety of habitats throughout lotic systems (Flotemersch and others, 2001). Additionally, the Commission has background macroinvertebrate data from various sites on the large rivers of the Susquehanna River Basin from previous subbasin surveys and interstate streams monitoring projects, as well as the pilot project on the Susquehanna River along the Pa. – N.Y. border.

The project will take place on the Susquehanna River between Afton, N.Y., and Marietta, Pa., during summer and early fall 2005. Additionally, sampling stations will be placed at the mouths of the major tributaries to the Susquehanna River: the Chemung, West Branch Susquehanna, and Juniata Rivers. All collections will take place during base flow conditions in the summer and early fall. Sites will be selected based on previous collection areas, as well as sites located to take into account the influence of tributaries and discharges throughout the river system.

B. Data Usage

The study will provide information to: (1) assess the chemical and biological condition of the streams within the subbasin; (2) document changes in stream quality over time; and (3) identify major sources of pollution and lengths of stream impacted. Data collected during the survey also will be used in completing the Commission's Consolidated Listing (formerly Section 305(b) Water Quality Assessment) Report, and in reviewing projects affecting water quality in the basin. Additionally, information collected

will be used to begin selecting and calculating metrics for a benthic macroinvertebrate index of biotic integrity (IBI) to assess the biological conditions in the rivers of the Susquehanna River Basin.

C. Monitoring Network Design and Rationale

The Commission has a long-term interstate streams water quality monitoring program through which collections take place at Windsor, N.Y., Conklin, N.Y., Sayre, Pa., and Marietta, Pa., in the Susquehanna River. Biological and habitat data are collected annually at these sites, while water quality information is collected quarterly. Additionally, the Commission has collected macroinvertebrate and water quality information from several sites on the mainstem of the Susquehanna River and mouths of the major tributaries during its past subbasin surveys. The sampling sites, shown in Figure 1 and listed in Table 1, were selected so that data collected during this survey can be compared with past data collected by the Commission and to document the possible changes in the riverine biota throughout this stretch of river.

D. Monitoring Parameters

Parameters of interest are listed in Table 2. Discharge at sites adjacent to U.S. Geological Survey (USGS) gaging stations will be obtained from USGS rating tables. If no gaging station is available at the sampling station, flows will be calculated based on watershed area and data from the nearest gaging station. Macroinvertebrate data will be comprised of a list of different genera collected and an estimate of population density. Chemical water quality and biological samples, as well as instream flow and physical habitat information, will be collected once during the summer/early fall low-flow period. Chemical water quality samples will be processed and analyzed by Pennsylvania Department of Environmental Protection (PADEP), Bureau of Laboratories (Lab), in Harrisburg, Pa. Macroinvertebrate samples will be processed and identified by Commission staff.

VI. PROJECT FISCAL INFORMATION

See U.S. Environmental Protection Agency (USEPA) grant application.

VII. SCHEDULE

	2004												2005											
Activity	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Coordination	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Sampler Placement						X	X	X																
Water Quality Sampling							X	X	X															
Macroinvertebrate Sampling							X	X	X															
Identify Macroinvertebrates										X	X	X	X	X										
Compile and Evaluate Data												X	X	X	X	X								
Report Writing															X	X	X	X						
Final Report																			X					

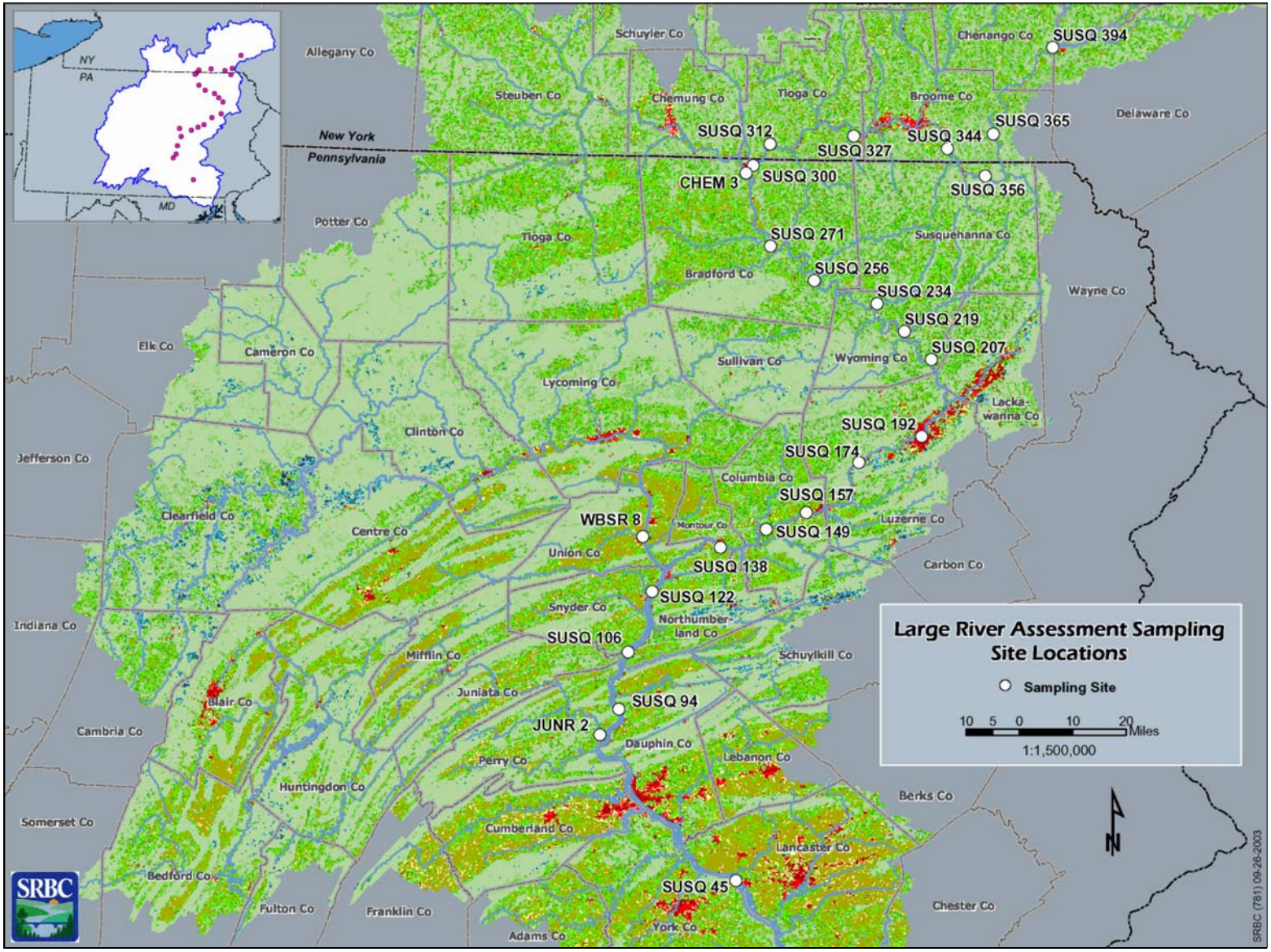


Figure 1. Large River Assessment Sampling Sites

Table 1. Large River Assessment Station Locations

Station Number	County/State	USGS Quad	Latitude	Longitude	Site Description
SUSQ 394	Chenango/N.Y.	Sidney, N.Y.	42.3113	-75.4199	Susquehanna River at Sidney, N.Y
SUSQ 365	Broome/N.Y.	Windsor, N.Y.	42.0747	-75.6351	Susquehanna River at Windsor, NY
SUSQ 356	Susquehanna/Pa.	Great Bend, Pa.	41.9612	-75.6620	Susquehanna River at PF&BC Great Bend near Oakland, Pa.
SUSQ 344	Broome/N.Y.	Binghamton East, N.Y.	42.0347	-75.8017	Susquehanna River at Kirkwood, NY
SUSQ 327	Tioga/N.Y.	Apalachin, N.Y.	42.0653	-76.1426	Susquehanna River near Apalachin, NY
SUSQ 312	Tioga/N.Y.	Barton, N.Y.	42.0400	-76.4464	Susquehanna River near Nichols, NY
SUSQ 300	Bradford/Pa.	Sayre, Pa.	41.9819	-76.5065	Susquehanna River near Sayre, PA
SUSQ 271	Bradford/Pa.	Towanda, Pa.	41.7627	-76.4393	Susquehanna River at Towanda, Pa.
SUSQ 256	Bradford/Pa.	Wyalusing, Pa.	41.6705	-76.2786	Susquehanna River near Wyalusing, Pa.
SUSQ 234	Wyoming/ Pa.	Meshoppen, Pa.	41.6099	-76.0509	Susquehanna River near Meshoppen, Pa.
SUSQ 219	Wyoming/ Pa.	Tunkhannock, Pa.	41.5351	-75.9502	Susquehanna River near Tunkhannock, Pa.
SUSQ 207	Wyoming/ Pa.	Ransom, Pa.	41.4594	-75.8524	Susquehanna River near West Falls, Pa.
SUSQ 192	Luzerne/ Pa.	Kingston, Pa.	41.2500	-75.8845	Susquehanna River at Wilkes-Barre, Pa.
SUSQ 174	Luzerne/Pa.	Nanticoke, Pa.	41.1774	-76.1085	Susquehanna River near Shickshinny, Pa.
SUSQ 157	Columbia/Pa.	Mifflinville, Pa.	41.0405	-76.2945	Susquehanna River near Berwick, Pa.
SUSQ 149	Columbia/Pa.	Catawissa, Pa.	40.9935	-76.4369	Susquehanna River near Bloomsburg, Pa.
SUSQ 138	Northumberland/Pa.	Danville, Pa.	40.9422	-76.6011	Susquehanna River near Danville, Pa.
SUSQ 122	Snyder/Pa.	Sunbury, Pa.	40.8182	-76.8420	Susquehanna River at Hummels Wharf, Pa.
SUSQ 106	Snyder/Pa.	Dalmatia, Pa.	40.6517	-76.9226	Susquehanna River at McKees Half Falls, Pa.
SUSQ 94	Dauphin/Pa.	Halifax, Pa.	40.4958	-76.9516	Susquehanna River at Montgomery Ferry, Pa.
SUSQ 45	Lancaster/Pa.	Columbia West, Pa.	40.0365	-76.5239	Susquehanna River at Marietta, Pa.
JUNR 2	Perry/Pa.	Duncannon, Pa.	40.4258	-77.0159	Juniata River at Amity Hall, Pa.
CHEM 3	Bradford/Pa.	Sayre, Pa.	41.9607	-76.5324	Chemung River at Athens, Pa.
WBSR 8	Northumberland/Pa.	Lewisburg, Pa.	40.9679	-76.8797	West Branch Susquehanna River at Lewisburg, Pa.

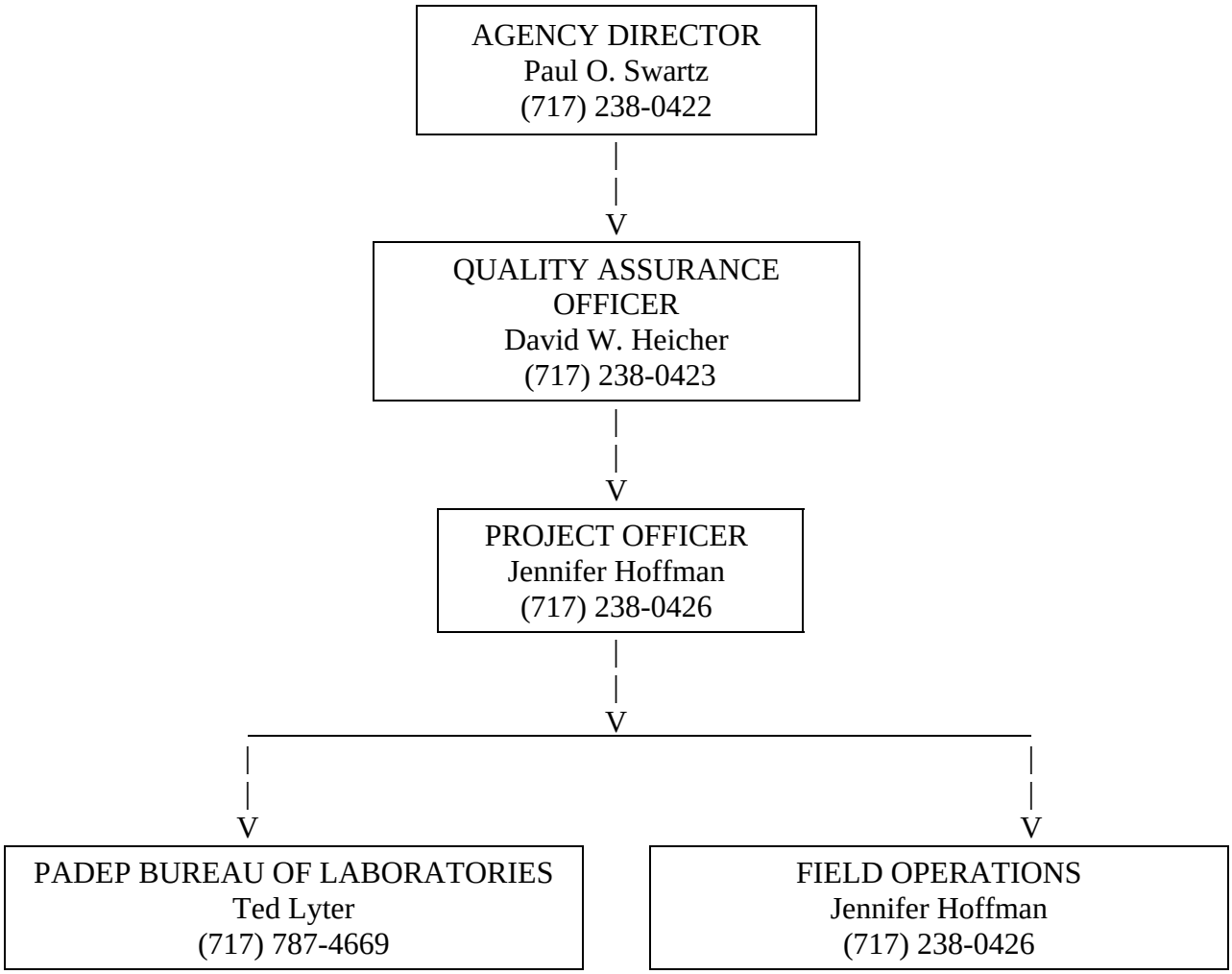
Table 2. Monitoring Parameters

Parameter	Number of Samples	Analytical Sample Matrix	Method Reference	Sample Preservation	Holding Time
Flow	NA	NA		NA	NA
Temperature	35	aq.	Field measurement on grab sample[1]	none	0
Dissolved Oxygen	35	aq.	Field measurement on grab sample[1]	none	0
Conductivity	35	aq.	Field measurement on grab sample[1]	none	0
pH	35	aq.	Field measurement on grab sample[1]	none	0
Alkalinity	35	aq.	Field measurement on grab sample[1]	none	0
Acidity	35	aq.	Field measurement on grab sample[1]	none	0
Total Alkalinity	35	aq.	SM 2320B[2]	cooling to 4° C	24 hours
Turbidity	35	aq.	EPA 180.1	cooling to 4° C	24 hours
Total Suspended Solids	35	aq.	USGS-I-3765[3]	cooling to 4° C	24 hours
Total Organic Carbon	35	aq.	SM 5310D	cooling to 4° C H_2SO_4 to pH <2	24 hours
Total Nitrite	35	aq.	EPA 300.0	cooling to 4° C	24 hours
Total Nitrate	35	aq.	EPA 300.0	cooling to 4° C	24 hours
Total Nitrogen	35	aq.	SM 4500N-ORG	cooling to 4° C	24 hours
Total Phosphorus	35	aq.	EPA 365.1	cooling to 4° C H_2SO_4 to pH <2	24 hours
Total Orthophosphate	35	aq.	EPA 365.1	cooling to 4° C	24 hours
Total Hardness	35	aq.	EPA 200.7	cooling to 4° C HNO_3 to pH<2	6 months
Total Sodium	35	aq.	EPA 200.7	preserve w/HNO_3 to a pH <2	6 months
Total Magnesium	35	aq.	EPA 200.7	preserve w/HNO_3 to a pH <2	6 months
Total Calcium	35	aq.	EPA 200.7	preserve w/HNO_3 to a pH <2	6 months
Total Chloride	35	aq.	EPA 300.0	cooling to 4°C	24 hours
Total Sulfate	35	aq.	EPA 300.0	cooling to 4°C	24 hours
Total Iron	35	aq.	EPA 200.7	preserve w/HNO_3 to a pH <2	6 months
Total Manganese	35	aq.	EPA 200.7	preserve w/HNO_3 to a pH <2	6 months
Total Aluminum	35	aq.	EPA 200.7	preserve w/HNO_3 to a pH <2	6 months
Macroinvertebrates	230		Barbour and others., 1999	preserve in denatured alcohol	1 year

1. See description in Section X.C.
2. Standard Methods, 19th edition
3. Methods for Determination of Inorganic Substances in Water and Fluvial Sediments, USGS

VIII. PROJECT ORGANIZATION AND RESPONSIBILITY

A. Project Organization



B. Project Responsibility

1. Sampling operations—J. Hoffman, Commission
2. Sampling QC—J. Hoffman, Commission
3. Laboratory analysis—T. Lyter, PADEP
4. Laboratory QC—T. Lyter, PADEP
5. Data processing activities—J. Hoffman, Commission
6. Data processing QC—J. Hoffman, Commission
7. Data quality review—J. Hoffman, Commission
8. Performance auditing—D. Heicher, Commission
9. Systems auditing—J. Hoffman, Commission
10. Overall QA—D. Heicher, Commission
11. Overall project coordination—D. Heicher, Commission

IX. DATA QUALITY REQUIREMENTS AND ASSESSMENTS

Table 3. Data Quality Requirements and Assessments

Parameter	Detection Limit (mg/l)	Accuracy[1]	Precision[2]
Total Alkalinity	0	**+/-10%**	+/-10%
Turbidity	1 NTU	**+/-10%**	+/-10%
Total Suspended Solids	2.0	**+/-10%**	+/-10%
Total Organic Carbon	0.5	**+/-10%**	+/-10%
Total Nitrite	0.04	**+/-10%**	+/-10%
Total Nitrate	0.04	**+/-10%**	+/-10%
Total Nitrogen	0.064	**+/-10%**	+/-10%
Total Phosphorus	0.01	**+/-10%**	+/-10%
Total Orthophosphate	0.01	**+/-10%**	+/-10%
Total Hardness	0.11	**+/-10%**	+/-10%
Total Sodium	0.2	**+/-10%**	+/-10%
Total Magnesium	0.01	**+/-10%**	+/-10%
Total Calcium	0.03	**+/-10%**	+/-10%
Total Chloride	0.05	**+/-10%**	+/-10%
Total Sulfate	1.0	**+/-10%**	+/-10%
Total Iron	0.02	**+/-10%**	+/-10%
Total Manganese	0.01	**+/-10%**	+/-10%
Total Aluminum	0.20	**+/-10%**	+/-10%
Macroinvertebrates	NA	**NA**	+/- 10%

1. Calculate Accuracy using the formulas:

For matrix spikes: $\%R = 100 \times \frac{S - U}{C_{sa}}$

%R = percent recovery
S = measured concentration in spiked aliquot
U = measured concentration in unspiked aliquot
C_{sa} = actual concentration of spike added

For standard reference material: $\%R = 100 \times \frac{C_m}{C_{rm}}$

%R = percent recovery
C_m = measured concentration of standard reference material
C_{rm} = actual concentration of standard reference material

2. Calculate precision using the formula: $RPD = \frac{(C_1 - C_2)}{(C_1 + C_2)/2} \times 100$

RPD = relative percent difference
C_1 = larger of two observed values
C_2 = smaller of two observed values

A. Data Representatives

Water samples will be collected at five points along a transect across the stream with depth-integrating samplers. The depth-integrating sampler provides a composite of the whole water column.

Vertical samples are then composited in a churn, where the final sample is withdrawn. This provides a composite sample representing average stream quality.

Field chemistry analysis will be performed at five stations across a transect for each site at the station where macroinvertebrate samples are collected.

Sampling stations will be placed at specific locations to represent specific segments of the river. Additionally, macroinvertebrate sampling will occur in riffle/run habitats or along the edge of islands to help ensure that the samples are representative of the best available habitat conditions.

B. Data Comparability

The purpose of this QA plan is to eliminate factors in sampling and analysis that reduce the comparability of data collected at different points in space and time. All sampling, analysis, and processing procedures are standardized to ensure comparability. One field crew will be used to collect samples at all sites to reduce variability in sampling.

C. Data Completeness

Collection of 95 percent of the total programmed samples will be deemed as fulfilling the project objectives**.**

Completeness can be calculated using the formula: $\%C = 100 \times \frac{V}{N}$

%C = percent completeness
V = number of measurements judged valid
N = total number of measurements necessary to achieve a specific s statistical level of confidence in decision making

X. SAMPLING PROCEDURES

A. Sample Collection

Water samples will be collected using depth-integrating samplers. Samples will be collected using a hand sampler by wading or from a bridge or boat when the transect area is not wadeable due to high flows or large depths. The sampler will be faced upstream into the current to prevent collection of sediments kicked up by the sampler or field personnel. At each station, five vertical samples will be collected, composited in a churn splitter and churned while the sample bottle is filled. The churn will be rinsed with distilled water and sample water to be tested between each sampling station.

B. Water Samples

One liter of water will be collected at each station for laboratory analysis. The samples will consist of one 250-ml bottle for nutrients, one 250-ml bottle for metals analysis, and one 500-ml bottle for all additional parameters. The samples for metals analyses will be acidified to pH 2 or less with 1 N nitric acid. Samples for total hardness, total phosphorus, and total organic carbon will be preserved in the field with 10 percent sulfuric acid. Duplicate samples will be collected at a frequency of one-per-day, or one per 10 samples, whichever is more frequent. The samples will be chilled on ice, and shipped within 24 hours to the PADEP Lab.

C. Field Chemistry

Temperature will be measured with a field thermometer in degrees Celsius. Dissolved oxygen will be measured using a YSI dissolved oxygen meter. Conductivity will be measured using a VWR conductivity meter. A Cole-Parmer meter will be used to measure pH. Alkalinity and acidity will be measured using field titrations. Alkalinity will be measured in the field by titrating a known volume of sample water to pH 4.5 with 0.02N H_2SO_4 (Attachment A). Acidity will be determined in the field by titrating a known volume of sample water to pH 8.3 with 0.02N NaOH (Attachment B**).** Titrations will be measured using syringes. Separate syringes will be used for sulfuric acid and for sodium hydroxide. Magnetic stirring bars and beakers will be thoroughly rinsed with distilled water and with sample water to be tested before titrations are conducted. Personnel conducting field titrations will be required to undergo six months of on-the-job training with an experienced field person.

D. Discharge Measurements

Discharge at sites near USGS gaging stations will be obtained from the USGS database. At other stations, flows will be calculated based on watershed area and data from the nearest gaging station.

E. Macroinvertebrates

Two different sampling protocols, rock baskets and traditional USEPA Rapid Bioassessment Protocol (RBP) III methods, will be used in this project.

Rock Basket

A rock substrate basket sampler will be used to sample the large rivers of the basin. Rock basket samplers are useful in assessing areas that are too deep to sample with traditional RBP methods (Merritt and others, 1996).

A wire basket filled with natural river rocks from the sampling area will be placed in a run area, where possible, to ensure a constant flow of water running through the sampler. In order to minimize the variation in surface area between baskets, all rocks used in the basket will be between 0.5 and 3 inches in diameter. Before the baskets are placed in the river, they will be attached to a concrete block for stabilization and a float to mark the sampler location. Five such baskets will be located on a transect across the river and left in place for six weeks to allow colonization. Sites will be chosen across the transect based on depth, velocity, substrate, and cover within the transect. The baskets will be placed six weeks prior to the collection using RBP III methods described in this document and collected at the time of sampling. To retrieve the substrates, the baskets will be separated from the concrete blocks and placed in an 800 micron mesh collecting bag while still under water, by a SCUBA diver. The net will be brought to shore, and all rocks will be brushed and rinsed to remove macroinvertebrates from the substrate. The net will be inspected, and any additional organisms found will be placed in the sample bottle. All macroinvertebrates collected will be placed in a jar labeled with site information and method of collection. The jar will be filled with 95 percent ethanol so that the final concentration is at least 70 percent ethanol. The capped sample bottles will be taken back to the laboratory to await analysis.

Modified Rapid Bioassessment Protocol

The Commission has used this procedure for sampling throughout the basin since 1992. Including this methodology will provide a link to past assessments in the river. USEPA's RBP III methodology (Barbour and others, 1999) will be used in riffle areas, where present. If no riffle/run area is present, this methodology will be used along the banks of the river and around the edges of islands. In

riffle/run areas, samples will be collected at both sides of the river, and at three internal sites for a total of five sites across the riffle/run area, where possible.

Sampling will be conducted by placing a 600 micron, 1-square-meter kick screen perpendicular to the current and raking the substrate so dislodged macroinvertebrates are carried into the screen. Two kick screens are composited at each site across the river. All collected specimens will be preserved in 95 percent ethanol and returned to the Commission's office for identification and enumeration.

Subsampling and sorting procedures are based on the 1999 RBP document (Barbour and others, 1999). In the laboratory, composite samples will be sorted into 200-organism subsamples using a gridded pan and a random numbers table. The organisms contained in the subsamples will be identified to genus (except Chironomidae and Oligochaeta), when possible, and enumerated. Benthic macroinvertebrates will be identified by professional biologists**,** with a Master of Science degree in biology, skilled at recognizing most benthos to the family level by sight, and to the genus level with appropriate keys. Biologists also attend the annual Mid-Atlantic Water Pollution Biology Workshop in Berkley Springs, WV and the annual Pennsylvania State Biologist Workshop. Work will be supervised by David Heicher, who was formerly Assistant Benthos Section Leader for Icthyological Associates, Inc. in Stamford, N.Y. Mr. Heicher has 15 graduate level credits in courses related to macroinvertebrate identification, including Entomology, Aquatic Insect Ecology, Identification and Quantification of Invertebrates, and his M.S. thesis research.

After sampling has been completed at a given site, all equipment that has come in contact with the sample will be rinsed thoroughly, examined carefully and picked free of algae or debris before sampling at the next site. Additional organisms that are found on examination will be placed into the sample containers.

F. Physical Habitat Assessment

Physical habitat conditions at each station will be assessed using a slightly modified version of the habitat assessment procedure outlined by Barbour and others (1999). Eleven habitat parameters will be field-evaluated at each site and used to calculate a site-specific habitat assessment score. Physical habitat assessments will be performed for riffle/run or glide/pool areas, depending on stream type. Figure 2 and Table 4 show habitat assessment forms and the criteria used to evaluate habitat in riffle/run streams, and Figure 3 and Table 5 show forms and criteria used to evaluate habitat in glide/pool stream types.

G. Training Records

Training records will be maintained in the Watershed Assessment and Protection Division files by the Quality Assurance Coordinator.

XI. SAMPLE CUSTODY PROCEDURES

Water quality samples will be delivered to the laboratory by the collectors or shipped to the PADEP Lab by overnight courier service. A sample submission sheet, provided by PADEP Lab, is included for each sample sent to the PADEP Lab by Commission staff. This submission sheet contains all relevant information about the sample, including collector, date, time, location, and method of preservation (if needed). Sample numbers, as well as field chemistry and flow data, will be stored in a field logbook and checked against sample numbers received from PADEP Lab. For macroinvertebrate samples, a logbook will be kept containing information regarding the collection, preservation,

subsampling, and identification of the macroinvertebrates. The station identification data will be recorded on each macroinvertebrate sample and entered into a logbook in the field. This logbook will be used to track the macroinvertebrate sample though the laboratory process. Staff members will be responsible for entering the date and their initials for each sample during processing and identification of the sample.

XII. CALIBRATION PROCEDURES AND PREVENTATIVE MAINTENANCE

A. Dissolved Oxygen (DO) Meter

A YSI dissolved oxygen meter will be calibrated using the air-saturated chamber technique prior to use each day. This calibration test also will be repeated in the event of a membrane replacement or other maintenance that may affect the accuracy of the meter. A calibration log will be maintained.

B. Specific Conductance Meter

The VWR conductivity meter will be calibrated prior to sampling by checking the meter readings against three fresh specific conductance standards. Calibration checks will be made after every 10 samples. Results will be recorded in the calibration log, and new rating curves will be generated, as necessary.

	Acceptable Criteria
Standards (<1000 µmhos/cm)	± 4%
(>1000 µmhos/cm)	± 3%

C. pH Meters

The meter will be calibrated against three buffers daily, before and after use. Calibration checks will be made after every 10 samples. These checks will be recorded in the calibration log.

Figure 2. Rifle/Run Habitat Assessment Sheet

Riffle/ Run Habitat Assessment Sheet

Stream	**Date**
Station ID	**Time**
Sample #	**Crew**
Location Description:	
Stream type: Limestone Sandstone Valley Headwater Large River Glacial Other _____	

Habitat Assessment		**Weather Conditions**			
Parameter	Score	Air Temperature ©	_____		
1. Epifaunal Substrate		Current Conditions: Sunny Cloudy Partly Cloudy			
		Present Precipitation: None Rain Snow Mixed Precip.			
		Heavy? (> 1 inch) Yes No			
2. Instream Cover		Precip. Within last 24 hours: None Rain Snow Mixed Precip.			
		Heavy? (> 1 inch) Yes No			
		Ice Present at Site? Yes No			
3. Embeddedness		**Functionally Important Stream Characteristics**			
4. Velocity/ Depth Regimes					
5. Sediment Deposition					
6. Channel Flow Status					
7. Channel Alteration		**Predominant Substrate Material (circle one)**			
		Bedrock (> 160 inches in diameter) Boulder (10 – 160 inches in diameter) Cobble (2.5 – 10 inches in diameter) Gravel (0.1 – 2.5 inches in diameter) Sand/Silt/Clay (< 0.1 inches in diameter)			
8. Frequency of Riffles					
9. Condition of Banks (Score each bank)		Residential		Commercial	
		Industrial		Cropland	
		Nursery		Pasture	
Left Bank		Abd. Mining		Old Fields	
		Forest		Other	
Right Bank		**Comments:**			
10. Vegetative Protective Cover (score each bank)					
Left Bank					
Right Bank					
11. Riparian Vegetative Zone Width (score each bank)					
Left Bank		**Temp.**	**Cond.**	**D.O.**	
Right Bank		**pH**	**Acid.**	**Alk.**	

Table 4. Riffle/Run Habitat Assessment Criteria

HABITAT PARAMETER	CATEGORY			
	OPTIMAL (20-16)	SUBOPTIMAL (15-11)	MARGINAL (10-6)	POOR (5-0)
1. Epifaunal Substrate	Well-developed riffle/run; riffle is as wide as stream and length extends 2 times the width of stream; abundance of cobble	Riffle is as wide as stream but length is less than 2 times width; abundance of cobble; boulders and gravel common	Run area may be lacking; riffle not as wide as stream and its length is less than 2 times the stream width; some cobble present	Riffle or run virtually nonexistent; large boulders and bedrock prevalent; cobble lacking
2. Instream Cover	> 50% mix of boulders, cobble, submerged logs, undercut banks or other stable habitat	30–50% mix of boulder, cobble, or other stable habitat; adequate habitat	10–30% mix of boulder, cobble, or other stable habitat; habitat availability less than desirable	<10% mix of boulder, cobble, or other stable habitat; lack of habitat is obvious
3. Embeddedness	Gravel, cobble, and boulder particles are 0–25% surrounded by fine sediments	Gravel, cobble, and boulder particles are 25–50% surrounded by fine sediments	Gravel, cobble, and boulder particles are 50–75% surrounded by fine sediments	Gravel, cobble, and boulder particles are >75% surrounded by fine sediments
4. Velocity/Depth Regimes	All 4 velocity/depth regimes present (slow/deep, slow/shallow, fast/deep, fast/shallow)	Only 3 of 4 regimes present (if fast/shallow is missing, score lower than if missing other regimes)	Only 2 of 4 regimes present (if fast/shallow or slow/shallow are missing, score low)	Dominated by 1 velocity/depth regime
5. Sediment Deposition	Little or no enlargement of islands or point bars and <5% of the bottom affected by sediment deposition	Some new increase in bar formation, mostly from coarse gravel; 5–30% of the bottom affected; slight deposition in pools	Moderate deposition of new gravel, coarse sand on old and new bars; 30–50% of the bottom affected; sediment deposits at obstructions; moderate deposition of pools prevalent	Heavy deposits of fine material, increased bar development; >50% of the bottom changing frequently; pools almost absent due to sediment deposition
6. 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 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
7. Channel Alteration	No channelization or dredging present	Some channelization present, usually in areas of bridge abutments; evidence of past channelization (>20 yr) may be present, but not recent	New embankments present on both banks; and 40-80% of stream reach channelized and disrupted	Banks shored with gabion or cement; >80% of the reach channelized and disrupted
8. Frequency of Riffles	Occurrence of riffles relatively frequent; distance between riffles divided by the width of the stream equals 5 to 7; variety of habitat	Occurrence of riffles infrequent; distance between riffles divided by the width of the stream equals 7 to 15	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the stream width is between 15-25	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is >25

Table 4. Riffle/Run Habitat Assessment Criteria *(continued)*

HABITAT PARAMETER	CATEGORY			
	OPTIMAL (20-16)	SUBOPTIMAL (15-11)	MARGINAL (10-6)	POOR (5-0)
9. Condition of Banks (score each bank 0-10)	Banks stable; no evidence of erosion or bank failure; 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 banks in reach have areas of erosion; high erosion potential during floods	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; on side slopes, 60-100% of bank has erosional scars
10. Vegetative Protective Cover (score each bank 0-10)	>90% of the streambank surfaces covered by vegetation; vegetative disruption through grazing or mowing minimal	70-90% of the streambank surfaces covered by vegetation; disruption evident but not affecting full plant growth potential to any great extent	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation	<50% of the steambank surfaces covered by vegetation; disruption is very high; vegetation removed to 5 cm or less
11. Riparian Vegetative Zone Width (score each bank 0-10)	Width of riparian zone >18 meters; human activities (i.e. parking lots, roadbeds, clearcuts, 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 only minimally	Width of riparian zone <6 meters; little or no riparian vegetation due to human activities

Figure 3. Glide/Pool Habitat Assessment

Glide/Pool Habitat Assessment Sheet

Stream	**Date**
Station ID	**Time**
Sample #	**Crew**
Location Description:	
Stream Type: Limestone Sandstone Valley Headwater Large River Glacial Other __	

Habitat Assessment		**Weather Conditions**			
Parameter	Score	Air Temperature (^{o}C)			
1. Epifaunal Substrate		Current Conditions: Sunny Cloudy Partly Cloudy			
		Present Precipitation: None Rain Snow Mixed Precip.			
		Heavy? (> 1 inch) Yes No			
2. Instream Cover		Precip. within last 24 Hours: None Rain Snow Mixed Precip.			
		Heavy? (>1 inch) Yes No			
		Ice Present at Site? Yes No			
3. Pool Substrate Characterization		**Functionally Important Stream Characteristics**			
4. Pool Variability					
5. Sediment Deposition					
6. Channel Flow Status					
7. Channel Alteration		**Predominant Substrate Material (circle one)**			
		Bedrock (>160 inches in diameter) Boulder (10-160 inches in diameter) Cobble (2.5 – 10 inches in diameter) Gravel (0.1 – 2.5 inches in diameter) Sand/Silt/Clay (<0.1 inches in diameter)			
8. Channel Sinuosity					
9. Condition of Banks (Score each bank)					
Left Bank		Residential	%	Commercial	%
		Industrial	%	Cropland	%
Right Bank		Nursery	%	Pasture	%
		Abd. Mining	%	Old Fields	%
10. Vegetative Protective Cover (score each bank)		Forest	%	Other	%
		Comments:			
Left Bank					
Right Bank					
11. Riparian Vegetative Zone Width (score each bank)					
Left Bank		**Temp.**	**Cond.**	**D.O.**	
Right Bank		pH	**Acid.**	**Alk.**	

Table 5. Glide/Pool Habitat Assessment Criteria

HABITAT PARAMETER	CATEGORY			
	OPTIMAL (20-16)	SUBOPTIMAL (15-11)	MARGINAL (10-6)	POOR (5-0)
1. Epifaunal Substrate	Preferred benthic substrate abundant throughout stream site and at stage to allow full colonization (i.e. log/snags that are not new fall and not transient)	Substrate common but not prevalent or well suited for full colonization potential	Substrate frequently disturbed or removed	Substrate unstable or lacking
2. Instream Cover	> 50% mix of snags, submerged logs, undercut banks or other stable habitat; rubble, gravel may be present	30-50% mix of stable habitat; adequate habitat for maintenance of populations	10-30% mix of stable habitat; habitat availability less than desirable	Less than 10% stable habitat; lack of habitat obvious
3. Pool Substrate Characterization	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present	All mud or clay or sand bottom; little or no root mat; no submerged vegetation	Hard-pan clay or bedrock; no root mat or vegetation
4. Pool Variability	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present	Majority of pools large-deep; very few shallow	Shallow pools much more prevalent than deep pools	Majority of pools small-shallow or pools absent
5. Sediment Deposition	Less than 20% of bottom affected; minor accumulation of fine and coarse material at snags and submerged vegetation; little or no enlargement of island or point bars	20-50% affected; moderate accumulation; substantial sediment movement only during major storm event; some new increase in bar formation	50-80% affected; major deposition; pools shallow, heavily silted; embankments may be present on both banks; frequent and substantial movement during storm events	Channelized; mud, silt, and/or sand in braided or non-braided channels; pools almost absent due to substantial sediment deposition
6. 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 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
7. Channel Alteration	No channelization or dredging present	Some channelization present, usually in areas of bridge abutments; evidence of past channelization (>20 yr) may be present, but not recent	New embankments present on both banks; and 40-80% of stream reach channelized and disrupted	Banks shored with gabion or cement; >80% of the reach channelized and disrupted

Table 5. Glide/Pool Habitat Assessment Criteria *(continued)*

HABITAT PARAMETER	CATEGORY			
	OPTIMAL (20-16)	SUBOPTIMAL (15-11)	MARGINAL (10-6)	POOR (5-0)
8. Channel Sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line	The bends in the stream increase the stream length 2 to 3 times longer than if it was in a straight line	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line	Channel straight; waterway has been channelized for a long time
9. Condition of Banks (score each bank 0-10)	Banks stable; no evidence of erosion or bank failure; side slopes generally <30%; little potential for future problems; <5% of bank affected	Moderately stable; infrequent, small areas of erosion mostly healed over; side slopes up to 40% on one bank; slight erosion potential in extreme floods; 5-30% of bank in reach has areas of erosion	Moderately unstable; moderate frequency and size of erosional areas; side slopes up to 60% on some banks; high erosion potential during extremely high flow; 30-60% of bank in reach has areas of erosion	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; on side slopes; side slopes >60% common; 60-100% of bank has erosional scars
10. Vegetative Protective Cover (score each bank 0-10)	>90% of the streambank surfaces covered by vegetation; vegetative disruption through grazing or mowing minimal	70-90% of the streambank surfaces covered by vegetation; disruption evident but not affecting full plant growth potential to any great extent	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation	<50% of the steambank surfaces covered by vegetation; disruption is very high; vegetation removed to 5 cm or less
11. Riparian Vegetative Zone Width (score each bank 0-10)	Width of riparian zone >18 meters; human activities (i.e. parking lots, roadbeds, clearcuts, 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 only minimally	Width of riparian zone <6 meters; little or no riparian vegetation due to human activities

XIII. DOCUMENTATION

Water and macroinvertebrate sample bottles will be labeled at the time of collection. Water samples will be labeled with a seven-digit identification number, the station, date, and time, and whether any fixatives were added to the sample. This information will be recorded on laboratory analysis forms. One copy will be submitted to the laboratory with the sample, while another will be retained as a record. Results of field chemistry will be recorded on this form.

Results of laboratory analyses will be entered into a computer database. Data entries will be verified, and reductions will be performed using computer files to eliminate transcription errors. Field chemistry and laboratory analysis sheets will be retained for a period of two years and subsequently archived. Excel spreadsheets containing all information will be retained on the Commission's server for ready access. Additionally, all information will be entered into STORET.

Databases for all water quality, physical habitat, field chemistry, and macroinvertebrate data will consist of Excel spreadsheets developed for in-house needs. The databases will be located on Commission's server. Back-up copies will be retained by the project manager, in addition to a copy kept in the filing system with hard copies of the data sheets. Currently, staff are developing an Access database for data storage and to assist in transferring data to USEPA's STORET.

Macroinvertebrate bottles will be labeled with the station and date. A logbook will be kept for all sites, containing information on the macroinvertebrate sample collection, such as station number, stream name, date, gear used to collect the sample, and the person who collected the sample. Identification will be conducted by staff biologists at the Commission's office, where additional information such as dates of subsampling and identification and the personnel associated with each activity will be added to the logbook. Log sheets (Figure 4) will be used to record the number of specimens for each genus identified. This information will be transcribed into Excel spreadsheets and verified. All data also will be entered into the Commission's Access database and into USEPA's STORET.

XIV. DATA REDUCTION

Water quality data will be formatted into tables by station. The data will be compared to state standards and to other limit values based on current state and federal regulations or references for approximate tolerances of aquatic life. The differences between each value and the limit value will be calculated for each site, and if the value does not exceed the limit value, the site will be given a score of zero. If the limit value is exceeded, the difference will be listed, and an average of all the parameters for each site will be calculated.

Data reduction procedures are similar to those described in RBP III (Barbour and others, 1999). The data for each station will be reduced to the following metrics: (1) taxa richness; (2) modified Hilsenhoff Biotic Index; (3) percent Ephemeroptera; (4) percent contribution of dominant taxon; (5) number of Ephemeroptera/Plecoptera/Trichoptera taxa; (6) percent Chironomidae; and (7) Shannon Weiner Diversity Index. These metrics will be quantified and compared to a reference station with the best available conditions based on physical habitat, water quality, and macroinvertebrate information.

The subsample data will be used to generate scores for each of the seven macroinvertebrate metrics listed above. Each metric score will then be converted to a biological condition score, based on the percent similarity of the metric score, relative to the metric score of the reference site. The sum of the biological condition scores will constitute the total biological score for the sample site, and total biological scores will be used to assign each site to a biological condition category. A sampling site that

scores 83 percent or greater as compared to the reference site will be designated nonimpaired. A score of 79 to 54 percent is termed slightly impaired; moderately impaired conditions are characterized as 50 to 21 percent of the reference site; and a score of less than 17 percent is designated severely impaired.

Habitat assessment scores of sample sites are compared to those of the reference sites to classify each sample site into a habitat condition category. Habitat parameters for riffle-run and glide-pool habitat types are listed in Tables 4 and 5, respectively. A site that scores 90 percent or greater as compared to the reference score is designated excellent (comparable to reference). A habitat score of 75 to 89 percent is designated supporting; partially supporting conditions are characterized as 60 to 74 percent of the reference score; and a score of less than 60 percent is determined to be nonsupporting.

XV. DATA VALIDATION

Primary responsibility for data validation lies with the project officer. The collector may assist the project officer in determining the acceptability of the data based on his knowledge of the stream conditions. Field collections are conducted according to the above methodology to insure accurate data. The use of duplicates, reviewed by the project officer, also validates the water quality analyses. The data also go through a series of validations as they are entered into the Commission's and STORET's database, including checking values for duplicate samples against one another, comparing computer entries to field and laboratory data sheets, looking for data gaps and missing information, and examining raw data for outliers or in appropriate measurements. A separate staff member also checks the information after input to ensure correct data entry.

Ten percent of the macroinvertebrate samples identified by one biologist are validated by a second biologist and recorded in the logbook. A biologist also spot-checks ten percent of the samples picked by laboratory personnel during subsampling and records the samples in the logbook.

XVI. PERFORMANCE AND SYSTEMS AUDITS

A. Laboratory Analyses

Analytical and quality assurance procedures for the PADEP Lab are detailed in the QA plan submitted by the laboratory. The laboratory analyzes a matrix spike/matrix spike duplicate at a frequency of one per 10 samples per matrix. Duplicate samples will be submitted to the laboratory (at least one per 10 samples). PADEP Lab is certified by USEPA for drinking water parameters; the laboratory ID number is PA0000.

B. Field Procedures

Yearly, field operator techniques are tested for pH, specific conductance, and alkalinity with USGS standard samples. In addition, Commission staff is tested annually in the collection of flow measurements. The project officer is responsible for insuring that all field personnel are competent in measurement and collection techniques prior to fieldwork. The project officer also is responsible for insuring the quality of all equipment and reagents. The quality assurance officer also performs a field audit in association with the sampling effort, preferably at the beginning of the project. The field audit for this project is projected to take place in August 2005, weather and river flows permitting.

Duplicate tests are performed on alkalinity and acidity in the same proportion as other duplicate analyses and results with a relative percent difference of 10 is acceptable. Temperature readings from the dissolved oxygen meter are checked against a standard laboratory thermometer. These checks are performed prior to fieldwork.

C. Biological Sampling

A second biologist will verify the identifications on ten percent of the sorted samples.

XVII. CORRECTIVE ACTION

Implementation of corrective action involving any of the sampling procedures, equipment, or data reduction and processing is the responsibility of the project officer. The QA officer is responsible for seeing that such corrective action is done. Implementation of corrective action involving laboratory analyses is the responsibility of the laboratory analysis officer, with oversight by the laboratory quality control officer.

The results of any corrective actions taken will be documented by the individual(s) taking the necessary actions.

XVIII. REPORTS

A report describing the results of the monitoring program will be published in summer 2006. This report will include a description of the methods and data analysis. Conclusions and recommendations will be made, as appropriate. The data will be available on the Commission's website (www.srbc.net) and in USEPA's STORET. In addition, the data are utilized by staff for project review and for inclusion in the Commission's Consolidated Listing report.

XIX. DATA QUALITY OBJECTIVES

Parameters with state or federal standards or references for approximate tolerances of aquatic life are listed in Table 6 below. Water quality data collected during this project will be compared against Pennsylvania, Maryland, and New York state standards (Table 7), as well as the limits listed in Table 6. Macroinvertebrate and physical habitat data will be compared against a reference station with best available conditions in the watershed as described in Section XIV.

Table 6. Water Quality Standards and Aquatic Life Tolerances

Parameter	Limit	Reference Code	Reference Code & References
Temperature	> 25 degrees	a,f	a. http://www.pacode.com/secure/data/025/chapter93/s93.7.html b. Hem (1970) c. Gagen and Sharpe (1987) and Baker and Schofield (1982) d. http://www.uky.edu/WaterResources/Watershed/KRB_AR/wq_standards.htm e. http://www.uky.edu/WaterResources/Watershed/KRB_AR/krww_parameters.htm f. http://www.hach.com/h2ou/h2wtrqual.htm g. http://sites.state.pa.us/PA_Exec/Fish_Boat/education/catalog/pondstream.pdf h. http://www.deq.virginia.gov/vpdes/pdf/vpdesregulationfeb02.pdf i. http://www.dec.state.ny.us/website/regs/part703.html j. http://water.usgs.gov/pubs/circ/circ1225/images/table.html k. http://www.crc.govt.nz/Land/pdf%20files/sheet13.pdf l. http://www.water.ncsu.edu/watershedss
Dissolved Oxygen	< 4 mg/l	a,g	
Conductivity	> 800 µmhos/cm	d	
pH	< 5	c,f	
Alkalinity	< 20 mg/l	a,g	
Total Suspended Solids	> 15 mg/l	h	
Total Nitrogen	> 1.0 mg/l	j,k,l	
Total Nitrite	> 1.0 mg/l	f	
Total Nitrate	> 1.0 mg/l	e	
Total Phosphorus	> 0.1 mg/l	e	
Total Organic Carbon	> 10 mg/l	b	
Total Hardness	> 300 mg/l	e	
Total Magnesium	> 35 mg/l	i	
Total Sodium	> 20 mg/l	i	
Total Chloride	> 150 mg/l	a	
Total Sulfate	> 250 mg/l	a	
Total Iron	> 1,500 µg/l	a	
Total Manganese	> 1,000 µg/l	a	
Total Aluminum	> 200 µg/l	c	
Total Orthophosphate	> 0.05 mg/l	l	

Table 7. Applicable New York, Pennsylvania, and Maryland State Water Quality Standards

Parameter	State	Criteria	Critical Use
Acidity	PA	Less than alkalinity	Aquatic Life
Alkalinity	PA	Minimum 20 mg/l as CaCO3, except where natural conditions are less.	Aquatic Life
Aluminum	PA	0.75 mg/l	Aquatic Life
	NY	100 ug/l	Aquatic Life (chronic)
Chlorine	NY	0.019 mg/l	Aquatic Life (acute)
	MD	0.019 mg/l	Aquatic Life
Dissolved oxygen	PA	5.0 mg/l (Cold Water Fisheries); 4.0 mg/l (Warm Water Fisheries); 5.0 mg/l February 15 – July 31, otherwise 4.0 mg/l (Trout Stocked Fishery)	Aquatic Life
	NY	5.0 mg/l (trout); 4.0 (non-trout)	Trout Waters
	NY	500 mg/l	General
Iron	PA	30-day average 1.5 mg/l as total recoverable	Aquatic Life
	NY	300 ug/l	Aquatic Life (chronic)
Manganese	PA	Maximum 1.0 mg/l, as total recoverable.	Aquatic Life and Public Water Supply
Nitrate + Nitrite	PA	10 mg/l	Public Water Supply
pH	PA	From 6.0 to 9.0 inclusive.	Aquatic Life
	NY	From 6.5 to 8.5 inclusive	General
Sulfate	PA	Maximum 250 mg/l.	Public Water Supply

Figure 4. Benthic Macroinvertebrate Enumeration Sheet

MACROINVERTEBRATE ENUMBERATION LIST

SITE _____ **DATE SAMPLED_____**
IDENTIFIED BY: _____ **DATE IDENTIFIED: _____**

FAMILY/GENUS	NUMBER OF INDIVIDUALS
1.	
2.	
3.	
4.	
5.	
6.	
7.	
8.	
9.	
10.	
11.	
12.	
13.	
14.	
15.	
16.	
17.	
18.	
19.	
20.	
21.	
22.	
23.	
24.	
25.	

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SUSQUEHANNA RIVER BASIN COMMISSION

STANDARD OPERATION PROCEDURE (SOP) FOR DETERMINATION OF ALKALINITY

Prepared by: Charles S. Takita Date: September 15, 2000
WQ Program Specialist

Reviewed by: David W. Heicher Date: September 18, 2000
Quality Assurance Coordinator

Procedural Section

1.0 Scope & application

1.1 This method is applicable to surface waters, sewage and industrial wastes.
1.2 The method is applicable for all ranges of alkalinity.

2.0 Summary of method

2.1 The alkalinity of a sample is its quantitative capacity to react with a strong acid to a certain pH. The pH of the unaltered sample is determined and a measured amount of standard acid is added to lower the pH to an endpoint of 4.5.

3.0 Interference

3.1 The sample must be analyzed as soon as practical; preferably, within a few hours.
3.2 Substances, such as salts of weak organic and inorganic acids present in large amounts, may cause interference in the electrometric pH measurements.
3.3 Oil and grease, by coating the pH electrode, may also interfere, causing sluggish response.

4.0 Apparatus

4.1 Analog field pH meter
4.2 Syringe with 0.2 ml graduation
4.3 Magnetic stirrer
4.4 Stirring bars
4.5 Glass beaker, 100 ml
4.6 Graduated cylinder, 50 ml

5.0 Reagent

5.1 0.02N H_2SO_4

6.0 Procedure

6.1 Measure 50 ml of sample with graduated cylinder and pour into the 100 ml beaker.
6.2 Measure the pH of the sample.
6.3 Using the syringe, drop 0.02N H_2SO_4 into sample in increments of 0.5 ml or less until the pH in the sample approaches 4.5 then add H_2SO_4, dropwise, pausing between drops to allow the pH to stabilize until a pH of 4.5 is reached.
6.4 Determine the amount of 0.02N H_2SO_4 added to sample.

7.0 Calculation

7.1 Calculate alkalinity, as mg/l, using the following formula:

$$\text{Alkalinity, mg/l as } CaCO_3 = \frac{A \times N \times 50{,}000}{\text{ml of sample}}$$

where:

A = ml of H_2SO_4used
N = normality of H_2SO_4

Quality Control and Quality Assurance

1.0 Choose one sample from the set of analyses and run a duplicate. Results should be within 10 percent.

Reference

1.0 Standard Methods for Examination of Water and Wastewater, 17th Edition.

SUSQUEHANNA RIVER BASIN COMMISSION

STANDARD OPERATION PROCEDURE (SOP) FOR DETERMINATION OF ACIDITY

Prepared by: Charles S. Takita Date: September 15, 2000
WQ Program Specialist

Reviewed by: David W. Heicher Date: September 18, 2000
Quality Assurance Coordinator

Procedural Section

1.0 Scope & application

1.1 This method is applicable to surface waters, sewage and industrial wastes, particularly mine drainage and receiving streams, and other wastes containing ferrous iron and other polyvalent ions in a reduced state.
1.2 The method is applicable for samples with acidities less than 1,000 mg/l using a 50 ml sample.

2.0 Summary of method

2.1 The acidity of a sample is its quantitative capacity to react with a strong base to a certain pH. The pH of the sample is determined and a measured amount of standard alkali is added to raise the pH to 8.3.

3.0 Interference

3.1 Suspended matter present in the sample or precipitates formed during the titration may cause a sluggish electrode response. This may be offset by allowing a 15-20 second pause between additions of titrant or by slow dropwise addition of titrant as the endpoint is approached.

4.0 Apparatus

4.1 Analog field pH meter
4.2 Syringe with 0.2 ml graduation
4.3 Magnetic stirrer
4.4 Stirring bars
4.5 Glass beaker, 100 ml
4.6 Graduated cylinder, 50 ml

5.0 Reagent

5.1 0.02N NaOH

6.0 Procedure

6.1 Measure 50 ml of sample with graduated cylinder and pour into the 100 ml beaker.
6.2 Measure the pH of the sample.
6.3 Using the syringe, drop 0.02N NaOH into sample in increments of 0.5 ml or less until the pH in the sample approaches 8.3 then add NaOH, dropwise, pausing between drops to allow the pH to stabilize until a pH of 8.3 is reached.
6.4 Determine the amount of 0.02N NaOH added to sample.

7.0 Calculation

7.1 Calculate acidity, as mg/l, using the following formula:

$$\text{Acidity, mg/l as } CaCO_3 = \frac{A \times N \times 50{,}000}{\text{ml of sample}}$$

where:

A = ml of NaOH used
N = normality of NaOH

Quality Control and Quality Assurance

1.0 Choose one sample from the set of analyses and run a duplicate. Results should be within 10 percent.

Reference

1.0 Standard Methods for Examination of Water and Wastewater, 17th Edition.