QUALITY ASSURANCE/WORK PLAN

MIDDLE SUSQUEHANNA RIVER SUBBASIN
SMALL WATERSHED STUDY—WYALUSING CREEK

Document Control Number SRBC - QA014

Project Officer: Susan R. LeFevre

Project QA Officer: David W. Heicher

Susquehanna River Basin Commission
1721 North Front Street
Harrisburg, PA 17102-2391
Phone (717) 238-0426
FAX (717) 238-2436

Project Officer Signature _____ Date _____
Susan R. LeFevre

Project QA Officer Signature _____ Date _____
David W. Heicher

EPA Project Officer Signature _____ Date _____
Agnes White

EPA QA Officer Signature _____ Date _____
Monica Jones

TABLE OF CONTENTS

I. PROJECT NAME 1
II. PROJECT OFFICER 1
III. QUALITY ASSURANCE OFFICER 1
IV. DATE OF PROJECT INITIATION 1
V. PROJECT DESCRIPTION 1

A. Objective and Scope 1
B. Data Usage 1
C. Monitoring Network Design and Rationale 1
D. Monitoring Parameters 4

VI. PROJECT FISCAL INFORMATION 4
VII. SCHEDULE 4
VIII. PROJECT ORGANIZATION AND RESPONSIBILITY 6

A. Project Organization 6
B. Project Responsibility 6

IX. DATA QUALITY REQUIREMENTS AND ASSESSMENTS 7

A. Data Representativeness 7
B. Data Comparability 8
C. Data Completeness 8

X. SAMPLING PROCEDURES 8

A. Sample Collection 8
B. Water Samples 8
C. Field Chemistry 8
D. Discharge Measurements 9
E. Macroinvertebrates 9
F. Physical Habitat Assessment 9
G. Training Records 9

XI. SAMPLE CUSTODY PROCEDURES 10
XII. CALIBRATION PROCEDURES AND PREVENTATIVE MAINTENANCE 10

A. Dissolved Oxygen (DO) Meter 10
B. Specific Conductance Meter 17
C. pH Meters 17
D. Flow meter 17

XIII. DOCUMENTATION 17
XIV. DATA REDUCTION 19
XV. DATA VALIDATION 19
XVI. PERFORMANCE AND SYSTEMS AUDITS 20

A. Laboratory Analyses 20
B. Field Procedures 21
C. Biological Sampling 21

XVII. CORRECTIVE ACTION 21
XVIII. REPORTS 21

REFERENCES 22

TABLES

Table 1. Wyalusing Creek Watershed Station Locations 2
Table 2. Monitoring Parameters 5
Table 3. Data Quality Requirements and Assessments 7
Table 4. Riffle/Run Habitat Assessment Criteria 12
Table 5. Glide/Pool Habitat Assessment Criteria 15
Table 6. Summary of Metrics Used to Evaluate the Overall Biological Integrity of Stream Benthic Macroinvertebrate Communities. 20

FIGURES

Figure 1. Middle Susquehanna Subbasin Year 2 Sampling Sites in the Wyalusing Creek Watershed. 3
Figure 2. Rifle/Run Habitat Assessment Sheet 11
Figure 3. Glide/Pool Habitat Assessment 14
Figure 4. Benthic Macroinvertebrate Enumeration Sheet 18

ATTACHMENTS

Attachment A. Standard Operation Procedure For Determination Of Alkalinity. 23
Attachment B. Standard Operation Procedure for Determination of Acidity 26

I. PROJECT NAME

Middle Susquehanna River Subbasin Small Watershed Study

II. PROJECT OFFICER

Susan R. LeFevre
Biologist

III. QUALITY ASSURANCE OFFICER

David W. Heicher, Chief
Watershed Assessment and Protection Division

IV. DATE OF PROJECT INITIATION

October 2002

V. PROJECT DESCRIPTION

A. Objective and Scope

In 1998, the Susquehanna River Basin Commission (Commission) reevaluated its subbasin survey program and added a Year 2 component to better assist local interests and to perform more detailed studies in selected watersheds. During July - September 2001, staff performed a subbasin assessment in the Middle Susquehanna Subbasin and surveyed state and local government and watershed groups regarding their suggestions for a follow-up study in a selected watershed. The Commission proposes to perform a small watershed survey on the Wyalusing Creek Watershed in Susquehanna and Bradford Counties, Pa., during FY-2003. This watershed assessment will provide valuable biological, chemical, and habitat information to the Wyalusing Creek Watershed Association and other interested parties. Streams to be sampled include: East Branch Wyalusing Creek, Middle Branch Wyalusing Creek, North Branch Wyalusing Creek, South Branch Wyalusing Creek, Wyalusing Creek mainstem, and selected tributaries. Staff will perform extensive coordination with the watershed groups, county conservation districts, local citizens, and other interested parties. Figure 1 shows the general location of the study area.

B. Data Usage

Data collected during this survey will be used by the watershed groups and conservation districts to conduct watershed management planning. The study also will provide information to: (1) assess the chemical, physical and biological condition of the streams within the watershed; (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 Section 305(b) Water Quality Assessment Report, and in reviewing projects affecting water quality in the basin.

C. Monitoring Network Design and Rationale

Commission staff surveyed state and local government and watershed groups regarding their suggestions for a follow-up assessment within the Middle Susquehanna Subbasin. The Bradford County Conservation District and Pennsylvania Environmental Council suggested the Wyalusing Creek Watershed due to erosion, sedimentation, and nutrient problems in the watershed. Additionally, the Pennsylvania Department of Environmental Protection (Pa. DEP) has developed a Total Maximum Daily Load plan for the South Branch Wyalusing Creek Watershed for agricultural-related sediment and nutrient problems. Little chemical data exists for the Wyalusing Watershed. The sampling sites listed in Table 1 were selected so that the effects of major tributaries could be evaluated.

Table 1. Wyalusing Creek Watershed Station Locations

Station Number	Stream	County/State	USGS Quad	Latitude	Longitude	Site Description
WYAL 0.1	Wyalusing Creek	Bradford/Pa.	Wyalusing	41.6655	-76.2608	Wyalusing Creek at mouth, upstream of Rt. 6 bridge
BREW 0.1	Brewer Creek	Bradford/Pa.	Wyalusing	41.6813	-76.2515	Brewer Creek at Rt. 706 bridge
WYAL 5.0	Wyalusing Creek	Bradford/Pa.	Wyalusing	41.6991	-76.2316	Wyalusing Creek at Merryall (Rt. 706 bridge)
BILL 0.1	Billing Creek	Bradford/Pa.	Laceyville	41.7335	-76.2422	Billing Creek upstream of Camptown along Rally Road
CAMP 0.1	Camp Creek	Bradford/Pa.	Laceyville	41.7316	-76.2333	Camp Creek upstream of Camptown along Rt. 706
COLD 0.1	Cold Creek	Bradford/Pa.	Laceyville	41.7482	-76.2073	Cold Creek upstream of Rt. 706
ROCK 0.1	Rockwell Creek	Bradford/Pa.	Le Raysville	41.7686	-76.1565	Rockwell Creek upstream of Rt. 706
ROCK 5.0	Rockwell Creek	Bradford/Pa.	Le Raysville	41.8105	-76.1877	Rockwell Creek at Brushville
ROSS 0.1	Ross Creek	Bradford/Pa.	Le Raysville	41.7815	-76.1390	Ross Creek upstream of Rt. 706 along SR 1011
WOLF 0.1	Wolf Creek	Bradford/Pa.	Le Raysville	41.7707	-76.1267	Wolf Creek near intersection of T599 and Schneider Road
WYAL 10.0	Wyalusing Creek	Bradford/Pa.	Le Raysville	41.7765	-76.1271	Wyalusing Creek upstream of T599 (near county line)
NBWC 0.1	North Branch Wyalusing Creek	Susquehanna/Pa.	Lawton	41.7916	-76.1117	North Branch Wyalusing Creek at mouth, along Rt. 858
GAYL 0.1	Gaylord Creek	Susquehanna/Pa.	Lawton	41.8154	-76.1062	Gaylord Creek at mouth, upstream of Rt. 858
NBWC 5.0	North Branch Wyalusing Creek	Susquehanna/Pa.	Lawton	41.8220	-76.1002	North Branch Wyalusing Creek upstream of Gaylord Creek, upstream of Rt. 858
EBWC 0.1	East Branch Wyalusing Creek	Susquehanna/Pa.	Lawton	41.7858	-76.0681	East Branch Wyalusing Creek upstream of Rt. 365 bridge
DEER 0.1	Deer Lick Creek	Susquehanna/Pa.	Lawton	41.7729	-76.0577	Deer Lick Creek along Rt. 267
LAKE 0.1	Lake Stream	Susquehanna/Pa.	Lawton	41.7792	-76.0452	Lake Stream upstream of T480 bridge
EBWC 5.0	East Branch Wyalusing Creek	Susquehanna/Pa.	Montrose West	41.8000	-75.9777	East Branch Wyalusing Creek upstream of SR3027 bridge
SBWC 0.1	South Branch Wyalusing Creek	Susquehanna/Pa.	Montrose West	41.7998	-75.9480	South Branch Wyalusing Creek at T512 bridge
EBWC 6.0	East Branch Wyalusing Creek	Susquehanna/Pa.	Montrose West	41.8097	-75.9661	East Branch Wyalusing Creek at Fairdale, upstream of Rt. 706 bridge
FOLC 0.1	Forest Lake Creek	Susquehanna/Pa.	Montrose West	41.8144	-75.9625	Forest Lake Creek upstream of SR 3029
EBWC 8.0	East Branch Wyalusing Creek	Susquehanna/Pa.	Montrose West	41.8337	-75.9088	East Branch Wyalusing Creek upstream of confluence with Pettis Creek
PETT 0.1	Pettis Creek	Susquehanna/Pa.	Montrose West	41.8239	-75.9116	Pettis Creek upstream of Rt. 706 bridge
MBWC 0.1	Middle Branch Wyalusing Creek	Susquehanna/Pa.	Lawton	41.7896	-76.0654	Middle Branch Wyalusing Creek upstream of T502 bridge

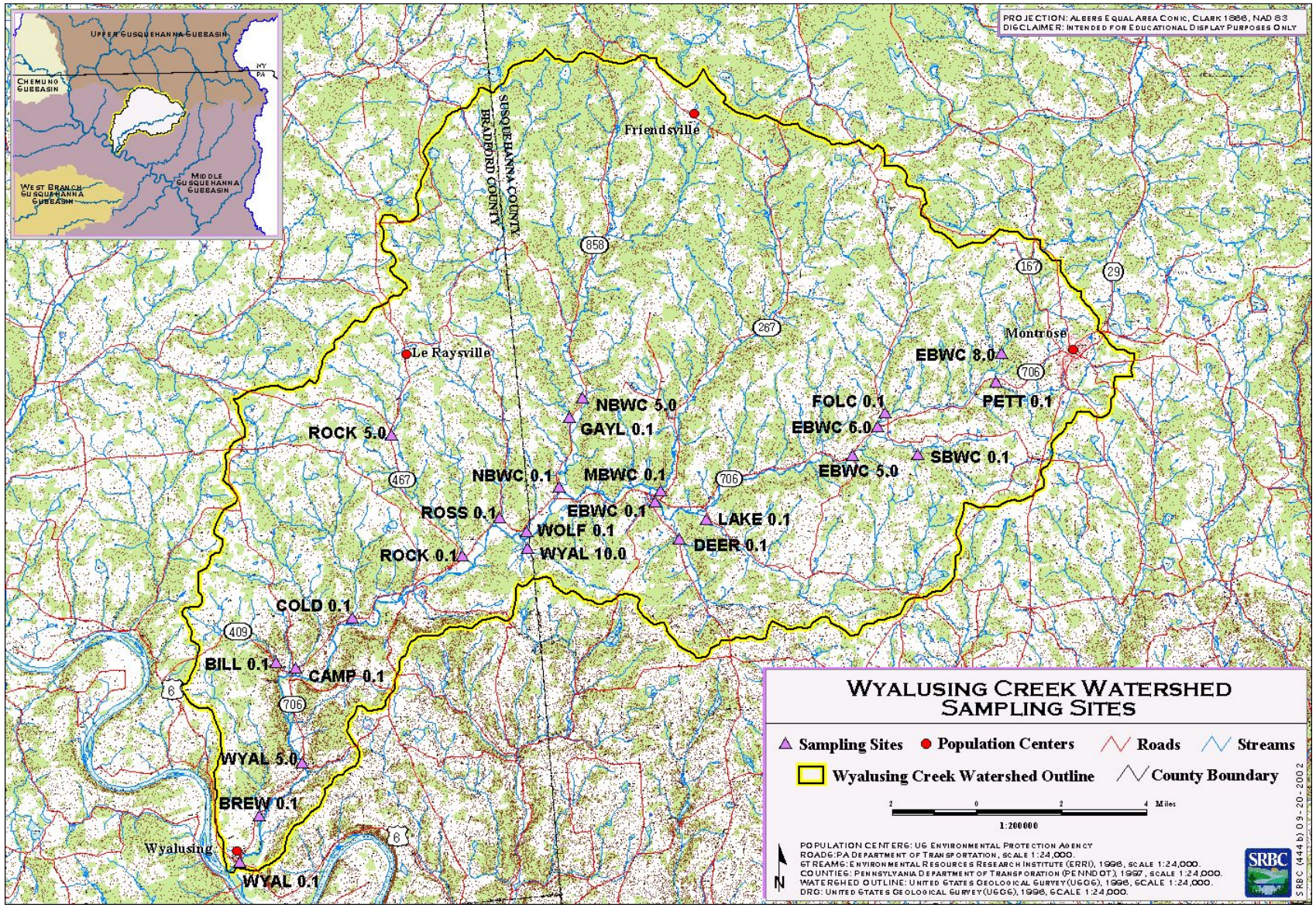


Figure 1. Middle Susquehanna Subbasin Year 2 Sampling Sites in the Wyalusing Creek Watershed.

D. Monitoring Parameters

Parameters of interest are listed in Table 2. Discharge will be measured manually at all stations using standard U.S. Geological Survey (USGS) equipment and methods (Buchanan and Somers, 1969). Macroinvertebrate data will be comprised of a list of different genera collected and an estimate of population density. Chemical water quality and instream flow information will be collected bimonthly at all stations, while biological samples and physical habitat information will be collected once during the late-spring time period.

VI. PROJECT FISCAL INFORMATION

See USEPA grant application.

VII. SCHEDULE

	2002			2003												2004						
Activity	**O**	**N**	**D**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**J**	**F**	**M**	**A**	**M**	**J**	**J**
Water Quality Sampling		X		X		X		X		X		X										
Macroinvertebrate Sampling							X	X														
Habitat Data Collection										X	X											
Identify Macroinvertebrates													X	X	X							
Compile and Evaluate Data													X	X	X	X	X					
Report Writing																	X	X	X	X		
Final Report																					X	

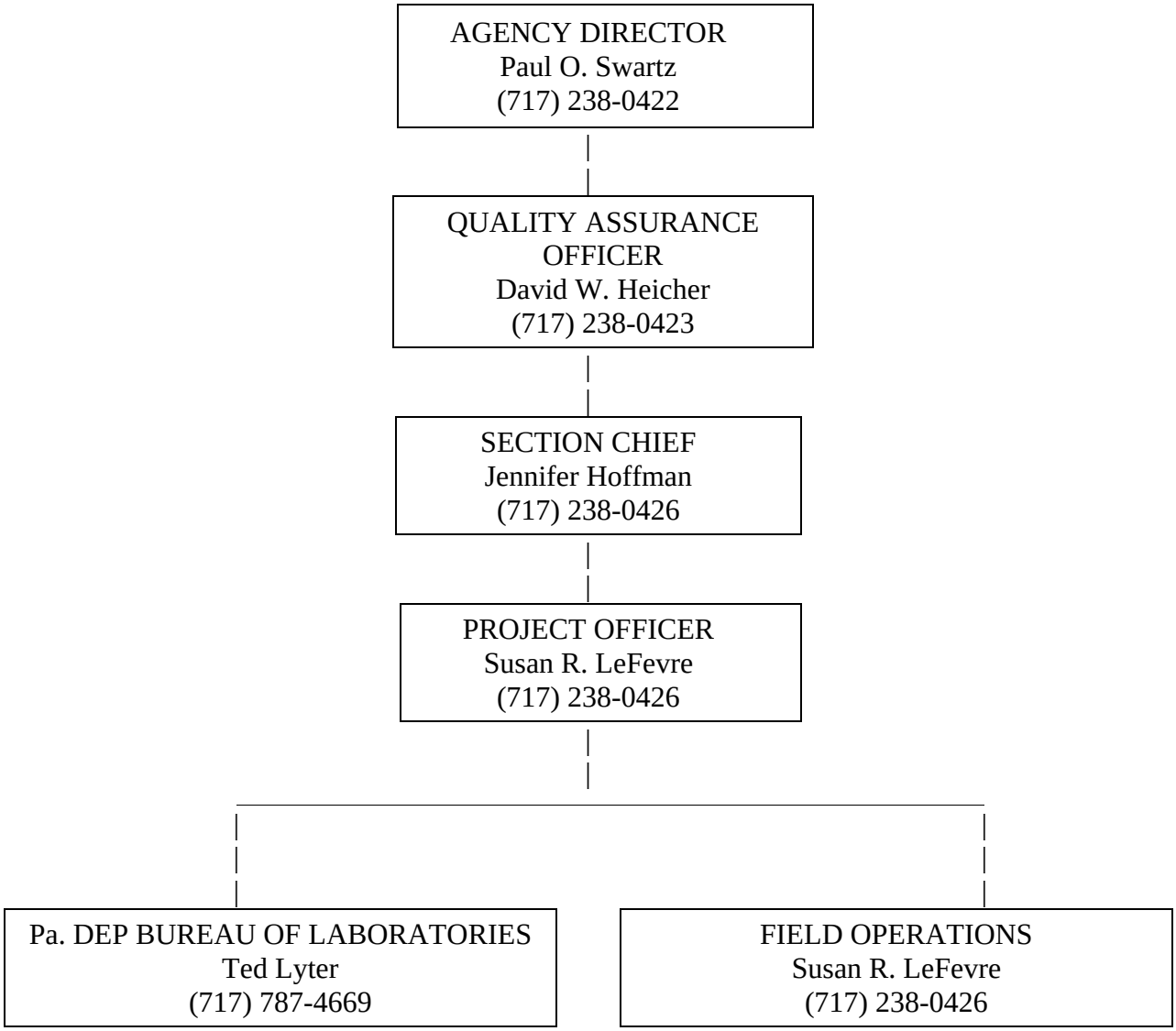
Table 2. Monitoring Parameters

Parameter	Number of Samples	Analytical Sample Matrix	Method Reference	Sample Preservation	Holding Time
Flow	NA	NA	Buchanan and Somers, 1969	none	none
Temperature	144	aq.	In situ	none	0
Dissolved Oxygen	144	aq.	In situ	none	0
Conductivity	144	aq.	In situ	none	0
pH	144	aq.	In situ	none	0
Alkalinity	144	aq.	In situ	none	0
Acidity	144	aq.	In situ	none	0
Total Residue	144	aq.	EPA 160.3	cooling to 4° C	24 hours
Tot Suspended Solids	144	aq.	EPA 160.2	cooling to 4° C	24 hours
Tot. Organic Carbon	144	aq.	EPA 415.2	cooling to 4° C H_2SO_4 to pH <2	24 hours
Total NH_3-N	144	aq.	EPA 350.1	cooling to 4° C H_2SO_4 to pH <2	24 hours
Total NO_2-N	144	aq.	EPA 353.2	cooling to 4° C	24 hours
Total NO_3-N	144	aq.	EPA 353.2	cooling to 4° C	24 hours
Total Nitrogen	144	aq.	Std Method 4500-N-D[1]	cooling to 4° C	24 hours
Total Phosphorus	144	aq.	EPA 365.3	cooling to 4° C H_2SO_4 to pH <2	24 hours
Total Orthophosphate	144	aq.	EPA 365.1	cooling to 4° C	24 hours
Suspended Sediment	144	aq.	USGS[2]	none	none
Macroinvertebrates	24		Barbour and others, 1999	preserve in denatured alcohol	1 year

1. Standard Methods, 19th edition
2. TWRI Book 5, Chapter C2, Laboratory Theory and Methods for Sediment Analysis

VIII. PROJECT ORGANIZATION AND RESPONSIBILITY

A. Project Organization



B. Project Responsibility

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

IX. DATA QUALITY REQUIREMENTS AND ASSESSMENTS

Table 3. Data Quality Requirements and Assessments

Parameter	Detection Limit (mg/l)	Accuracy[1]	Precision[2]
Total Organic Carbon	1	**+/-10%**	+/-10%
Total Residue	2.0	**+/-10%**	+/-10%
Tot Suspended Solids	2.0	**+/-10%**	+/-10%
Total NH_3-N	0.02	**+/-10%**	+/-10%
Total NO_2-N	0.004	**+/-10%**	+/-10%
Total NO_3-N	0.04	**+/-10%**	+/-10%
Total Nitrogen	0.04	**+/-10%**	+/-10%
Total Phosphorus	0.01	**+/-10%**	+/-10%
Total Orthophosphate	0.002	**+/-10%**	+/-10%
Suspended Sediment	NA	**NA**	+/- 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 Representativeness

Water samples are 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.

Sampling stations are placed at specific locations, such as the mouths of streams, headwater areas, and below significant tributaries, to represent large segments of the watershed. Additionally, macroinvertebrate sampling will occur in riffle/run habitats 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 is 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 are collected using depth-integrating samplers. Samples are collected using a hand-line sampler from a boat or bridge, or a hand sampler by wading. The sampler is faced upstream into the current to prevent collection of sediments kicked up by the sampler or field personnel. At each station, five vertical samples are collected, composited in a churn splitter and churned while the sample bottle is filled.

B. Water Samples

Nalgene bottles, provided by the Pa. DEP Bureau of Laboratories (Lab), Harrisburg, Pa. will be used to collect water at each station for laboratory analysis. The samples consist of one 500-ml bottle for nutrients, one 500-ml bottle for all additional parameters, and a cleaned glass bottle for sediment analysis. Samples for total ammonia, 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 Pa. DEP Lab.

C. Field Chemistry

Temperature and dissolved oxygen are measured using a YSI dissolved oxygen meter. Conductivity is measured using a VWR conductivity meter. A Cole-Parmer meter is used to measure pH. Alkalinity and acidity are measured using field titrations. Alkalinity is measured in the field by titrating a known volume of sample water to pH 4.5 with 0.02N H_2SO_4. (See SOP, Attachment A) Acidity is measured in the field by titrating a known volume of sample water to pH 8.3 with 0.02N NaOH. (See SOP, Attachment B**)** Titrations are 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

At all stations, flow measurements are made by field personnel using pygmy or AA meters and standard USGS procedures (Buchanan and Somers, 1969).

E. Macroinvertebrates

Macroinvertebrate assessments are adapted from Rapid Bioassessment Protocol (RBP) III, described by Barbour and others (1999). Macroinvertebrate sampling is conducted in riffle/run habitats at each station. Sampling is conducted by placing a kick screen perpendicular to the current and raking the substrate so dislodged macroinvertebrates are carried into the screen. All collected specimens are preserved in 95 percent ethanol and returned to Commission offices for identification and enumeration. Duplicate samples will be collected at a frequency of one per day, or one per 10 samples, whichever is more frequent. Subsampling and sorting procedures are based on the 1999 RBP document (Barbour and others, 1999). In the laboratory, composite samples are sorted into 200-organism subsamples using a gridded pan and a random numbers table. The organisms contained in the subsamples are identified to genus (except Chironomidae and Oligochaeta), when possible, and enumerated. Benthic macroinvertebrates are identified by professional biologists**,** with a minimum of a Bachelor-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 is supervised by Jennifer Hoffman, who has eight years field and laboratory macroinvertebrate identification experience, and 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. The project officer, Susan LeFevre, has completed private instruction at Pennsylvania State University in conjunction with her M.S. thesis research, has one year of macroinvertebrate identification experience at the Commission, and has completed an identification workshop with Maryland Department of Natural Resources.

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 are placed into the sample containers.

F. Physical Habitat Assessment

Physical habitat conditions at each station are assessed using a slightly modified version of the habitat assessment procedure outlined by Barbour and others (1999). Eleven habitat parameters are field-evaluated at each site and used to calculate a site-specific habitat assessment score. Physical habitat assessments are 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 are delivered to the laboratory by the collectors or shipped to the Pa. DEP Lab by overnight courier service. Sample numbers, as well as field chemistry and flow data, are stored in a field logbook and checked against sample numbers received from Pa. DEP Lab. For macroinvertebrate samples, a logbook is kept containing information regarding the collection, preservation, subsampling, and identification of the macroinvertebrates. The station identification data is recorded on each macroinvertebrate sample and entered into a logbook in the field. This logbook is used to track the macroinvertebrate sample though the laboratory process. Staff members are 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 model dissolved oxygen meter is calibrated using the air-saturated chamber technique prior to use each day. An additional calibration check is performed prior to beginning the fieldwork using the Winkler test. This calibration test is repeated in the event of a membrane replacement or other maintenance that may affect the accuracy of the meter. Calibration of the zero using Na_2SO_3 solution, and the temperature at three points is performed every three months. These data are recorded in a calibration log.

	Acceptable Criteria
Winkler	$\pm$ 0.4 mg/l
Air saturated water	$\pm$ 0.3 mg/l
Zero	less than 0.2 mg/l
Temperature	$\pm$ 0.5^{o}C

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

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

HABITAT PARAMETER	CATEGORY			
	OPTIMAL (20-16)	SUBOPTIMAL (15-11)	MARGINAL (10-6)	POOR (5-0)
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
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 streambank 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 streambank 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

B. Specific Conductance Meter

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

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

C. pH Meters

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

D. Flow meter

Current meters are sent to the manufacturer for calibration, as necessary. Spin tests are performed before and after each day of use. A logbook is kept where each spin time is recorded to determine the accuracy of the current meter.

XIII. DOCUMENTATION

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

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

Databases for all water quality, physical habitat, field chemistry, and macroinvertebrate data consist of Excel spreadsheets developed for in-house needs. The databases are located on the Commission's server. Back-up copies are retained by the project manager in addition to a copy kept in the filing system with hard copies of the data sheets.

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

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.	
26.	

XIV. DATA REDUCTION

Water quality data are formatted into tables by station. The data are compared to state standards. A simple water quality index is computed by averaging the percentile rank of the observations for each station. Only the data collected during this monitoring program are used to determine percentile. This index gives a simple comparison of overall water quality between monitoring stations.

Data reduction procedures are similar to those described in Rapid Bioassessment Protocol III (Barbour and others, 1999). The data for each station are reduced to the following metrics: (1) taxa richness; (2) modified Hilsenhoff Biotic Index; (3) percent Ephemeroptera; (4) percent Univoltine taxa; (5) percent contribution of dominant taxon; (6) number of Ephemeroptera/Plecoptera/Trichoptera taxa; (7) percent Chironomidae; and (8) Shannon Weiner Diversity Index. A description of these metrics and their responses to disturbance are provided in Table 6. The metrics were chosen to cover a variety of categories, including richness, composition, tolerance/intolerance, and life cycle measures. All metrics were derived from those suggested in the RBP manual (Barbour and others, 1999). These metrics are quantified and compared to a reference station with the best available conditions based on physical habitat, water quality, and macroinvertebrate information.

The subsample data are used to generate scores for each of the eight-macroinvertebrate metrics listed above. Each metric score is then 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 constitutes the total biological score for the sample site, and total biological scores are 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 is 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. For sites where the value falls between categories, the project manager will use best professional judgment based on knowledge about the site to determine the proper impairment category. These cut-off values were derived from Plafkin and others (1989) as those advocated for Rapid Bioassessment III.

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. The parameters are derived from the Rapid Bioassessment Protocol document (Barbour and others, 1999). 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. These cut-off values were derived from Plafkin and others (1989).

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 database.

Five 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 five percent of the samples picked by laboratory personnel during subsampling and records the samples in the logbook.

Table 6. Summary of Metrics Used to Evaluate the Overall Biological Integrity of Stream Benthic Macroinvertebrate Communities.

Metric	Description
Taxa Richness (number of total taxa) (a)	A richness metric. The total number of taxa present in the 200-organism subsample. Measures the overall variety of the macroinvertebrate community. Decreases in response to disturbance.
Hilsenhoff Biotic Index (a)	A tolerance/intolerance metric. Measures the pollution tolerance of a macroinvertebrate community. Increases in response to disturbance.
Percent Ephemeroptera (a)	A composition metric. Measure the percent of mayfly nymphs in a community. Decreases in response to disturbance.
Percent Univoltine Taxa (a)	A life cycle metric. Measures the percent of long-lived (life cycles of 1 or more years) taxa. Decreases in response to disturbance.
Percent Contribution of Dominant Taxa (a)	A tolerance/intolerance metric. Measures the dominance of the single most abundant taxon. Increases in response to disturbance.
Number of Ephemeroptera-Plecoptera-Trichoptera Taxa (a)	A richness metric. The total number of Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) present in the subsample. Decreases in response to disturbance.
Percent Chironomidae (a)	A composition metric. Measures the percent of midge larvae in a community. Increases in response to disturbance.
Shannon Weiner Diversity Index (b)	A tolerance/intolerance metric. Measures the complexity of the biological community based on the number of equally or nearly equally abundant taxa in the community. Decreases in response to disturbance.

(a) Barbour and others, 1999.
(b) Klemm and others, 1990.

XVI. PERFORMANCE AND SYSTEMS AUDITS

A. Laboratory Analyses

Analytical and quality assurance procedures for the Pa. DEP 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 and blanks will be submitted to the laboratory (at least one per 10 samples).

B. Field Procedures

Yearly, field operator techniques are tested for pH and specific conductance with USGS standard samples. 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.

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 percent are acceptable. Temperature readings from the dissolved oxygen meter are checked against a standard laboratory thermometer. Dissolved oxygen measurements are checked against a titration test. These checks are performed prior to fieldwork.

C. Biological Sampling

A second biologist verifies the identifications on five 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 data report containing the results of the monitoring program will be published. The data also will be available on the Commission's website (www.srbc.net). In addition, the data will be utilized by staff for project review and for inclusion in the Commission's 305(b) report.

REFERENCES

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

Buchanan, T.J. and W.P. Somers. 1969. Discharge Measurements at Gaging Stations. USGS Techniques of Water-Resources Investigations, Book 3, Chapter A8.

Klemm, D.J., P.A. Lewis, F. Fulk, and J.M. Lazorchak. 1990. Macroinvertebrate field and laboratory methods for evaluating the biological integrity of surface waters. U.S. Environmental Protection Agency, Office of Research and Development, Cincinnati, Ohio, USA.

Plafkin, J.L., M.T. Barbour, K.D. Porter, S.K. Gross, and R.M. Hughes. 1989. Rapid Bioassessment Protocols for Use in Streams and Rivers: Benthic Macroinvertebrates and Fish. U.S. Environmental Protection Agency, Office of Water, Document No. EPA/444/4-89-001, Washington, D.C.

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.