SUSQUEHANNA RIVER PILOT STUDY: LARGE RIVER ASSESSMENT PROJECT

Publication 228   *August 2003*

Prepared by
Jennifer L. R. Hoffman
Section Chief, Monitoring and Assessment

Watershed Assessment and Protection Program
Susquehanna River Basin Commission

SUSQUEHANNA RIVER BASIN COMMISSION

Paul O. Swartz, Executive Director

The Susquehanna River Basin Commission was created as an independent agency by a federal-interstate compact* among the states of Maryland, New York, Commonwealth of Pennsylvania, and the federal government. In creating the Commission, the Congress and state legislatures formally recognized the water resources of the Susquehanna River Basin as a regional asset vested with local, state, and national interests for which all the parties share responsibility. As the single federal-interstate water resources agency with basinwide authority, the Commission's goal is to coordinate the planning, conservation, management, utilization, development and control of basin water resources among the public and private sectors.

*Statutory Citations: Federal - Pub. L. 91-575, 84 Stat. 1509 (December 1970); Maryland - Natural Resources Sec. 8-301 (Michie 1974); New York - ECL Sec. 21-1301 (McKinney 1973); and Pennsylvania - 32 P.S. 820.1 (Supp. 1976).

This report is available on our website (www.SRBC.net) by selecting Public Information/Technical Reports. For a CD Rom or for a hard copy, contact the Susquehanna River Basin Commission, 1721 N. Front Street, Harrisburg, Pa. 17102-2391, (717) 238-0423, FAX (717) 238-2436, E-mail: srbc@srbc.net.

TABLE OF CONTENTS

TABLES

FIGURES

APPENDICES

ACKNOWLEDGMENTS

SUSQUEHANNA RIVER PILOT STUDY:

LARGE RIVER ASSESSMENT PROJECT

Jennifer L. R. Hoffman, Section Chief, Monitoring and Assessment

ABSTRACT

The Susquehanna River Basin Commission (SRBC) conducted a pilot study to determine appropriate methods of biologically assessing the large rivers of the Susquehanna River Basin. Data were collected at eight of ten original sites along the New York–Pennsylvania border during September 2002. To biologically assess the river, SRBC staff used four methods: vacuum benthic sampler; rock basket sampler; multi-plate sampler; and a traditional Rapid Bioassessment Protocol (RBP) III kick net. Additionally, water quality and physical habitat data were collected at the time of sampling.

Only 10 of 216 water quality data points exceeded standards, all of which were nutrient or total suspended-sediment parameters, indicating that the Susquehanna River, in this reach, contains fairly good water quality. High flows at the time of sampling precluded complete biological sample collection; however, several inferences can be drawn from the data set: (1) Rock baskets and RBP methods were most effective at collecting the large numbers of organisms needed for bioassessment; (2) rock baskets consistently had better scores for several metrics; and (3) assessment results tended to vary with location across the river. Physical habitat assessments may not be appropriate for a riverine system, due to the extreme width of the river in some areas.

For future projects, SRBC plans to use a combination of rock basket samplers and traditional RBP methods to effectively sample the Susquehanna River, as these proved to be the most efficient and consistent collection methods. Staff also will be considering alternative methods for assessing physical habitat and determining ways to assess the reservoir system at the lower end of the Susquehanna River.

INTRODUCTION

SRBC has been assessing streams biologically throughout the Susquehanna basin since the late 1970s. When the U.S. Environmental Protection Agency (USEPA) introduced the first version of the RBP manual (Plafkin and others, 1989), SRBC adopted those methods for use in its interstate stream monitoring program and its rotating subbasin surveys. However, neither the previous nor current RBP methods (Barbour and others, 1999) used by SRBC in the aforementioned surveys accurately depict the biological integrity of the basin's large rivers: the mainstem Susquehanna; Chemung; West Branch; and Juniata Rivers. Thus, in 2002, SRBC initiated a pilot project to determine proper methods of biologically assessing the large rivers in the Basin. The information collected during the pilot project will be used in future years to select and calculate metrics for a benthic macroinvertebrate index of biotic integrity (IBI) to assess the biological conditions in the rivers of the basin. The data also will be used in SRBC's 305(b) assessments and to complement state assessment efforts.

Benthic macroinvertebrates were used to assess biological conditions for several reasons. They 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, 2001a). Additionally, SRBC has background macroinvertebrate data from various sites on the large rivers of the basin from subbasin surveys and interstate streams monitoring.

Basin Geography

The Susquehanna River basin is the largest river basin on the east coast of the United States, draining 27,510 square miles. The Susquehanna River originates at Otsego Lake, N.Y., and flows 444 miles through New York, Pennsylvania, and Maryland to the Chesapeake Bay at Havre de Grace, Md.

The study area is located in the Upper Susquehanna Subbasin, which encompasses an area of approximately 4,950 square miles. The subbasin is sparsely populated, with only one large city, Binghamton, N.Y., and several small population centers, such as Sayre, Pa., and Waverly, N.Y. The subbasin lies almost entirely within the Northern Appalachian Plateau and Uplands Region (Wood, 1996). This ecoregion is characterized by low hills covered with hardwood forests and open valleys of scattered agricultural lands. The fertile, but rocky, soils were deposited by receding glaciers during the Wisconsinan Age.

The Upper Susquehanna Subbasin includes the drainage areas of several large rivers: the Chenango; Otselic; Sangerfield; Tioughnioga; Unadilla; and Susquehanna. Forests cover approximately 60 percent of the Upper Susquehanna Subbasin. Agriculture, the second leading land use, covers about 36 percent of available land in the subbasin (Stoe, 1999).

Study Area

SRBC staff conducted the pilot project on the Susquehanna River between Windsor, N.Y., and Sayre, Pa., during September 2002 (Figure 1). This stretch of river was chosen because background biological information from SRBC's interstate streams monitoring program (LeFevre and Sitlinger, 2003) is available for a 13-year period from three stations: Windsor and Conklin, N.Y., and Sayre, Pa. Biological and habitat data are collected annually at these sites, while water quality information is collected quarterly. The 10 sampling sites on this 76-mile stretch of river (Table 1) were selected so that data collected during this survey could be compared with past data collected by SRBC and to document the possible changes in the riverine biota throughout this stretch of river.

METHODS

Field and Laboratory Methods

Data collection

During September 23-26, 2002, SRBC staff collected samples from the Susquehanna River between Windsor, N.Y., and Sayre, Pa. Macroinvertebrate samples were collected at eight of the ten proposed sites. High river flows at the time of sampling precluded collection at sites SUSQ 8 and SUSQ 9 and reduced the collection effort at several other sites. River flows quadrupled during the study from base flow conditions that were present at the time of sampler placement. Habitat was rated, and chemical water quality samples were collected at the sites where a macroinvertebrate sample was collected.

Samples were labeled with the site number (SUSQ 1 through SUSQ 10), the type of equipment used (VBS for vacuum benthic sampler, RBP for rapid bioassessment protocol, RS for rock basket sampler, and HD for multi-plate sampler), and the location of the sampler with relation to the site (sampler one at the left bank and sampler five at the right bank). For example, a vacuum benthic sample taken at SUSQ 2 in the middle of the river would be designated as 2VBS3.

The field crew consisted of six members, three of which were trained biologists. Additionally, three members of the field crew had received SCUBA training prior to the sampling effort. All members of the field crew had CPR and Basic First Aid training. Latitude and longitude were recorded using a hand-held Global Positioning System unit at all sites.
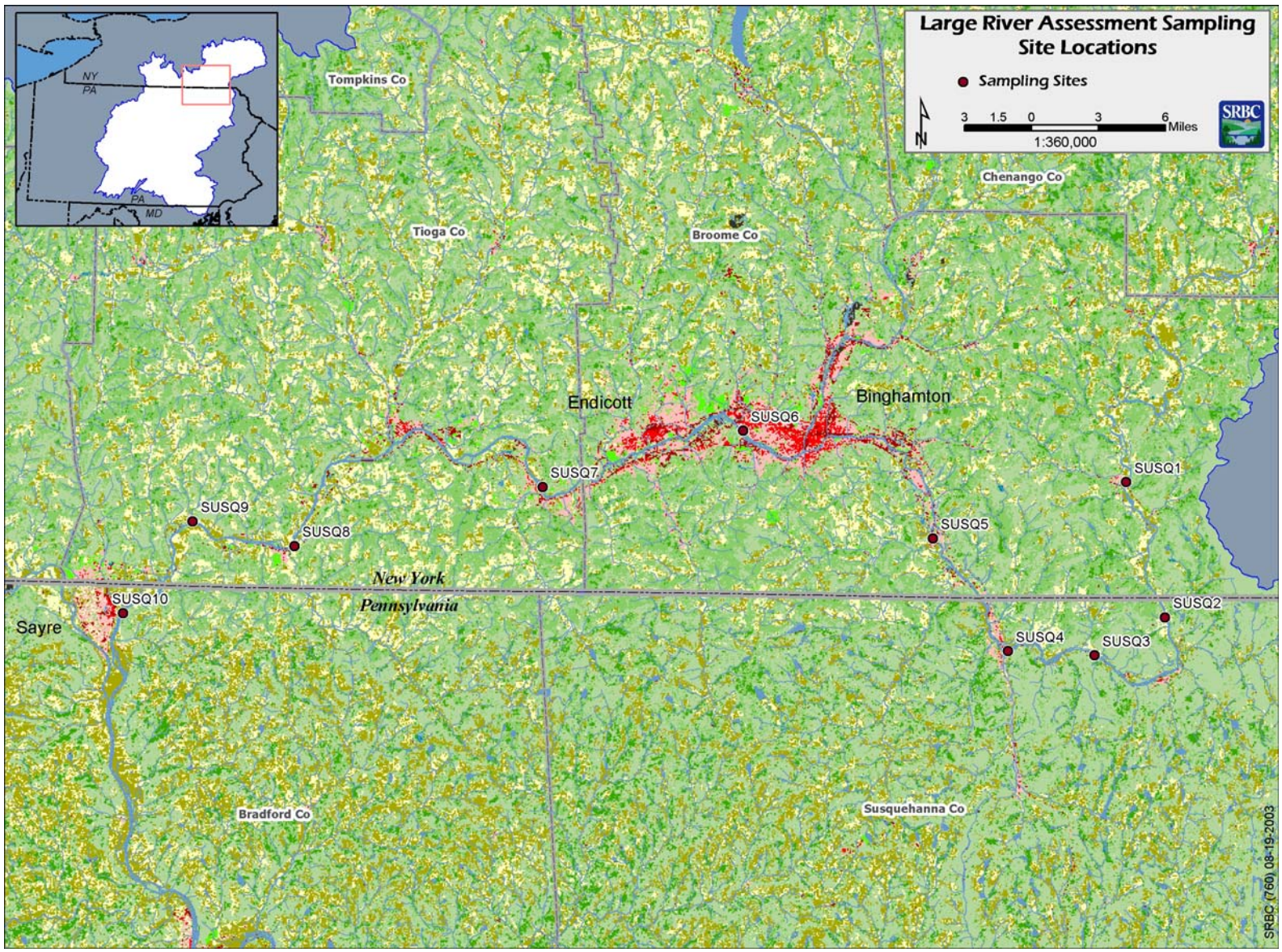
Figure 1.   Large River Assessment Sampling Site Locations

Table 1.   Susquehanna River Station Locations

Station Number	County/State	USGS Quad	Latitude	Longitude	Site Description
SUSQ 365/SUSQ 1	Broome/N.Y	Windsor, N.Y.	42.0747	-75.6351	Susquehanna River at Windsor, N.Y.
SUSQ 359/SUSQ 2	Susquehanna/Pa.	Susquehanna, Pa.	41.9910	-75.6023	Susquehanna River at PF&BC Oakland access along Rt. 92, upstream of Oakland, Pa.
SUSQ 356/SUSQ 3	Susquehanna/Pa.	Great Bend, Pa.	41.9612	-75.6620	Susquehanna River at PF&BC Great Bend access along SR1010, upstream of Hallstead, Pa.
SUSQ 350/SUSQ 4	Susquehanna/Pa.	Great Bend, Pa.	41.9636	-75.7377	Susquehanna River at Hallstead, Pa., at I-81 bridge
SUSQ 344/SUSQ 5	Broome/N.Y.	Binghamton East, N.Y.	42.0347	-75.8017	Susquehanna River at Veteran's River Park at Kirkwood, N.Y.
SUSQ 334/SUSQ6	Broome/N.Y.	Binghamton West, N.Y.	42.1026	-75.9687	Susquehanna River at fishing access site in Binghamton, N.Y.
SUSQ 327/SUSQ 7	Tioga/N.Y.	Apalachin, N.Y.	42.0653	-76.1426	Susquehanna River at fishing access site near Apalachin, N.Y.
SUSQ 322/SUSQ 8	Tioga/N.Y.	Owego, N.Y.	42.0250	-76.3625	Susquehanna River at Town of Nichols Fishing Access along East River Drive, near Nichols, N.Y.
SUSQ 312/ SUSQ 9	Tioga/N.Y.	Barton, N.Y.	42.0400	-76.4464	Susquehanna River at Barton Fishing Access along East Barton Road, Barton, N.Y.
SUSQ 300/ SUSQ 10	Bradford/Pa.	Sayre, Pa.	41.9819	-76.5065	Susquehanna River downstream of Lockhart Street bridge in Sayre, Pa.

Chemical water quality

Water samples were collected at each sampling site to measure nutrient and metal concentrations in the river. Field water quality measurements included water temperature, dissolved oxygen, conductivity, pH, alkalinity and acidity. Temperature was measured with a field thermometer in degrees Celsius. Dissolved oxygen was measured with a YSI 55 meter that was calibrated at the beginning of every day when samples were collected, and conductivity was measured with a Cole-Parmer Model 1481 meter. A Cole-Parmer Model 5996 meter that was calibrated at the beginning of each sampling day and randomly checked throughout the day was used to measure pH. Alkalinity was determined by titrating a known volume of sample water to pH 4.5 with 0.02 N sulfuric acid (H_2SO_4). Acidity was measured by titrating a known volume of sample water to pH 8.3 with 0.02 N sodium hydroxide (NaOH).

A list of laboratory parameters is located in Table 2. Laboratory samples consisted of one 500-ml bottle of raw water and two 250-ml bottles of acidified water. One of the 250-ml bottles was acidified with nitric acid (HNO_3) for metal analyses. The other 250-ml bottle was acidified with H_2SO_4 for nutrient analyses. Samples were iced and shipped to the Pennsylvania Department of Environmental Protection (Pa. DEP), Bureau of Laboratories, in Harrisburg, Pa., for analysis.

Physical habitat

The physical habitat conditions were evaluated at each site using a modified version of RBP III (Plafkin and others, 1989; Barbour and others, 1999). A total of 11 physical stream characteristics relating to substrate, pool and riffle composition, channel morphology, streambank condition, and the riparian area were rated on a scale of 0-20, with 20 considered optimal and used to calculate a site-specific habitat score. Physical habitat assessments were performed for riffle/run or glide/pool areas, depending on stream type. Other characteristics, such as stream type, weather conditions, substrate material, land use, and other important stream features also were noted at the time of sampling. Tables 3 (riffle/run habitat) and 4 (glide/pool habitat) summarize the criteria used to evaluate physical habitat.

Macroinvertebrates

Staff collected benthic macroinvertebrate samples using four separate methodologies to determine the proper methods of biologically assessing the large rivers of the basin. Each methodology is described in detail below.

Table 2. Parameters for Laboratory Analysis

Parameter	
Specific Conductance, µmhos/cm[a]	Total Suspended Solids (TSS), mg/l
pH, S.U.[b]	Total Sodium, mg/l
Alkalinity, mg/l[c]	Total Potassium, mg/l
Total Nitrogen, mg/l	Total Chloride, mg/l
Total Ammonia, mg/l	Total Sulfate, mg/l
Total Nitrite, mg/l	Total Fluoride, mg/l
Total Nitrate, mg/l	Total Copper, µg/l[d]
Total Phosphorus, mg/l	Total Iron, µg/l
Total Orthophosphate, mg/l	Total Lead, µg/l
Total Organic Carbon (TOC), mg/l	Total Manganese, µg/l
Total Hardness, mg/l	Total Nickel, µg/l
Total Calcium, mg/l	Total Zinc, µg/l
Total Magnesium, mg/l	Total Aluminum, µg/l

[a] µmhos/cm = micromhos per centimeter   [b] S.U. = Standard Units
[c] mg/l = milligrams per liter   [d] µg/l = micrograms per liter

Table 3.   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
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

Table 4. 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
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

Vacuum Benthic Sampler (VBS)

A vacuum benthic sampler (Figure 2), operated by a SCUBA diver, can be very useful in sampling large rivers and can be used on a variety of substrates (Brown and others, 1987). For this project, three field crew members had SCUBA training prior to sample collection.

With this collecting method, five riffle/run areas were targeted at each site, where available. If riffle/run areas were not present, samples were taken in a transect across the stream bottom. The sampler was lowered to the river bottom by a helper in a boat, and the diver positioned the sampler in the appropriate sampling area. The diver settled the sampler on the bottom, the helper activated the pump, and the diver vacuumed the substrate into a net bag. Substrate was removed to a depth of approximately five centimeters over a time period of five minutes. Large organisms, such as crayfish and hellgrammites, also were hand-collected in a separate net bag for inclusion in the total sample. The collecting bag and its contents were placed in a jar labeled with the site information and method of collection. The jar was filled with 95 percent ethanol so that the final concentration was at least 70 percent ethanol. The capped sample bottles were taken back to the laboratory to await analysis (Gale and Thomas, 1975).

Rock Basket (RS)

The second method was a rock substrate basket sampler (Figure 3). 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 was placed in a run area, where possible, to ensure a constant flow of water running through the sampler. Before the baskets were placed in the river, they were attached to a concrete block for stabilization and a float for marking the sampler location. Five such baskets were located on a transect across the river and left in place for six weeks to allow colonization. Samplers were placed by hand during August 12–15, 2002. Sites were chosen across the transect based on depth, velocity, substrate, and cover within the transect. To retrieve the substrates, the baskets were separated from the concrete blocks and placed in a collecting bag while still under water by a SCUBA diver. The net was brought to shore, and all macroinvertebrates were rinsed from the substrate and placed in a jar labeled with site information and method of collection. The jar was filled with 95 percent ethanol so that the final concentration was at least 70 percent ethanol. The capped sample bottles were taken back to the laboratory to await analysis.

Multiplate Sampler (HD)

Additionally, at the request of Pa. DEP, multiplate samplers (Figure 4) were placed in conjunction with the rock baskets mentioned above at each of the sites to produce information regarding colonization of each type of artificial substrate sampler and their comparability. Three multi-plate samplers were deployed at each of the sampling stations (at the right and left banks and in the middle of the river). The multiplate samplers were retrieved by a SCUBA diver and processed in the same manner as the rock baskets.

Modified Rapid Bioassessment Protocol (RBP)

SRBC has used this procedure for sampling throughout the basin since 1992. Including this methodology provides a link to past assessments in the river. The USEPA RBP III methodology (Barbour and others, 1999) was used in riffle areas, where present. When no riffle/run area was present, this methodology was used along the banks of the river and around the edges of islands. In riffle/run areas, samples were 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.

Figure 2.   Benthic Vacuum Sampler Used in River Assessment Project (from Brown and others, 1987)

Fig. 1. Diagram of the vacuum benthos sampler.
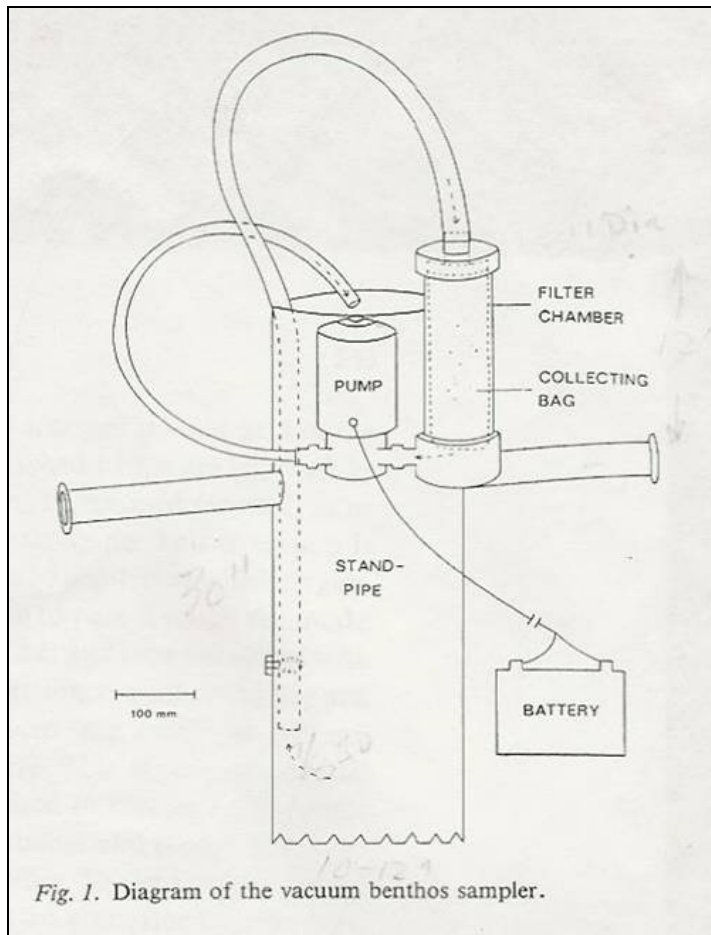
Figure 3.   Rock Baskets Used in River Assessment Project

Figure 4.   Multi-plate Samplers Used in River Assessment Project

Sampling was conducted by placing a one meter square kick screen perpendicular to the current and disrupting the substrate so dislodged macroinvertebrates are carried into the screen. All collected specimens were preserved in 95 percent ethanol and returned to SRBC offices for identification and enumeration.

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

Subsampling and sorting procedures were based on the 1999 RBP document (Barbour and others, 1999). In the laboratory, composite samples were sorted into 200-organism subsamples, when possible, using a gridded pan and a random numbers table. The organisms contained in the subsamples were identified to genus (except Chironomidae and Oligochaeta), when possible, and enumerated. Benthic macroinvertebrates were identified by professional biologists, with a minimum of 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.

Data Analysis

Chemical water quality

Chemical water quality was assessed by examining field and laboratory parameters. Limit values were obtained for each parameter based on current state and federal regulations or references for aquatic life tolerances (Table 5, from LeFevre, 2003).

Table 5.   ***Water Quality Limits and References***

Parameter	Limit	Reference Code
Temperature	> 25°C	a,f
Dissolved oxygen	< 4 mg/l	a,g
Conductivity	> 800 µmhos/cm	d
pH	6 – 9	c,f
Alkalinity	< 20 mg/l	a,g
Nitrogen	>1.0 mg/l	k,l,m
Ammonia	>0.2 mg/l	f
Nitrite	> 1.0 mg/l	f
Nitrate	> 1.0 mg/l	e,i
Phosphorus	> 0.1 mg/l	e
Orthophosphate	> 0.05 mg/l	m
TOC	> 10 mg/l	b
Hardness	> 300 mg/l	e
Magnesium	> 35 mg/l	j
TSS	> 15 mg/l	h
Sodium	> 20 mg/l	j
Potassium	> 30 mg/l	b
Chloride	> 150 mg/l	a
Sulfate	> 250 mg/l	a
Fluoride	> 2.0 mg/l	a
Copper	> 12 µg/l	e
Iron	> 1,500 µg/l	a
Lead	> 1.0 µg/l	e
Manganese	> 1,000 µg/l	a
Nickel	> 158 µg/l	d
Zinc	> 106 µg/l	e
Aluminum	> 200 mg/l	c

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.state.va.us/pdf/watrregs/fish.pdf

i: http://www.fisheries.org/publications/bookpdf/aquaticmethods.pdf

j: http://www.dec.state.ny.us/website/regs/703.htm

k: http://water.usgs.gov/pubs/circ/circ1225/images/table.html

l: http://www.ecan.govt.nz/Land/pdf%20files/sheet13.pdf

m: http://h2osparc.wq.ncsu.edu/info/

Macroinvertebrate analysis

In-depth statistical analyses comparing the overall sampling methods, both between and within sites, could not be performed due to a reduced data collection effort from high waters precluding sampling at two of the sites and reducing the amount of information collected at most of the other sites. However, basic metrics for macroinvertebrates were calculated and assessments of the sites were performed. Benthic macroinvertebrate samples were assessed using procedures described by Barbour and others (1999), Klemm and others (1990), and Plafkin and others (1989). Using these methods, staff calculated a series of biological indexes for each type of sampler at each station. The metrics used in this survey are summarized in Table 6. Metric 2 (Shannon-Wiener Diversity Index) followed the methods described in Klemm and others (1990), and all other metrics were derived from Barbour and others (1999).

Three approaches were used to assess the 84 samples produced by the large river assessment project to evaluate how an IBI-type analysis compares to use of a reference site (the best available suite of biological conditions at a single site) or a reference condition (the combined best overall score for each metric) for impairment decisions. To produce the IBI analysis (Approach 1), the 75th and 25th percentiles of the highest value for each metric were used to determine a biological condition score. A score of six was given to each metric that was greater than the 75th percentile, a score of three was given to metrics that were between the 75th and 25th percentiles, a score of zero was given to those metrics that had values less than the 25th percentile. A total biological score of 28 or greater received a nonimpaired designation, scores of 27 through 14 received a partially impaired designation, and scores of less than 14 received a severely impaired designation.

The reference site approach (Approach 2) entails determining the best available biological condition at a single site. To determine the best available conditions, each metric score was ranked against all other scores for that metric. The rankings were then averaged to determine which site contained the best available overall conditions of the 84 samples collected. For this analysis, staff determined that 1VBS2 (a vacuum benthic sample taken at SUSQ1, second sample from the left) contained the best overall suite of biological conditions. The 200-organism subsample data were used to generate scores for each of the seven metrics. Scores for metrics 1-4 were converted to a biological condition score, based on the percent similarity of the metric score, relative to the metric score of the reference site. Scores for metrics 5-7 were based on set scoring criteria developed for the percentages (Plafkin and others, 1989; Ohio Environmental Protection Agency, 1987). The sum of the biological condition scores constituted the total biological score for the sample site, and total biological scores were used to assign each site to a biological condition category (Table 7).

The third appraoch was the use of reference conditions. For this technique, the best score for each metric was determined. Each site was then compared against the highest score for each metric. To determine levels of impairment, the same protocol was used as in the reference site approach.

Physical habitat analysis

Habitat assessment scores of sample sites were compared to those of the reference site (SUSQ 1) to classify each sample site into a habitat condition category (Table 8).

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

Metric	Description
1. Taxonomic Richness (a)	The total number of taxa present in the 200-organism subsample. Number decreases with increasing disturbance or stress.
2. Shannon-Wiener Diversity Index (b)	A measure of biological community complexity based on number of equally or nearly equally abundant taxa in the community. Index value decreases with increasing stress.
3. Hilsenhoff Biotic Index (a)	A measure of the organic pollution tolerance of a benthic macroinvertebrate community. Index value increases with increasing stress.
4. EPT Index (a)	The total number of Ephemeroptera (mayfly), Plecoptera (stonefly), and Trichoptera (caddisfly) taxa present in the 200-organism subsample. The index decreases with increasing stress.
5. Percent Ephemeroptera (a)	The percentage of Ephemeroptera in a 200-organism subsample. Percentage decreases with increasing stress.
6. Percent Dominant Taxa (a)	A measure of community balance at the lowest positive taxonomic level. Percentage increases with increasing stress.
7. Percent Chironomidae (a)	The percentage of Chironomidae in a 200-organism subsample. Percentage increases with increasing stress.

Sources: (a) Barbour and others, 1999
                (b) Klemm and others, 1990

Table 7.   Summary of Criteria Used to Classify the Biological Conditions of Sample Sites

SAMPLING AND ANALYSIS

↓
↓

TOTAL BIOLOGICAL SCORE DETERMINATION				
	Biological Condition Scoring Criteria			
Metric	6	4	2	0
1. Taxonomic Richness (a)	> 80%	79-60%	59-40%	<40%
2. Shannon Diversity Index (a)	> 75%	74-50%	49-25%	<25%
3. Hilsenhoff Biotic Index (b)	> 85%	84-70%	69-50%	<50%
4. EPT Index (a)	> 90%	89-80%	79-70%	< 70%
5. Percent Ephemeroptera (c)	> 25%	10-25%	1-9%	< 1%
6. Percent Chironomidae (c)	< 5%	5-20%	21-35%	>35%
7. Percent Dominant Taxa (c)	< 20%	20-30%	31-40%	>40%
Total Biological Score (d)				

↓
↓

BIOASSESSMENT	
Percent Comparability of Study and Reference Site Total Biological Scores (e)	Biological Condition Category
>83%	Nonimpaired
79-54	Slightly Impaired
50-21	Moderately Impaired
<17%	Severely Impaired

(a)   Score is study site value/reference site value X 100
(b)   Score is reference site value/study site value X 100.
(c)   Scoring Criteria evaluate actual percentage contribution, not percent comparability to the reference station.
(d)   Total Biological Score = the sum of Biological Condition Scores assigned to each metric
(e)   Values obtained that are intermediate to the indicated ranges will require subjective judgment as to the correct placement into a biological condition category.

Table 8.   Summary of Criteria Used to Classify the Habitat Conditions of Sample Sites

DETERMINATION OF HABITAT ASSESSMENT SCORES				
Parameter	**Habitat Parameter Scoring Criteria**			
	Excellent	**Good**	**Fair**	**Poor**
Epifaunal Substrate	20-16	15-11	10-6	5-0
Instream Cover	20-16	15-11	10-6	5-0
Embeddedness/Pool Substrate	20-16	15-11	10-6	5-0
Velocity/Depth Regimes/Pool Variability	20-16	15-11	10-6	5-0
Sediment Deposition	20-16	15-11	10-6	5-0
Channel Flow Status	20-16	15-11	10-6	5-0
Channel Alteration	20-16	15-11	10-6	5-0
Frequency of Riffles/Channel Sinuosity	20-16	15-11	10-6	5-0
Condition of Banks (a)	20-16	15-11	10-6	5-0
Vegetative Protective Cover (a)	20-16	15-11	10-6	5-0
Riparian Vegetative Zone Width (a)	20-16	15-11	10-6	5-0
Habitat Assessment Score (b)				

↓

↓

HABITAT ASSESSMENT	
Percent Comparability of Study and Reference Site Habitat Assessment Scores	**Habitat Condition Category**
>90%	Excellent (comparable to reference)
89-75	Supporting
74-6	Partially Supporting
<60	Nonsupporting

(a)   Combined score of each bank
(b)   Habitat Assessment Score = Sum of Habitat Parameter Scores

RESULTS

Water Quality

During September 2002, water quality at most of the river sites met water quality standards (Appendix A). Limit values were exceeded for only 10 out of 216 total water chemistry values. The exceedances are listed in Table 9.

Biological Communities

Raw data for the benthic macroinvertebrate analysis can be found in Appendix B. The results of the metrics for the IBI, reference site, and reference condition approaches are found in Appendix C. A high RBP score indicates a low degree of impairment and a comparatively healthy macroinvertebrate community. Results of the data are summarized below for each site and for each assessment method (Table 10). Table 10 shows the number of samplers within each station that received a nonimpaired, partially impaired, or severely impaired designation for the IBI-type analysis and the number of samplers within each station that received a nonimpaired, slightly impaired, moderately impaired, or severely impaired designation for the reference site and reference condition approaches.

Table 11 indicates an average for each metric for each sampler type. HD had the lowest and RS had the highest score for Taxa Richness, while HD had the lowest and RBP had the highest average score for Hilsenhoff Biotic Index and Shannon-Wiener Diversity Index. RBP had the lowest and HD had the highest average score for Percent Ephemeroptera, Percent Dominant Taxa, and Percent Chironomidae. RBP had the lowest and RS had the highest average score for EPT Index.

Physical Habitat

Physical habitat data are presented in Table 12. A high score indicates a high-quality physical habitat. SUSQ 1 was used as the reference site for habitat assessment, as it exhibited the best available habitat. All sites had either excellent (comparable to reference) or supporting habitat.

Table 9.   Summary of Exceedances of Water Quality Standards

Station	Date	Parameter	Observed Concentration	Limit Concentration
SUSQ 1	9/23/02	Total Suspended Solids	18 mg/l	15 mg/l
SUSQ 4	9/24/02	Total Nitrate	1.45 mg/l	1.0 mg/l
SUSQ 5	9/25/02	Total Ammonia	0.23 mg/l	0.2 mg/l
SUSQ 5	9/25/02	Total Phosphorus	0.22 mg/l	0.1 mg/l
SUSQ 5	9/25/02	Total Orthophosphate	0.11 mg/l	0.05 mg/l
SUSQ 6	9/25/02	Total Ammonia	0.29 mg/l	0.2 mg/l
SUSQ 7	9/25/02	Total Nitrogen	1.01 mg/l	1.0 mg/l
SUSQ 7	9/25/02	Total Ammonia	0.28 mg/l	0.2 mg/l
SUSQ 10	9/26/02	Total Suspended Solids	20 mg/l	15 mg/l
SUSQ 10	9/26/02	Total Ammonia	0.26 mg/l	0.2 mg/l

Table 10.   Summary of Impairment Designations for Each Site and Analysis Type

Station	IBI-type analysis			Reference site				Reference Condition			
	Non	Partial	Severe	Non	Slight	Moderate	Severe	Non	Slight	Moderate	Severe
SUSQ1	15	3	0	6	12	0	0	5	13	0	0
SUSQ2	1	4	7	0	4	8	0	0	2	10	0
SUSQ3	5	7	3	1	13	1	0	1	12	1	0
SUSQ4	4	6	1	3	7	1	0	0	8	3	0
SUSQ5	1	6	1	0	7	1	0	0	7	1	0
SUSQ6	1	7	2	1	6	1	2	0	6	2	2
SUSQ7	0	2	2	0	2	2	0	0	2	2	0
SUSQ10	0	4	2	0	5	1	0	0	4	2	0

Table 11.   Summary of Averages for Each Sampler Type for Each Metric

Parameter	Sampler Type			
	HD	RBP	RS	VBS
Taxa Richness	14.9	18.8	20.4	18.6
Hilsenhoff Biotic Index	4.8	5.1	5.0	4.9
Percent Ephemeroptera	29.13	21.4	25.2	25.5
Percent Dominant Taxa	38.3	30.7	33.7	36.2
EPT Index	9.3	8.7	12.8	8.9
Percent Chironomidae	28.3	9.4	24.9	23.2
Shannon-Wiener Diversity Index	1.86	2.21	2.17	1.99

Table 12.   Summary of Physical Habitat Data

Parameter	SUSQ1	SUSQ2	SUSQ3	SUSQ4	SUSQ5	SUSQ6	SUSQ7	SUSQ10
Epifaunal Substrate	14	11	13	10	13	12	14	13
Instream Cover	16	9	13	10	11	13	14	12
Embeddedness/Pool Substrate	15	14	13	11	14	14	15	15
Velocity/ Depth Regimes/ Pool Variability	18	13	12	14	13	16	16	14
Sediment Deposition	14	14	14	15	14	14	15	14
Channel Flow Status	14	14	15	17	17	17	18	18
Channel Alteration	15	15	16	10	14	13	15	12
Frequency of Riffles/ Channel Sinuosity	14	11	10	10	12	10	12	13
Condition of Banks	16	16	16	15	11	14	15	10
Left Bank	8	8	8	7	7	7	8	4
Right Bank	8	8	8	8	4	7	7	6
Vegetative Protective Cover	16	16	16	15	12	12	14	12
Left Bank	8	8	8	7	8	6	7	6
Right Bank	8	8	8	8	4	6	7	6
Riparian Vegetative Zone Width	10	10	7	6	9	7	12	6
Left Bank	5	6	2	2	7	4	6	2
Right Bank	5	4	5	4	2	2	6	4
Total Habitat Score								
Total Habitat Score	162	143	145	133	140	142	160	139
Habitat Percent of Reference	100	88	90	82	86	88	99	86

DISCUSSION

Water Quality

A comparison of water quality data from the present large river assessment project (September 2002) to water quality samples collected for the most recent (July 2001) interstate streams report (LeFevre and Sitlinger, 2003) indicates that water quality conditions for the Susquehanna River between Windsor, N.Y., and Sayre, Pa., are stable and generally within limits, although temperatures were greater than 25 degrees Celsius in the July samples. One parameter of interest is total organic carbon (TOC). TOC concentrations doubled between SUSQ 5 and SUSQ 6, which is located downstream of the wastewater treatment plant in Binghamton. Overall, from the data analysis, it appears that the Susquehanna River, in the stretch encompassed by this study, contains fairly good water quality, with a few nutrient parameters that are slightly elevated.

Macroinvertebrate Communities

A storm that quadrupled base flows just prior to the start of this study precluded sample collection completely at two sites and greatly reduced the number of samples collected at all other sites, except SUSQ 1 and SUSQ 2. Out of a total of 180 potential samples (3 HD samples, 5 RBP samples, 5 RS samples, and 5 VBS samples at each of the 10 sampling sites), only 84 samples were collected (see Appendix B). Thus, a detailed statistical analysis was not possible. However, several inferences can be drawn from the existing data.

- A 200-organism subsample was used for assessments in this study. However, in six of the 20 HD samples and 8 of the 17 VBS samples, less than 200 organisms total were collected. In comparison, only 3 (one due to subsampling error) out of 31 total RS samples and 2 (one due to subsampling error) out of 15 RBP samples contained less than 200 organisms. It appears that HD and VBS samplers are less effective in collecting larger numbers of benthic macroinvertebrates.

- The rock substrate basket samplers consistently scored higher for taxa richness, EPT Index, and Shannon-Wiener Diversity Index than all other samplers.

- In comparing the three types of data analysis (Table 10), the IBI assessment type tended to assess more sites as nonimpaired than did the other two types of analyses (reference site and reference condition). This may be due to using only three assessment designations (nonimpaired, partially impaired, and severely impaired) rather than four (nonimpaired, slightly impaired, moderately impaired, and severely impaired), as in the reference site and reference condition analyses. These later assessment types were very similar in their assessment categorizations (see Table 10).

- At several sites, the biological assessment of the river varied depending upon location of the sampler. For example, at the same station, the left side of the river had a nonimpaired designation while the right side had a slightly impaired designation. This result was expected as the microhabitats do vary across the width of the river. However, at only one site (SUSQ 6), for one sampler type (RS), did an assessment vary from nonimpaired to severely impaired. This site appears to be an anomaly as it is almost completely (>90 percent) dominated by Chironomidae. The sampler also was located downstream of the wastewater treatment plant discharge from Binghamton.

- The biological communities found during the current pilot study were similar to those assessed during the most recent interstate streams survey (LeFevre and Sitlinger, 2003). In both surveys, staff used the Susquehanna River at Windsor, N.Y., as a reference site as it contained the best available biological and physical habitat conditions. The Susquehanna River at Sayre, Pa., was assessed as nonimpaired in the interstate streams survey while it appeared to be slightly to

moderately impaired in the current survey. However, this may be due to high flows, which precluded a complete sampling effort at the site.

Physical Habitat

All stations in this study had either excellent (comparable to reference) or supporting habitat, even though conditions throughout the river were dissimilar. Some parameters used in the habitat form are not applicable to the large river setting. For example, vegetative protective cover, channel flow status, and riparian vegetative zone width may have little bearing on samplers located in the middle of a river that, in some areas, is a mile wide. The habitat directly adjacent to the samplers and the type of substrate on which the sampler is located may have more impact on the benthic macroinvertebrate community composition and will be addressed in future studies.

Comparison of Sampler Types

One of the main goals of this project was to assess different types of samplers for their ability to collect macroinvertebrates from the large rivers of the Susquehanna basin. Four different samplers were used in this study: vacuum benthic samplers; rock baskets; multi-plate samplers; and kick screens. Each of the sampler types has advantages and disadvantages. These are detailed below.

Vacuum benthic sampler

One of the advantages associated with a vacuum benthic sampler is that it collects organisms from a discrete area and can be quantified. Additionally, it gives a point-in-time collection that does not require a colonization period and can be used on a variety of substrates. However, it does have several limitations, as indicated below.

- The wires that connect to the pump must be above the water. Thus, it has depth limitations of approximately three feet.
- The sampler must be used in conjunction with a SCUBA diver and a boat.

- Staff had a difficult time controlling the sampler when velocities increased. The high stovepipe design made the sampler difficult to control.
- The sampler did not collect larger numbers of macroinvertebrates reliably.
- The sampler costs approximately $300 to produce and is difficult to maintain.

Rock baskets

An advantage associated with rock substrate basket samplers is the ability to use them in any water depth and any flow regime. Additionally, since this type of sampler uses natural river rocks and pebbles, artificial substrate is not an issue for colonization of organisms. Rock baskets also are very economical to produce, costing about $2 per basket, and can be used from year to year. However, there are some disadvantages with this type of sampler as well.

- Theft and/or displacement sometimes occur when using rock baskets.
- Rock baskets require a six-week colonization period, thus creating an extra trip to the sampling sites.
- In deeper water, a SCUBA diver is recommended to collect the rock baskets without greatly disturbing the contents of the sampler.

Multiplate samplers

Like the rock baskets, a major advantage of using multiplate samplers is the ability to use them in any water depth and flow regime. Additionally, since the total sample area encompassed in the sampler can be calculated, the sample can be quantified. Multiplate samplers are very economical to produce as well, costing approximately $2 per sampler. Disadvantages are the same as those of rock baskets, above. Additional disadvantages are:

- Multiplate samplers use artificial substrates, in this case hardboard, which may not reflect the substrate preferences of macroinvertebrates.

18

- Multiplate samplers are inconsistent in collecting larger numbers of organisms to allow a 200-organism subsample.

RBP kick screens

An advantage of using kick screens is ease of use. SRBC staff has been using traditional RBP methods since 1992 in the subbasin survey and interstate streams projects, and are, thus, very familiar with the process and have a database on which to build. Additionally, kick nets are economical, costing approximately $100 and can be used for several years before replacing. Another advantage is that a kick net sample does not require colonization time and provides a point-in-time sample. Several disadvantages are discussed below.

- There are depth limitations with the kick nets. The top of the net is approximately three feet high and cannot be used in depths exceeding the top of the net. Thus, most samples must be taken near the shore, in riffle areas, or adjacent to islands.
- Velocity can be an issue with kick nets as they are difficult to control during higher flows.

FUTURE DIRECTIONS

Based on lessons learned from the pilot project, SRBC staff has determined that for future river assessment projects, a combination of rock baskets and RBP methods will be used. Rock baskets will be used as they are effective in sampling deeper waters and produce consistent results. RBP methods also will be used as a comparison to the subbasin survey and interstate stream projects. The vacuum benthic sampler method will not be used in the free-flowing river, as it is difficult to control and inconsistent in collecting larger numbers of macroinvertebrates needed for bioassessment. Multiplate samplers will not be used as they also collect large numbers of macroinvertebrates inconsistently.

In summer 2004, SRBC staff will be sampling a larger portion of the mainstem Susquehanna River and its large tributaries: West Branch Susquehanna; Chemung; and Juniata Rivers. Twenty sites on the mainstem Susquehanna River from Sidney, N.Y., to Marietta, Pa., and one site at the mouth of each of the larger tributaries will be sampled using the methods described above. Staff also will be considering different ways to assess habitat in conjunction with the sampling effort. Additionally, SRBC is interested in determining a sampling protocol for the reservoir system, which encompasses the final 45 miles of the river.

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.

Brown, A.V. and P.P. Brussock. 1991. Comparisons of benthic invertebrates between riffles and pools. Hydrobiologia, 220: 99-108.

Brown, A.V., M.D. Schram, and P.P. Brussock. 1987. A vacuum benthos sampler suitable for diverse habitats. Hydrobiologia, 153: 241-247.

Cooper, S.D. and L.A. Barmuta. 1993. Field Experiments in Biomonitoring. In Freshwater Biomonitoring and Benthic Macroinvertebrates. Ed. by D.M. Rosenbert and V.H. Resh. Chapman and Hall, N.Y. 488 pp.

Doisy, K.E. and C.F. Rabeni. 2001. Flow conditions, benthic food resources, and invertebrate community composition in a low-gradient stream in Missouri. J. N. Am. Benthol. Soc, 20(1): 17-32.

Flotemersch, J.E., B.C. Autrey, and S.M. Cormier. 2001a. Comparisons of Boating and Wading Methods Used to Assess the Status of Flowing Waters. EPA/600/R-00/108. U.S. Environmental Protection Agency, Cincinnati, OH.

Flotemersch, J.E., B.C. Autrey, and S.M. Cormier (editors). 2001b. Logistics of Ecological Sampling on Large Rivers. EPA/600/R-00/109. U.S. Environmental Protection Agency, Cincinnati, OH.

Gale, W.F. and J.D. Thompson. 1975. A suction sampler for quantitatively sampling benthos on rocky substrates in rivers. Trans. Amer. Fish. Soc., pp. 398-405.

Hall, L.W., Jr. and others. 1999. Pilot Study to Develop Assessment Methods and Biological Indicators for Tidal Streams in Maryland's Coastal Plain. Chesapeake Bay and Watershed Programs, Monitoring and Non-Tidal Assessment, State of Maryland, Department of Natural Resources, CBWP-MANTA-EA-99-1.

Karr, J.R. 1999. Defining and measuring river health. Freshwater Biology 41:221-234.

Kay, W.R., and others. 1999. Patterns of distribution of macroinvertebrate families in rivers of north-western Australia. Freshwater Biology 41: 299-316.

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. EPA/600/4-90/030. U.S. Environmental Protection Agency, Office of Research and Development, Cincinnati, Ohio.

LeFevre, S.R. 2003. West Branch Susquehanna Subbasin Survey: A Water Quality and Biological Assessment, July – November 2002. Publication 226. Susquehanna River Basin Commission, Harrisburg, Pennsylvania.

LeFevre, S.R. and D.L. Sitlinger. 2003. Assessment of Interstate Streams in the Susquehanna River Basin: Monitoring Report No. 16, July 1, 2001, through June 30, 2002. Publication . Susquehanna River Basin Commission, Harrisburg, Pennsylvania.

Merritt, R.W., K. W. Cummins, and V.H. Resh. 1996. Design of Aquatic Insect Studies: Collecting, Sampling and Rearing Procedures. In: An Introduction to the Aquatic Insects of North America, 3rd ed. Ed. by R.W. Merritt and K.W. Cummins. Kendall/Hunt Publishing Company, Dubuque, Iowa.

Norris, R.H. and M.C. Thoms. 1999. What is river health? Freshwater Biology, 41: 197-209.

Ohio Environmental Protection Agency. 1987. Biological Criteria for the Protection of Aquatic Life: Volumes I – III. Ohio Environmental Protection Agency, Columbus, Ohio.

Parsons, M. and R.H. Norris. 1996. The effect of habitat-specific sampling on biological assessment of water quality using a predictive model. Freshwater Biology, 36: 419-434.

Plafkin, J.L., M.T. Barbour, D.P. Kimberly, S.K. Gross, and R.M. Hughes. 1989. Rapid Bioassessment Protocols for Use in Streams and Rivers: Benthic Macroinvertebrates and Fish. Washington, D.C., U.S. Environmental Protection Agency, Office of Water, EPA/440/4-89/001.

Resh, V.H. and E.P. McElravy. 1993. Contemporary Quantitative Approaches to Biomonitoring Using Benthic Macroinvertebrates. In Freshwater Biomonitoring and Benthic Macroinvertebrates. Ed. by D.M. Rosenbert and V.H. Resh. Chapman and Hall, N.Y. 488 pp.

Resh, V.H. and J.K. Jackson. 1993. Rapid Assessment Approaches to Biomonitoring Using Benthic Macroinvertebrates. In Freshwater Biomonitoring and Benthic Macroinvertebrates. Ed. by D.M. Rosenbert and V.H. Resh. Chapman and Hall, N.Y. 488 pp.

Stoe, T.W. 1999. Upper Susquehanna Subbasin: A Water Quality and Biological Assessment. Publication 203. Susquehanna River Basin Commission, Harrisburg, Pennsylvania.

Stribling, J.B. and others. 1998. Development of a Benthic Index of Biotic Integrity for Maryland Streams. Chesapeake Bay and Watershed Programs, Monitoring and Non-Tidal Assessment, State of Maryland, Department of Natural Resources, CBWP-MANTA-EA-98-3.

Thorp, J.H. 1992. Linkage between island and benthos in the Ohio River, with implications for riverine management. Can. J. Aquat. Sci. 49: 1873-1882.

United States Geological Survey. Methods for Collecting Benthic Invertebrate Samples as part of the National Water Quality Assessment Program. Open File Report 93-406. http://water.usgs.gov/nawqa/protocols/OFR-93-406/inv1.html

Wood, A.J., J.M. Omernick, D.D. Brown, and C.W. Killsguard. 1996. Level III and IV Ecoregions of Pennsylvania and the Blue Ridge Mountains, the Ridge and Valley, and the Central Appalachians of Virginia, West Virginia, and Maryland. U.S. Environmental Protection Agency, EPA/600/R-96/077, Digital Coverage.

APPENDIX A

WATER QUALITY DATA FOR LARGE RIVER ASSESSMENT SITES ON THE SUSQUEHANNA RIVER

Parameter	Units	SUSQ 1	SUSQ 2	SUSQ 3	SUSQ 4	SUSQ 5	SUSQ 6	SUSQ 7	SUSQ 10
Date	yyyymmdd	20020923	20020923	20020924	20020924	20020925	20020925	20020925	20020926
Time	hhmm	1415	1810	1115	1700	1100	1505	1750	1345
Temperature	degrees C	20.1	20.4	18.9	20.6	17.8	19.0	19.0	18.2
Conductance	umhos/cm	270	239	235	226	250	249	234	269
Dissolved Oxygen	mg/l	6.4	5.91	60.9	6.49	6.72	7.06	6.80	6.74
pH	S.U.	8.0	7.8	7.8	7.7	7.3	7.5	7.3	7.6
Alkalinity	mg/l	88	74	72	70	78	82	70	84
Acidity	mg/l	6	8	8	2	8	6	8	6
Total Suspended Solids	mg/l	18	8	6	6	<2	10	14	20
Total Nitrogen	mg/l	0.66	0.6	0.63	0.61	0.63	0.86	1.01	1.01
Total Ammonia	mg/l	0.1	0.09	0.08	0.13	0.23	0.29	0.28	.024
Total Nitrite	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01
Total Nitrate	mg/l	0.49	0.42	0.39	0.45	0.42	0.47	0.44	0.49
Total Phosphorus	mg/l	0.02	0.03	0.03	0.028	0.22	0.059	0.064	0.061
Total Orthophosphate	mg/l	<0.01	0.012	0.012	0.013	0.11	0.018	0.019	0.019
Total Organic Carbon	mg/l	2.1	2.2	2.4	2.4	2.4	4.7	4.5	4.2
Total Hardness	mg/l	107	91	94	95	103	94	90	106
Total Magnesium	mg/l	4.68	4.12	4.02	3.82	4.12	4.22	4.17	5.18
Total Calcium	mg/l	35.1	29.6	30.8	31.6	24.5	30.5	29.2	34.0
Total Sodium	mg/l	11.1	9.58	9.8	9.6	11.0	11.0	12.5	15.1
Total Potassium	mg/l	1.35	1.22	1.1	1.41	1.3	1.48	1.88	1.88
Total Chloride	mg/l	21	18.7	17.9	18.2	21.1	20.4	22.1	25.0
Total Sulfate	mg/l	14.6	14	13.9	13.8	14.4	13.3	13.1	13.6
Total Fluoride	mg/l	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Total Copper	µg/l	<4	<4	<4	<4	<4	<4	<4	<4
Total Iron	µg/l	134	239	245	149	25	258	255	234
Total Lead	µg/l	<1	<1	<1	<1	<1	<1	<1	<1
Total Manganese	µg/l	31	43	41	26	32	35	24	45
Total Nickel	µg/l	<4	<4	<4	<4	<4	<4	<4	<4
Total Zinc	µg/l	<5	<5	<5	<5	<5	<5	<5	<5
Total Aluminum	µg/l	47	96	90	76	96	128	128	119

APPENDIX B

RAW MACROINVERTEBRATE DATA FOR LARGE RIVER SAMPLING SITES

Order	Family	Genus	SUSQ 1										
			1HD1	1HD2	1HD3	1RBP1	1RBP2	1RBP3	1RBP4	1RBP5	1RS1	1RS2	1RS3
Coleoptera	**Elmidae**	*Dibiraphia*											
		Macronychus	1		1								
		Optioservus		2		19	32	13	16	21	1		
		Promoresia				1					5		7
		Stenelmis	2			33	27	25	83	67	4	1	6
	Hydrophilidae	*Berosus*											
	Psephenidae	*Psephenus*				10	1	1		2	12	4	1
Diptera	**Athericidae**	*Atherix*											
	Ceratopogonidae	*Probezzia*											
		Stilobezzia											
	Chironomidae		2	18	6	15	15	9	11	8	6	9	18
	Empididae	*Hemerodromia*	1	3		3	6	3		2			1
	Simuliidae	*Simulium*		1		3		5	1			2	15
	Tipulidae	*Antocha*											
		Ormosia											
Ephemeroptera	**Baetidae**	*Acentrella*	3	2	3	2	5	7	4	4			
		Baetis	5	6	13	16	10	5	3	5	3	11	11
		Centroptilum											
		Heterocloeon											
	Caenidae	*Caenis*											
	Ephemerellidae	*Ephemerella*											
		Serratella		15	1	1	2	13	8	10		17	41
	Ephemeridae	*Hexagenia*											
	Heptageniidae	*Leucrocuta*	5			2					3	2	
		Stenacron											
		Stenonema	5	17	10	14	14	24	11	13	21	32	12
	Isonychidae	*Isonychia*	2	28	6	16	9	20	15	9	5	17	5
	Leptophlebiidae	*Leptophlebia*											
		Paraleptophlebia											
	Polymitarcyidae	*Ephoron*											
	Potamanthidae	*Potamanthus*				3	1	1	2	6	1	1	
	Siphlonuridae	*Siphlonisca*											
		Siphlonorus											
	Tricorythidae	*Tricorythodes*			2						4	3	1
Lepidoptera	**Pyralidae**	*Petrophila*						1					
Megaloptera	**Corydalidae**	*Corydalus*				6	2	6	4	6			
	Sialidae	*Sialis*											

Order	Family	Genus	SUSQ 1										
			1HD1	1HD2	1HD3	1RBP1	1RBP2	1RBP3	1RBP4	1RBP5	1RS1	1RS2	1RS3
Odonata	Calopterygidae	*Enallagma*											
	Coenagrionidae	*Argia*				2				1	1		
	Corduliidae	*Didymops*											
		Neurocordulia											
	Gomphidae	*Ophiogomphus*											
		Stylogomphus											
Plecoptera	Perlidae	*Acroneuria*				5		2	1	2	1		
		Agnetina	6	3	6						1	3	1
		Neoperla											
		Paragnetina			1								
	Pteronarciidae	*Pteronarcys*											
Trichoptera	Brachycentridae	*Brachycentrus*		1								1	1
	Glossosomatidae	*Glossosoma*										1	2
	Helicopsychidae	*Helicopsyche*									1		1
	Hydropsychidae	*Ceratopsyche*		42		14	20	31	7	8		21	26
		Cheumatopsyche		3		10	5	14	10	7	5		9
		Hydropsyche		46	1	5	10	8	4	7	9	18	39
		Macrostemum				3			1	5			
		Parapsyche											
	Hydroptilidae	*Dibusa*											
		Hydroptila											
	Leptoceridae	*Ceraclea*											
		Mystacides											
		Oecetis	1										1
		Triaenodes											
	Philopotamidae	*Chimarra*	2	29	2	81	67	86	97	61		9	37
	Polycentropodidae	*Crynellus*											
		Neureclipsis											
		Polycentropus	3								5	6	
	Psychomyiidae	*Psychomyia*											
	Rhyacophilidae	*Rhyacophila*											
	Uenoidae										15		
Amphipoda	Gammaridae	*Gammarus*	4			1					8	1	
	Haustoriidae	*Pontoporeia*											
Isopoda	Asellidae	*Lirceus*											
Collembola	Poduridae	*Podura*											
Decapoda	Cambaridae	*Orconectes*											

Order	Family	Genus	SUSQ 1										
			1HD1	1HD2	1HD3	1RBP1	1RBP2	1RBP3	1RBP4	1RBP5	1RS1	1RS2	1RS3
Gastropoda	**Ancylidae**	*Ferrissia*						2				2	
	Hydrobiidae	*Amnicola*											
	Physidae	*Physa*									1		
	Planorbidae	*Gyralus*											
	Pleuroceridae	*Leptotoxis*	2		3	23	6	7	4	8	54	19	
Gnathobdellida	**Huridinidae**	*Helobdella*											
Oligochaeta	**Lumbriculidae**												
	Naididae												
Pelecypoda	**Corbiculidae**	*Corbicula*											
	Sphaeriidae	*Psidium*											
Turbellaria	**Planaridae**	*Dugesia*			4							2	

Order	Family	Genus	SUSQ 1							SUSQ 2			
			1RS4	1RS5	1VBS1	1VBS2	1VBS3	1VBS4	1VBS5	2HD1	2HD2	2HD3	2RBP5
Coleoptera	**Elmidae**	*Dibiraphia*			9								
		Macronychus									1		
		Optioservus			19	31	47	44	64				1
		Promoresia	2	1		2	3	2	1		1		
		Stenelmis	2	2	62	54	54	93	38		1	1	23
	Hydrophilidae	*Berosus*											
	Psephenidae	*Psephenus*		1	54	1	7	1	4				10
Diptera	**Athericidae**	*Atherix*											
	Ceratopogonidae	*Probezzia*											
		Stilobezzia			1	1							
	Chironomidae		32	12	7	7	4	14	7	150	45	128	8
	Empididae	*Hemerodromia*	2				1	2	2				
	Simuliidae	*Simulium*	9	5		1				1			
	Tipulidae	*Antocha*							1				
		Ormosia											
Ephemeroptera	**Baetidae**	*Acentrella*	2	4				1					
		Baetis	6	26		2	1	1	2	3			1
		Centroptilum											
		Heterocloeon											
	Caenidae	*Caenis*			1								25
	Ephemerellidae	*Ephemerella*											
		Serratella	30	13		1		5			2		
	Ephemeridae	*Hexagenia*											
	Heptageniidae	*Leucrocuta*		3		1	2	5	4				
		Stenacron								13	1	31	67
		Stenonema	7	48	5	20	12	19	17	38	47	23	7
	Isonychidae	*Isonychia*	9	46		4	3	13	2	2	14		
	Leptophlebiidae	*Leptophlebia*											
		Paraleptophlebia											12
	Polymitarcyidae	*Ephoron*			1								
	Potamanthidae	*Potamanthus*			17	52	80	11	33				
	Siphlonuridae	*Siphlonisca*											
		Siphlonorus										1	10
	Tricorythidae	*Tricorythodes*		4	3	1				1	1	1	
Lepidoptera	**Pyralidae**	*Petrophila*											
Megaloptera	**Corydalidae**	*Corydalus*									1		
	Sialidae	*Sialis*											1

Order	Family	Genus	SUSQ 1							SUSQ 2			
			1RS4	1RS5	1VBS1	1VBS2	1VBS3	1VBS4	1VBS5	2HD1	2HD2	2HD3	2RBP5
Odonata	Calopterygidae	*Enallagma*											
	Coenagrionidae	*Argia*				2						1	3
	Corduliidae	*Didymops*											
		Neurocordulia											
	Gomphidae	*Ophiogomphus*			1								
		Stylogomphus											
Plecoptera	Perlidae	*Acroneuria*	2	1		1		1	1		1		
		Agnetina	1	7	1	4	3	3	2				3
		Neoperla											
		Paragnetina											
	Pteronarciidae	*Pteronarcys*											
Trichoptera	Brachycentridae	*Brachycentrus*				1							
	Glossosomatidae	*Glossosoma*		2		14	15	6	25		2		
	Helicopsychidae	*Helicopsyche*			1				1				
	Hydropsychidae	*Ceratopsyche*	46	1		5							
		Cheumatopsyche	2	4		5	1	7	3	40	124	5	
		Hydropsyche	41	5		14	1	5	1	1	9	1	1
		Macrostemum				1		1					
		Parapsyche			1								
	Hydroptilidae	*Dibusa*							2				
		Hydroptila											
	Leptoceridae	*Ceraclea*			1								
		Mystacides											
		Oecetis			1					1	2	1	
		Triaenodes											
	Philopotamidae	*Chimarra*	64	5		3		6					3
	Polycentropodidae	*Crynellus*								27	23	5	
		Neureclipsis											
		Polycentropus								6	3		
	Psychomyiidae	*Psychomyia*											2
	Rhyacophilidae	*Rhyacophila*											
	Uenoidae	*Neophylax*		1									
Amphipoda	Gammaridae	*Gammarus*		3	7	1		2	2	2		1	26
	Haustoriidae	*Pontoporeia*								8		7	5
Isopoda	Asellidae	*Lirceus*											
Collembola	Poduridae	*Podura*											
Decapoda	Cambaridae	*Orconectes*											1

Order	Family	Genus	SUSQ 1							SUSQ 2			
			1RS4	1RS5	1VBS1	1VBS2	1VBS3	1VBS4	1VBS5	2HD1	2HD2	2HD3	2RBP5
Gastropoda	**Ancylidae**	*Ferrissia*							1	1		2	6
	Hydrobiidae	*Amnicola*											
	Physidae	*Physa*		1									
	Planorbidae	*Gyralus*											
	Pleuroceridae	*Leptotoxis*	1	8	2	1	1	2	1				
Gnathobdellida	**Huridinidae**	*Helobdella*											
Oligochaeta	**Lumbriculidae**					5	11	5	12				
	Naididae												
Pelecypoda	**Corbiculidae**	*Corbicula*				2			2				
	Sphaeriidae	*Psidium*			3								
Turbellaria	**Planaridae**	*Dugesia*	2									3	

Order	Family	Genus	SUSQ 3										
			3RBP1	3RBP3	3RS1	3RS2	3RS3	3RS4	3RS5	3VBS1	3VBS2	3VBS3	3VBS4
Coleoptera	**Elmidae**	*Dibiraphia*	21	32	2		1			6		52	24
		Macronychus											
		Optioservus	2	15						1	27		9
		Promoresia								1			3
		Stenelmis	27	43	3		5	8		21	45	14	75
	Hydrophilidae	*Berosus*										1	2
	Psephenidae	*Psephenus*	4	1	18	2		53	30				
Diptera	**Athericidae**	*Atherix*											
	Ceratopogonidae	*Probezzia*								11	1		1
		Stilobezzia											
	Chironomidae		29	16	91	51	113	18	77	18	41	44	43
	Empididae	*Hemerodromia*											
	Simuliidae	*Simulium*			4	11	9	1	14				
	Tipulidae	*Antocha*											
		Ormosia											
Ephemeroptera	**Baetidae**	*Acentrella*									1		
		Baetis	36	1	4	38	4	2	16				
		Centroptilum											
		Heterocloeon											
	Caenidae	*Caenis*	24	5									1
	Ephemerellidae	*Ephemerella*			5	2	3		8				
		Serratella						1					
	Ephemeridae	*Hexagenia*										2	1
	Heptageniidae	*Leucrocuta*			1	1	1		2				
		Stenacron	1	2	20	17	10	29	3	1			
		Stenonema	1	6	34	51	14	25	32		2		
	Isonychidae	*Isonychia*			10	8		2	14				
	Leptophlebiidae	*Leptophlebia*		2	1					1			1
		Paraleptophlebia	1	1									
	Polymitarcyidae	*Ephoron*											
	Potamanthidae	*Potamanthus*	1	87	1	1	4			17	105	45	27
	Siphlonuridae	*Siphlonisca*	28	2	1	2	7						
		Siphlonorus											
	Tricorythidae	*Tricorythodes*		1		1	1	1					2
Lepidoptera	**Pyralidae**	*Petrophila*											
Megaloptera	**Corydalidae**	*Corydalus*											
	Sialidae	*Sialis*											

Order	Family	Genus	SUSQ 3										
			3RBP1	3RBP3	3RS1	3RS2	3RS3	3RS4	3RS5	3VBS1	3VBS2	3VBS3	3VBS4
Odonata	**Calopterygidae**	*Enallagma*					4					1	
	Coenagrionidae	*Argia*	3		2	1	5	4					
	Corduliidae	*Didymops*						1					
		Neurocordulia			1			1					
	Gomphidae	*Ophiogomphus*											
		Stylogomphus											
Plecoptera	**Perlidae**	*Acroneuria*				1							
		Agnetina		1	1	5	1		3	1	5		
		Neoperla											
		Paragnetina											
	Pteronarciidae	*Pteronarcys*											
Trichoptera	**Brachycentridae**	*Brachycentrus*				4	3	2	1				2
	Glossosomatidae	*Glossosoma*				1							
	Helicopsychidae	*Helicopsyche*											
	Hydropsychidae	*Ceratopsyche*				1							
		Cheumatopsyche	2		12	8	1	8	43				
		Hydropsyche			5	2	4		8				
		Macrostemum											
		Parapsyche											
	Hydroptilidae	*Dibusa*											
		Hydroptila											
	Leptoceridae	*Ceraclea*						1					
		Mystacides		2			1	1	1				1
		Oecetis											1
		Triaenodes		2	2	2	12	7		1	1	1	
	Philopotamidae	*Chimarra*					3	1		1			12
	Polycentropodidae	*Crynellus*											
		Neureclipsis	3		87	6	24	10	20	1		2	
		Polycentropus											
	Psychomyiidae	*Psychomyia*			9	2	6	2	1				
	Rhyacophilidae	*Rhyacophila*											
	Uenoidae	*Neophylax*											
Amphipoda	**Gammaridae**	*Gammarus*	20	4	3		10	26	9			11	10
	Haustoriidae	*Pontoporeia*											
Isopoda	**Asellidae**	*Lirceus*											
Collembola	**Poduridae**	*Podura*	1	1	6			2	2				
Decapoda	**Cambaridae**	*Orconectes*						1					

Order	Family	Genus	SUSQ 3										
			3RBP1	3RBP3	3RS1	3RS2	3RS3	3RS4	3RS5	3VBS1	3VBS2	3VBS3	3VBS4
Gastropoda	**Ancylidae**	*Ferrissia*	1	2	2	2	2	2	1			2	1
	Hydrobiidae	*Amnicola*				3			1				
	Physidae	*Physa*	1				2	1				1	1
	Planorbidae	*Gyralus*		3			8	20			1	4	14
	Pleuroceridae	*Leptotoxis*											
Gnathobdellida	**Huridinidae**	*Helobdella*		1									
Oligochaeta	**Lumbriculidae**			18						4	3	1	18
	Naididae												
Pelecypoda	**Corbiculidae**	*Corbicula*	6	11						1	5		3
	Sphaeriidae	*Psidium*											
Turbellaria	**Planaridae**	*Dugesia*		1	1	3		21	4				5

Order	Family	Genus	SUSQ 3	SUSQ 4									
			3VBS5	4HD1	4HD2	4HD3	4RBP1	4RBP5	4RS1	4RS2	4RS3	4RS4	4RS5
Coleoptera	**Elmidae**	*Dibiraphia*	4					1					
		Macronychus											
		Optioservus					5	44				1	
		Promoresia	2										
		Stenelmis	62		1	2	21	105	9	3	1		
	Hydrophilidae	*Berosus*					4						
	Psephenidae	*Psephenus*						2	4	3	2	1	2
Diptera	**Athericidae**	*Atherix*											
	Ceratopogonidae	*Probezzia*	1		1								
		Stilobezzia											
	Chironomidae		85	47	120	79	14	27	20	77	91	59	151
	Empididae	*Hemerodromia*		1	1								
	Simuliidae	*Simulium*		19	33				48	69	63	130	69
	Tipulidae	*Antocha*											
		Ormosia					5						
Ephemeroptera	**Baetidae**	*Acentrella*		1			1	2	1	2	1	1	4
		Baetis		9	4			3	10	19	5	7	17
		Centroptilum				1				1	1		
		Heterocloeon				1							2
	Caenidae	*Caenis*	1	1									
	Ephemerellidae	*Ephemerella*		4	15	12			4	6	8	8	8
		Serratella											
	Ephemeridae	*Hexagenia*											
	Heptageniidae	*Leucrocuta*				1							
		Stenacron	1			4			5	1	1		
		Stenonema	5	31	21	57			27	28	51	19	21
	Isonychidae	*Isonychia*		36	35	34			24	13	6	23	5
	Leptophlebiidae	*Leptophlebia*											
		Paraleptophlebia											
	Polymitarcyidae	*Ephoron*											
	Potamanthidae	*Potamanthus*	39	1		1	5	1		3	3	2	1
	Siphlonuridae	*Siphlonisca*											
		Siphlonorus				1	8	1					
	Tricorythidae	*Tricorythodes*	1	3		2	1			1	1		1
Lepidoptera	**Pyralidae**	*Petrophila*											
Megaloptera	**Corydalidae**	*Corydalus*											
	Sialidae	*Sialis*	1										

Order	Family	Genus	SUSQ 3	SUSQ 4									
			3VBS5	4HD1	4HD2	4HD3	4RBP1	4RBP5	4RS1	4RS2	4RS3	4RS4	4RS5
Odonata	**Calopterygidae**	*Enallagma*				3	6						
	Coenagrionidae	*Argia*		2				1	3		1	1	2
	Corduliidae	*Didymops*											
		Neurocordulia											
	Gomphidae	*Ophiogomphus*											
		Stylogomphus											
Plecoptera	**Perlidae**	*Acroneuria*											
		Agnetina			5	1			2	1			
		Neoperla											
		Paragnetina											
	Pteronarciidae	*Pteronarcys*											
Trichoptera	**Brachycentridae**	*Brachycentrus*									1		1
	Glossosomatidae	*Glossosoma*											
	Helicopsychidae	*Helicopsyche*											
	Hydropsychidae	*Ceratopsyche*		14	15	7			1	11	5	3	8
		Cheumatopsyche	5	45	7	28			22	24	5	6	21
		Hydropsyche	9	23	11	4			16	12	13	6	14
		Macrostemum											
		Parapsyche											
	Hydroptilidae	*Dibusa*											
		Hydroptila											
	Leptoceridae	*Ceraclea*								1			
		Mystacides											
		Oecetis	1					1	2	1		1	
		Triaenodes	2		1								
	Philopotamidae	*Chimarra*		66	29	28	3		5	12	9	1	13
	Polycentropodidae	*Crynellus*	5	11	1	3			38	17	8	9	11
		Neureclipsis											
		Polycentropus	1						1				
	Psychomyiidae	*Psychomyia*											
	Rhyacophilidae	*Rhyacophila*											
	Uenoidae	*Neophylax*											
Amphipoda	**Gammaridae**	*Gammarus*	4	2	1	5	8	6				1	2
	Haustoriidae	*Pontoporeia*											
Isopoda	**Asellidae**	*Lirceus*											
Collembola	**Poduridae**	*Podura*									1	1	
Decapoda	**Cambaridae**	*Orconectes*											

Order	Family	Genus	SUSQ 3	SUSQ 4									
			3VBS5	4HD1	4HD2	4HD3	4RBP1	4RBP5	4RS1	4RS2	4RS3	4RS4	4RS5
Gastropoda	**Ancylidae**	*Ferrissia*	3				1	3					1
	Hydrobiidae	*Amnicola*						1					
	Physidae	*Physa*				1	8						
	Planorbidae	*Gyralus*				1	2		1				
	Pleuroceridae	*Leptotoxis*											
Gnathobdellida	**Huridinidae**	*Helobdella*											
Oligochaeta	**Lumbriculidae**		6				32	6					
	Naididae												
Pelecypoda	**Corbiculidae**	*Corbicula*	2				8	24	1		2		
	Sphaeriidae	*Psidium*											
Turbellaria	**Planaridae**	*Dugesia*					1						

Order	Family	Genus	SUSQ 4	SUSQ 5								SUSQ 6	
			4VBS5	5HD1	5HD2	5RBP1	5RBP5	5RS1	5RS2	5RS3	5RS4	6HD1	6HD2
Coleoptera	**Elmidae**	*Dibiraphia*				5							
		Macronychus											
		Optioservus	8			8	8						2
		Promoresia						1	3		1		
		Stenelmis	78			54	62	1	7				
	Hydrophilidae	*Berosus*											
	Psephenidae	*Psephenus*	2			5	7				1		
Diptera	**Athericidae**	*Atherix*											
	Ceratopogonidae	*Probezzia*											
		Stilobezzia											
	Chironomidae		27	17	55	11	26	18	88	73	9	218	10
	Empididae	*Hemerodromia*											
	Simuliidae	*Simulium*		24				40	7	7	52		
	Tipulidae	*Antocha*											
		Ormosia											
Ephemeroptera	**Baetidae**	*Acentrella*	3					2	2		2		
		Baetis		7	3	10		2	4	8	10		
		Centroptilum											
		Heterocloeon						1					
	Caenidae	*Caenis*	1										
	Ephemerellidae	*Ephemerella*		67	71			31	29	43	8		
		Serratella											
	Ephemeridae	*Hexagenia*											
	Heptageniidae	*Leucrocuta*							3	3			
		Stenacron				9	5						
		Stenonema	10	8	13	2		2	16	12	7		5
	Isonychidae	*Isonychia*	3	24	28			5	22	2	24		
	Leptophlebiidae	*Leptophlebia*						1					
		Paraleptophlebia				1	1						
	Polymitarcyidae	*Ephoron*											
	Potamanthidae	*Potamanthus*	134			7	5		5		1		
	Siphlonuridae	*Siphlonisca*	1					1					
		Siphlonorus											
	Tricorythidae	*Tricorythodes*			1			3	16	5	12		1
Lepidoptera	**Pyralidae**	*Petrophila*											
Megaloptera	**Corydalidae**	*Corydalus*											
	Sialidae	*Sialis*											

| Order | Family | Genus | SUSQ 4 | SUSQ 5 | | | | | | | | SUSQ 6 | |
			4VBS5	5HD1	5HD2	5RBP1	5RBP5	5RS1	5RS2	5RS3	5RS4	6HD1	6HD2
Odonata	**Calopterygidae**	*Enallagma*						1					
	Coenagrionidae	*Argia*	1			15	1						1
	Corduliidae	*Didymops*											
		Neurocordulia											
	Gomphidae	*Ophiogomphus*											
		Stylogomphus				1							
Plecoptera	**Perlidae**	*Acroneuria*								1			
		Agnetina	1	3				1	2		1		10
		Neoperla					1						
		Paragnetina											
	Pteronarciidae	*Pteronarcys*											
Trichoptera	**Brachycentridae**	*Brachycentrus*			1				2				
	Glossosomatidae	*Glossosoma*											
	Helicopsychidae	*Helicopsyche*											
	Hydropsychidae	*Ceratopsyche*		58	32	1		26		20			
		Cheumatopsyche		17	8			7	13	21	4	1	9
		Hydropsyche	1	22	39			84	12	41	14		2
		Macrostemum		1	1								
		Parapsyche											
	Hydroptilidae	*Dibusa*											
		Hydroptila											
	Leptoceridae	*Ceraclea*											
		Mystacides											
		Oecetis	1						2				
		Triaenodes											
	Philopotamidae	*Chimarra*	1	4									2
	Polycentropodidae	*Crynellus*			5				2	1			
		Neureclipsis											
		Polycentropus											
	Psychomyiidae	*Psychomyia*											
	Rhyacophilidae	*Rhyacophila*											
	Uenoidae	*Neophylax*											
Amphipoda	**Gammaridae**	*Gammarus*	2			3	8		2		1	1	
	Haustoriidae	*Pontoporeia*											
Isopoda	**Asellidae**	*Lirceus*											
Collembola	**Poduridae**	*Podura*											
Decapoda	**Cambaridae**	*Orconectes*											

Order	Family	Genus	SUSQ 4	SUSQ 5								SUSQ 6	
			4VBS5	5HD1	5HD2	5RBP1	5RBP5	5RS1	5RS2	5RS3	5RS4	6HD1	6HD2
Gastropoda	**Ancylidae**	*Ferrissia*	1							1	1		
	Hydrobiidae	*Amnicola*	1										
	Physidae	*Physa*										1	1
	Planorbidae	*Gyralus*	1								1		
	Pleuroceridae	*Leptotoxis*									1		
Gnathobdellida	**Huridinidae**	*Helobdella*		3									3
Oligochaeta	**Lumbriculidae**												
	Naididae					31	94						
Pelecypoda	**Corbiculidae**	*Corbicula*											
	Sphaeriidae	*Psidium*				7							
Turbellaria	**Planaridae**	*Dugesia*							5	6	5		

Order	Family	Genus	SUSQ 6								SUSQ 7		
			6HD3	6RBP3	6RS1	6RS3	6RS4	6RS5	6VBS4	6VBS5	7HD3	7RBP1	7RBP5
Coleoptera	**Elmidae**	*Dibiraphia*							4	11			2
		Macronychus											
		Optioservus	1	23				3	21	11	1	6	13
		Promoresia	1	1									
		Stenelmis	3	97		4	3	5	81	26	1	64	49
	Hydrophilidae	*Berosus*									1	17	2
	Psephenidae	*Psephenus*	1			1			1			1	
Diptera	**Athericidae**	*Atherix*											
	Ceratopogonidae	*Probezzia*											
		Stilobezzia											
	Chironomidae		66	38	243	89	57	41	88	51	95	70	25
	Empididae	*Hemerodromia*							1				
	Simuliidae	*Simulium*	14		1	38	28	31			1		9
	Tipulidae	*Antocha*								1			
		Ormosia											
Ephemeroptera	**Baetidae**	*Acentrella*	2										
		Baetis	5	5		2	1	2	1	1		4	9
		Centroptilum											
		Heterocloeon				1							5
	Caenidae	*Caenis*	1										
	Ephemerellidae	*Ephemerella*	2	2									
		Serratella				8	31	13	2				
	Ephemeridae	*Hexagenia*											
	Heptageniidae	*Leucrocuta*		2	1				9				
		Stenacron		3					1	1		1	
		Stenonema	37	32	1	5	24	47	18	5			3
	Isonychidae	*Isonychia*	33	8		5	31	24	6		1		1
	Leptophlebiidae	*Leptophlebia*											
		Paraleptophlebia											
	Polymitarcyidae	*Ephoron*											
	Potamanthidae	*Potamanthus*		36		1	1	1	38	19			10
	Siphlonuridae	*Siphlonisca*											
		Siphlonorus											
	Tricorythidae	*Tricorythodes*	6		1	8		9	4		1	1	9
Lepidoptera	**Pyralidae**	*Petrophila*							2				
Megaloptera	**Corydalidae**	*Corydalus*											
	Sialidae	*Sialis*											

Order	Family	Genus	SUSQ 6								SUSQ 7		
			6HD3	6RBP3	6RS1	6RS3	6RS4	6RS5	6VBS4	6VBS5	7HD3	7RBP1	7RBP5
Odonata	**Calopterygidae**	*Enallagma*											
	Coenagrionidae	*Argia*		3	1	1		2		1		4	6
	Corduliidae	*Didymops*											
		Neurocordulia											
	Gomphidae	*Ophiogomphus*											
		Stylogomphus											
Plecoptera	**Perlidae**	*Acroneuria*											
		Agnetina	6	1		1	3	3					
		Neoperla											
		Paragnetina											
	Pteronarciidae	*Pteronarcys*											
Trichoptera	**Brachycentridae**	*Brachycentrus*											
	Glossosomatidae	*Glossosoma*											
	Helicopsychidae	*Helicopsyche*											
	Hydropsychidae	*Ceratopsyche*					8	1	1		1		
		Cheumatopsyche	36	9	13	36	64	26	12	2	97		10
		Hydropsyche				12	17	5	2	1	18		
		Macrostemum					4				1		
		Parapsyche											
	Hydroptilidae	*Dibusa*											
		Hydroptila											
	Leptoceridae	*Ceraclea*											
		Mystacides											
		Oecetis	1	3				5		2			
		Triaenodes											
	Philopotamidae	*Chimarra*	2	6		1	5		2			1	
	Polycentropodidae	*Crynellus*											
		Neureclipsis											
		Polycentropus			1								
	Psychomyiidae	*Psychomyia*											
	Rhyacophilidae	*Rhyacophila*											
	Uenoidae	*Neophylax*											
Amphipoda	**Gammaridae**	*Gammarus*	5	2		4	2	5			24	2	43
	Haustoriidae	*Pontoporeia*											
Isopoda	**Asellidae**	*Lirceus*									1		
Collembola	**Poduridae**	*Podura*									1		
Decapoda	**Cambaridae**	*Orconectes*							1				

Order	Family	Genus	SUSQ 6								SUSQ 7		
			6HD3	6RBP3	6RS1	6RS3	6RS4	6RS5	6VBS4	6VBS5	7HD3	7RBP1	7RBP5
Gastropoda	**Ancylidae**	*Ferrissia*				2		2		2			
	Hydrobiidae	*Amnicola*											
	Physidae	*Physa*						2			17	32	3
	Planorbidae	*Gyralus*										1	
	Pleuroceridae	*Leptotoxis*										5	3
Gnathobdellida	**Huridinidae**	*Helobdella*		1		7	15	2			6	4	
Oligochaeta	**Lumbriculidae**											13	
	Naididae			4			1		4			4	3
Pelecypoda	**Corbiculidae**	*Corbicula*											
	Sphaeriidae	*Psidium*		12			2		3	1	1	6	7
Turbellaria	**Planaridae**	*Dugesia*	2										

Order	Family	Genus	SUSQ 7	SUSQ 10					
			7RS5	10HD2	10HD3	10RS1	10RS2	10RS3	10RS5
Coleoptera	**Elmidae**	*Dibiraphia*							
		Macronychus							
		Optioservus				1	1		2
		Promoresia							
		Stenelmis	4			1	8	1	
	Hydrophilidae	*Berosus*				2			23
	Psephenidae	*Psephenus*	7			1		1	1
Diptera	**Athericidae**	*Atherix*							
	Ceratopogonidae	*Probezzia*							
		Stilobezzia							
	Chironomidae		71	50	4	87	102	85	10
	Empididae	*Hemerodromia*		4				2	
	Simuliidae	*Simulium*	2	11		21	19	8	
	Tipulidae	*Antocha*		1					3
		Ormosia							
Ephemeroptera	**Baetidae**	*Acentrella*							
		Baetis		3		10	5	3	
		Centroptilum							
		Heterocloeon							
	Caenidae	*Caenis*	1			2	1	2	
	Ephemerellidae	*Ephemerella*							
		Serratella		10		2	5	2	1
	Ephemeridae	*Hexagenia*							
	Heptageniidae	*Leucrocuta*				2		3	
		Stenacron	2					3	
		Stenonema	1	31	1	18	22	15	7
	Isonychidae	*Isonychia*	3	9	1	4	10	4	
	Leptophlebiidae	*Leptophlebia*					1		
		Paraleptophlebia							
	Polymitarcyidae	*Ephoron*							
	Potamanthidae	*Potamanthus*				1	2	2	
	Siphlonuridae	*Siphlonisca*							
		Siphlonorus							
	Tricorythidae	*Tricorythodes*	14	5		55	29	20	7
Lepidoptera	**Pyralidae**	*Petrophila*		2			4	1	
Megaloptera	**Corydalidae**	*Corydalus*							
	Sialidae	*Sialis*							

Order	Family	Genus	SUSQ 7	SUSQ 10					
			7RS5	10HD2	10HD3	10RS1	10RS2	10RS3	10RS5
Odonata	**Calopterygidae**	*Enallagma*							
	Coenagrionidae	*Argia*	5			3			6
	Corduliidae	*Didymops*							
		Neurocordulia							
	Gomphidae	*Ophiogomphus*							
		Stylogomphus							
Plecoptera	**Perlidae**	*Acroneuria*							
		Agnetina		4		1		2	
		Neoperla							
		Paragnetina							
	Pteronarciidae	*Pteronarcys*							
Trichoptera	**Brachycentridae**	*Brachycentrus*							1
	Glossosomatidae	*Glossosoma*							
	Helicopsychidae	*Helicopsyche*							
	Hydropsychidae	*Ceratopsyche*	4	5				3	1
		Cheumatopsyche	82	56	1	7	56	59	11
		Hydropsyche	35	17		6	11	37	1
		Macrostemum		1					
		Parapsyche							
	Hydroptilidae	*Dibusa*							
		Hydroptila							
	Leptoceridae	*Ceraclea*						2	
		Mystacides							
		Oecetis				1			
		Triaenodes							
	Philopotamidae	*Chimarra*					1		
	Polycentropodidae	*Crynellus*							
		Neureclipsis		3				5	1
		Polycentropus					6		
	Psychomyiidae	*Psychomyia*							
	Rhyacophilidae	*Rhyacophila*							
	Uenoidae	*Neophylax*							
Amphipoda	**Gammaridae**	*Gammarus*	31		132	3			140
	Haustoriidae	*Pontoporeia*							
Isopoda	**Asellidae**	*Lirceus*							
Collembola	**Poduridae**	*Podura*	1						
Decapoda	**Cambaridae**	*Orconectes*							

Order	Family	Genus	SUSQ 6	SUSQ 10					
			7RS5	10HD2	10HD3	10RS1	10RS2	10RS3	10RS5
Gastropoda	**Ancylidae**	*Ferrissia*				3			1
	Hydrobiidae	*Amnicola*			9				
	Physidae	*Physa*	1						9
	Planorbidae	*Gyralus*	1						1
	Pleuroceridae	*Leptotoxis*					1		
Gnathobdellida	**Huridinidae**	*Helobdella*	11	1	2	1	6	7	20
Oligochaeta	**Lumbriculidae**								
	Naididae								
Pelecypoda	**Corbiculidae**	*Corbicula*							
	Sphaeriidae	*Psidium*							
Turbellaria	**Planaridae**	*Dugesia*			1				

APPENDIX C

SUMMARY OF ASSESSMENT DESIGNATIONS FOR LARGE RIVER SAMPLING SITES: IBI-TYPE, REFERENCE SITE AND REFERENCE CONDITIONS

Table C1. Summary of IBI-Type Analysis Biological Metric Scores and Designations

Metric Scores	SUSQ1											
	1HD1	**1HD2**	**1HD3**	**1RBP1**	**1RBP2**	**1RBP3**	**1RBP4**	**1RBP5**	**1RS1**	**1RS2**	**1RS3**	**1RS4**
Number of Individuals	44	216	59	288	232	283	282	252	166	182	236	260
Taxa Richness	15	15	14	24	17	21	18	20	22	22	21	18
Hilsenhoff Biotic Index	3.98	3.95	4.25	4.36	4.39	4.13	4.27	4.26	4.58	4.06	4	4.22
Percent Ephemeroptera	45.5	31.5	59.3	18.8	17.7	24.7	15.2	18.7	22.3	45.6	29.7	20.8
Percent Dominant Taxa	13.6	21.3	22	28.1	28.9	30.4	34.4	26.6	32.5	17.6	17.4	24.6
EPT Index	9	11	10	13	10	11	12	12	13	14	14	11
Percent Chironomidae	4.5	8.3	10.2	5.2	6.5	3.2	3.9	3.2	3.6	4.9	7.6	12.3
Shannon-Weiner Diversity Index	2.56	2.19	2.32	2.56	2.32	2.44	1.98	2.29	2.42	2.6	2.43	2.17
Biological Condition Scores												
Taxa Richness	3	3	0	6	3	3	3	3	3	3	3	3
Hilsenhoff Biotic Index	6	6	6	3	3	6	6	6	3	6	6	6
Percent Ephemeroptera	6	6	6	3	0	3	0	3	3	6	3	3
Percent Dominant Taxa	6	6	6	6	6	3	3	6	3	6	6	6
EPT Index	3	3	3	6	3	3	6	6	6	6	6	3
Percent Chironomidae	6	3	3	3	3	6	6	6	6	3	3	3
Shannon-Weiner Diversity Index	6	6	6	6	6	6	3	6	6	6	6	6
Total Biological Score												
Total Biological Score	36	33	30	33	24	30	27	36	30	36	33	30
Assessment Designation	Non	Non	Non	Non	Partially	Non	Partially	Non	Non	Non	Non	Non

Table C1. Summary of IBI-Type Analysis Biological Metric Scores and Designations – continued.

Metric Scores	SUSQ 1						SUSQ 2				
	1RS5	1VBS1	1VBS2	1VBS3	1VBS4	1VBS5	2HD1	2HD2	2HD3	2RBP5	2RS1
Number of Individuals	203	197	237	247	249	228	294	278	211	218	261
Taxa Richness	23	20	28	17	23	24	15	17	15	21	15
Hilsenhoff Biotic Index	3.58	4.57	4.02	4.07	4.21	3.89	5.53	4.79	5.4	4.89	6.65
Percent Ephemeroptera	70.9	13.7	34.2	39.7	22.1	25.4	19.4	23.4	26.5	56	6.9
Percent Dominant Taxa	23.6	31.5	22.8	32.4	37.3	28.1	51	44.6	60.7	30.7	45.6
EPT Index	15	10	16	9	14	12	10	12	8	10	11
Percent Chironomidae	5.9	3.6	3	1.6	5.6	3.1	51	16.2	60.7	3.7	26.8
Shannon-Weiner Diversity Index	2.41	2.04	2.44	1.96	2.24	2.29	1.63	1.72	1.4	2.36	1.68
Biological Condition Scores											
Taxa Richness	6	3	6	3	6	6	3	3	3	3	3
Hilsenhoff Biotic Index	6	3	6	6	6	6	0	3	3	3	0
Percent Ephemeroptera	6	0	6	6	3	3	3	3	3	6	0
Percent Dominant Taxa	6	3	6	3	3	6	0	0	0	3	0
EPT Index	6	3	6	3	6	6	3	6	3	3	3
Percent Chironomidae	3	6	6	6	3	6	0	3	0	6	3
Shannon-Weiner Diversity Index	6	3	6	3	6	6	0	0	0	6	0
Total Biological Score											
Total Biological Score	39	21	42	30	33	39	9	18	12	30	9
Assessment Designation	Non	Partially	Non	Non	Non	Non	Severely	Partially	Severely	Non	Severely

Table C1. Summary of IBI-Type Analysis Biological Metric Scores and Designations – continued.

	SUSQ 2							SUSQ 3		
Metric Scores	**2RS2**	**2RS3**	**2RS5**	**2VBS1**	**2VBS2**	**2VBS3**	**2VBS5**	**3HD1**	**3HD2**	**3HD3**
Number of Individuals	270	236	207	118	49	61	41	236	65	152
Taxa Richness	14	20	25	21	14	16	12	17	15	16
Hilsenhoff Biotic Index	5.81	6.03	5.94	5.42	5.22	5.64	5.44	5.59	5.32	4.63
Percent Ephemeroptera	5.9	6.8	13	10.2	24.5	18	22.0	26.3	35.4	54.6
Percent Dominant Taxa	36.3	30.5	42.5	4.24	49	50.8	43.9	49.6	29.2	31.6
EPT Index	8	14	13	8	5	10	3	10	8	9
Percent Chironomidae	22.6	30.5	42.5	42.4	49	50.8	43.90244	49.6	29.2	13.8
Shannon-Weiner Diversity Index	1.7	1.91	2.19	2.04	1.84	1.93	1.884711	1.71	2.26	2.21
Biological Condition Scores										
Taxa Richness	0	3	6	3	0	3	0	3	3	3
Hilsenhoff Biotic Index	0	0	0	3	3	0	0	0	3	3
Percent Ephemeroptera	0	0	0	0	3	0	3	3	6	6
Percent Dominant Taxa	3	3	3	3	0	0	3	0	3	3
EPT Index	3	6	6	3	0	3	0	3	3	3
Percent Chironomidae	3	3	0	0	0	0	0	0	3	3
Shannon-Weiner Diversity Index	0	3	6	3	0	3	3	0	6	6
Total Biological Score										
Total Biological Score	9	18	21	15	6	9	9	9	27	27
Assessment Designation	Severely	Partially	Partially	Partially	Severely	Severely	Severely	Severely	Partially	Partially

Table C1. Summary of IBI-Type Analysis Biological Metric Scores and Designations – continued.

Metric Scores	SUSQ 3										
	3RBP1	3RBP3	3RS1	3RS2	3RS3	3RS4	3RS5	3VBS1	3VBS2	3VBS3	3VBS4
Number of Individuals	212	260	326	226	258	251	290	86	237	181	257
Taxa Richness	20	25	26	26	27	28	21	15	12	14	23
Hilsenhoff Biotic Index	5.98	4.96	5.65	4.70	5.72	5.00	4.95	5.28	4.56	5.48	5.44
Percent Ephemeroptera	43.4	41.2	23.6	53.5	17.1	23.9	25.9	22.1	45.6	26.0	12.5
Percent Dominant Taxa	17.0	33.5	27.9	22.6	43.8	21.1	26.6	24.4	44.3	28.7	29.2
EPT Index	9	12	15	19	17	14	13	7	5	4	9
Percent Chironomidae	13.7	6.2	27.9	22.6	43.8	7.2	26.6	20.9	17.3	24.3	16.7
Shannon-Weiner Diversity Index	2.36	2.25	2.25	2.38	2.32	2.61	2.38	2.05	1.58	1.79	2.31
Biological Condition Scores											
Taxa Richness	3	6	6	6	6	6	3	3	0	0	6
Hilsenhoff Biotic Index	0	3	0	3	0	3	3	3	3	0	0
Percent Ephemeroptera	6	6	3	6	0	3	3	3	6	3	0
Percent Dominant Taxa	6	3	6	6	3	6	6	6	0	6	3
EPT Index	3	6	6	6	6	6	6	3	0	0	3
Percent Chironomidae	3	3	3	3	0	3	3	3	3	3	3
Shannon-Weiner Diversity Index	6	6	6	6	6	6	6	3	0	0	6
Total Biological Score											
Total Biological Score	27	33	30	36	21	33	30	24	12	12	21
Assessment Designation	Partially	Non	Non	Non	Partially	Non	Non	Partially	Severely	Severely	Partially

Table C1. Summary of IBI-Type Analysis Biological Metric Scores and Designations – continued.

Metric Scores	SUSQ 3	SUSQ 4									
	3VBS5	4HD1	4HD2	4HD3	4RBP1	4RBP5	4RS1	4RS2	4RS3	4RS4	4RS5
Number of Individuals	244	316	301	276	132	224	245	305	280	286	354
Taxa Richness	23	18	17	22	17	16	21	22	22	18	20
Hilsenhoff Biotic Index	5.27	4.48	4.67	4.25	6.17	4.96	5.07	5.18	4.97	5.23	5.40
Percent Ephemeroptera	20.9	27.2	24.9	41.3	10.6	2.7	29.4	23.9	27.9	21.0	16.7
Percent Dominant Taxa	34.8	20.9	39.9	28.6	24.2	45.5	19.6	25.2	32.5	45.5	42.7
EPT Index	13	13	11	16	4	5	14	17	15	12	14
Percent Chironomidae	34.8	14.9	39.9	28.6	10.6	12.1	8.2	25.2	32.5	20.6	42.7
Shannon-Weiner Diversity Index	2.00	2.32	2.02	2.16	2.43	1.69	2.48	2.31	2.06	1.83	1.99
Biological Condition Scores											
Taxa Richness	6	3	3	3	3	3	3	3	3	3	3
Hilsenhoff Biotic Index	3	3	3	6	0	3	3	3	3	3	3
Percent Ephemeroptera	3	3	3	6	0	0	3	3	3	3	0
Percent Dominant Taxa	3	6	3	6	6	0	6	6	3	0	3
EPT Index	6	6	3	6	0	0	6	6	6	6	6
Percent Chironomidae	3	3	3	3	3	3	3	3	3	3	0
Shannon-Weiner Diversity Index	3	6	3	6	6	0	6	6	3	0	3
Total Biological Score											
Total Biological Score	27	30	21	36	18	9	30	30	24	18	18
Assessment Designation	Partially	Non	Partially	Non	Partially	Severely	Non	Non	Partially	Partially	Partially

Table C1. Summary of IBI-Type Analysis Biological Metric Scores and Designations – continued.

Metric Scores	SUSQ 4	SUSQ 5									SUSQ 6
	4VBS5	5HD1	5HD2	5RBP1	5RBP5	5RS1	5RS2	5RS3	5RS4		6HD1
Number of Individuals	279	255	257	170	218	227	242	245	155		221
Taxa Richness	20	13	12	16	11	18	20	16	19		4
Hilsenhoff Biotic Index	4.48	3.66	3.57	5.71	6.31	4.22	4.31	4.33	4.56		6.00
Percent Ephemeroptera	54.5	41.6	45.1	17.1	5.0	21.1	40.1	29.8	41.3		0.0
Percent Dominant Taxa	48.0	26.3	27.6	31.8	43.1	37.0	36.4	29.8	33.5		98.6
EPT Index	10	10	11	6	4	13	14	12	10		1
Percent Chironomidae	9.7	6.7	21.4	6.5	11.9	7.9	36.4	29.8	5.8		98.6
Shannon-Weiner Diversity Index	1.56	2.10	1.92	2.22	1.57	1.94	2.29	2.09	2.23		0.09
Biological Condition Scores											
Taxa Richness	3	0	0	3	0	3	3	3	3		0
Hilsenhoff Biotic Index	3	6	6	0	0	6	6	6	3		0
Percent Ephemeroptera	6	6	6	0	0	3	6	3	6		0
Percent Dominant Taxa	0	6	6	3	3	3	3	3	3		0
EPT Index	3	3	3	3	0	6	6	6	3		0
Percent Chironomidae	3	3	3	3	3	3	3	3	3		0
Shannon-Weiner Diversity Index	0	3	3	6	0	3	6	3	6		0
Total Biological Score											
Total Biological Score	18	27	27	18	6	27	33	27	27		0
Assessment Designation	Partially	Partially	Partially	Partially	Severely	Partially	Non	Partially	Partially		Severely

Table C1. Summary of IBI-Type Analysis Biological Metric Scores and Designations – continued.

Metric Scores	SUSQ6									SUSQ 7
	6HD2	6HD3	6RBP3	6RS1	6RS3	6RS4	6RS5	6VBS4	6VBS5	7HD3
Number of Individuals	46	224	288	261	227	297	239	293	134	268
Taxa Richness	11	19	20	7	20	18	22	21	14	17
Hilsenhoff Biotic Index	4.35	4.47	4.72	5.93	5.28	4.45	4.26	4.96	5.21	5.59
Percent Ephemeroptera	13.0	38.4	30.6	0.8	13.7	29.6	44.4	23.9	18.7	0.7
Percent Dominant Taxa	21.7	29.5	33.7	93.1	39.2	21.5	19.7	30.0	38.1	36.2
EPT Index	6	11	11	4	12	11	13	11	6	6
Percent Chironomidae	21.7	29.5	13.2	93.1	39.2	19.2	17.2	30.0	38.1	35.4
Shannon-Weiner Diversity Index	2.06	2.12	2.20	0.32	2.02	2.30	2.47	2.03	1.87	1.62
Biological Condition Scores										
Taxa Richness	0	3	3	0	3	3	3	3	0	3
Hilsenhoff Biotic Index	3	3	3	0	3	3	6	3	3	0
Percent Ephemeroptera	0	6	6	0	0	3	6	3	3	0
Percent Dominant Taxa	6	3	3	0	3	6	6	3	3	3
EPT Index	3	3	3	0	6	3	6	3	3	3
Percent Chironomidae	3	3	3	0	3	3	3	3	3	3
Shannon-Weiner Diversity Index	3	3	6	0	3	6	6	3	3	0
Total Biological Score										
Total Biological Score	18	24	27	0	21	27	36	21	18	12
Assessment Designation	Partially	Partially	Partially	Severely	Partially	Partially	Non	Partially	Partially	Severely

61

Table C1. Summary of IBI-Type Analysis Biological Metric Scores and Designations – continued.

	SUSQ7			SUSQ 10					
Metric Scores	**7RBP1**	**7RBP5**	**7RS5**	**10HD2**	**10HD3**	**10RS1**	**10RS2**	**10RS3**	**10RS5**
Number of Individuals	236	212	276	213	151	232	291	267	246
Taxa Richness	18	19	18	17	8	22	20	22	19
Hilsenhoff Biotic Index	6.04	5.38	5.21	4.62	6.07	5.03	5.02	4.95	5.69
Percent Ephemeroptera	2.5	17.5	7.6	27.2	1.3	40.5	26.1	20.2	6.1
Percent Dominant Taxa	29.7	23.1	29.7	26.3	87.4	37.5	35.1	31.8	56.9
EPT Index	4	7	8	11	3	12	13	15	8
Percent Chironomidae	29.7	11.8	25.7	23.5	2.6	37.5	35.1	31.8	4.1
Shannon-Weiner Diversity Index	2.04	2.43	2.01	2.17	0.57	1.99	2.14	2.15	1.70
Biological Condition Scores									
Taxa Richness	3	3	3	3	0	3	3	3	3
Hilsenhoff Biotic Index	0	3	3	3	0	3	3	3	0
Percent Ephemeroptera	0	0	0	3	0	6	3	3	0
Percent Dominant Taxa	3	6	3	6	0	3	3	3	0
EPT Index	0	3	3	3	0	6	6	6	3
Percent Chironomidae	3	3	3	3	6	3	3	3	6
Shannon-Weiner Diversity Index	3	6	3	6	0	3	3	6	0
Total Biological Score									
Total Biological Score	12	24	18	27	6	27	24	27	12
Assessment Designation	Severely	Partially	Partially	Partially	Severely	Partially	Partially	Partially	Severely

Table C2. Summary of Reference Site Analysis Biological Metric Scores and Designations

Metric Scores	SUSQ1									
	1HD1	1HD2	1HD3	1RBP1	1RBP2	1RBP3	1RBP4	1RBP5	1RS1	1RS2
Number of Individuals	44	216	59	288	232	283	282	252	166	182
Taxa Richness	15	15	14	24	17	21	18	20	22	22
Hilsenhoff Biotic Index	3.98	3.95	4.25	4.36	4.39	4.13	4.27	4.26	4.57	4.06
Percent Ephemeroptera	45.5	31.5	59.3	18.8	17.7	24.7	15.2	18.7	22.3	45.6
Percent Dominant Taxa	13.6	21.3	22.0	28.1	28.9	30.4	34.4	26.6	32.5	17.6
EPT Index	9	11	10	13	10	11	12	12	13	14
Percent Chironomidae	4.5	8.3	10.2	5.2	6.5	3.2	3.9	3.2	3.6	4.9
Shannon-Weiner Diversity Index	2.56	2.19	2.32	2.56	2.32	2.44	1.98	2.29	2.42	2.60
Percent of Reference										
Taxa Richness	53.57	53.57	50.00	85.71	60.71	75.00	64.29	71.43	78.57	78.57
Hilsenhoff Biotic Index	101.10	101.82	94.52	92.20	91.64	97.35	94.18	94.35	87.94	99.03
Percent Ephemeroptera	45.45	31.48	59.32	18.75	17.67	24.73	15.25	18.65	22.29	45.60
Percent Dom Taxa	13.64	21.30	22.03	28.13	28.88	30.39	34.40	26.59	32.53	17.58
EPT Index	56.25	68.75	62.50	81.25	62.50	68.75	75.00	75.00	81.25	87.50
Percent Chironomidae	4.55	8.33	10.17	5.21	6.47	3.18	3.90	3.17	3.61	4.95
Shannon-Weiner Diversity Index	105.04	89.89	95.39	105.24	95.30	100.31	81.11	94.00	99.40	106.87
Biological Condition Scores										
Taxa Richness	2	2	2	6	4	4	4	4	4	4
Hilsenhoff Biotic Index	6	6	6	6	6	6	6	6	6	6
Percent Ephemeroptera	6	6	6	4	4	4	4	4	4	6
Percent Dominant Taxa	6	4	4	4	4	2	2	4	2	6
EPT Index	0	0	0	4	0	0	2	2	4	4
Percent Chironomidae	6	4	4	4	4	6	6	6	6	6
Shannon-Weiner Diversity Index	6	6	6	6	6	6	6	6	6	6
Total Biological Score										
Total Biological Score	32	28	28	34	28	28	30	32	32	38
Percent of Reference	80	70	70	85	70	70	75	80	80	95
Assessment Designation	Slightly	Slightly	Slightly	Non	Slightly	Slightly	Slightly	Slightly	Slightly	Non

Table C2. Summary of Reference Site Analysis Biological Metric Scores and Designations – continued.

Metric Scores	SUSQ 1								SUSQ 2	
	1RS3	1RS4	1RS5	1VBS1	1VBS2	1VBS3	1VBS4	1VBS5	2HD1	2HD2
Number of Individuals	236	260	203	197	237	247	249	228	294	278
Taxa Richness	21	18	23	20	28	17	23	24	15	17
Hilsenhoff Biotic Index	4.00	4.22	3.58	4.57	4.02	4.07	4.21	3.89	5.53	4.79
Percent Ephemeroptera	29.7	20.8	70.9	13.7	34.2	39.7	22.1	25.4	19.4	23.4
Percent Dominant Taxa	17.4	24.6	23.6	31.5	22.8	32.4	37.3	28.1	51.0	44.6
EPT Index	14	11	15	10	16	9	14	12	10	12
Percent Chironomidae	7.6	12.3	5.9	3.6	3.0	1.6	5.6	3.1	51.0	16.2
Shannon-Weiner Diversity Index	2.43	2.17	2.41	2.04	2.44	1.96	2.24	2.29	1.63	1.72
Percent of Reference										
Taxa Richness	75.00	64.29	82.14	71.43	100.00	60.71	82.14	85.71	53.57	60.71
Hilsenhoff Biotic Index	100.42	95.30	112.28	88.02	100.00	98.83	95.45	103.36	72.71	83.92
Percent Ephemeroptera	29.66	20.77	70.94	13.71	34.18	39.68	22.09	25.44	19.39	23.38
Percent Dom Taxa	17.37	24.62	23.65	31.47	22.78	32.39	37.35	28.07	51.02	44.60
EPT Index	87.50	68.75	93.75	62.50	100.00	56.25	87.50	75.00	62.50	75.00
Percent Chironomidae	7.63	12.31	5.91	3.55	2.95	1.62	5.62	3.07	51.02	16.19
Shannon-Weiner Diversity Index	99.81	89.19	98.80	83.88	100.00	80.68	91.87	94.01	66.74	70.64
Biological Condition Scores										
Taxa Richness	4	4	6	4	6	4	6	6	2	4
Hilsenhoff Biotic Index	6	6	6	6	6	6	6	6	4	4
Percent Ephemeroptera	6	4	6	4	6	6	4	6	4	4
Percent Dominant Taxa	6	4	4	2	4	2	2	4	0	0
EPT Index	4	0	6	0	6	0	4	2	0	2
Percent Chironomidae	4	4	4	6	6	6	4	6	0	4
Shannon-Weiner Diversity Index	6	6	6	6	6	6	6	6	4	4
Total Biological Score										
Total Biological Score	36	28	38	28	40	30	32	36	14	22
Percent of Reference	90	70	95	70	100	75	80	90	35	55
Assessment Designation	Non	Slightly	Non	Slightly	Reference	Slightly	Slightly	Non	Moderately	Slightly

Table C2. Summary of Reference Site Analysis Biological Metric Scores and Designations – continued.

Metric Scores	SUSQ 2								
	2HD3	2RBP5	2RS1	2RS2	2RS3	2RS5	2VBS1	2VBS2	2VBS3
Number of Individuals	211	218	261	270	236	207	118	49	61
Taxa Richness	15	21	15	14	20	25	21	14	16
Hilsenhoff Biotic Index	5.40	4.89	6.65	5.81	6.03	5.94	5.42	5.22	5.64
Percent Ephemeroptera	26.5	56.0	6.9	5.9	6.8	13.0	10.2	24.5	18.0
Percent Dominant Taxa	60.7	30.7	45.6	36.3	30.5	42.5	42.4	49.0	50.8
EPT Index	8	10	11	8	14	13	8	5	10
Percent Chironomidae	60.7	3.7	26.8	22.6	30.5	42.5	42.4	49.0	50.8
Shannon-Weiner Diversity Index	1.40	2.36	1.68	1.70	1.91	2.19	2.04	1.84	1.93
Percent of Reference									
Taxa Richness	53.57	75.00	53.57	50.00	71.43	89.29	75.00	50.00	57.14
Hilsenhoff Biotic Index	74.43	82.31	60.49	69.20	66.64	67.73	74.26	76.97	71.30
Percent Ephemeroptera	26.54	55.96	6.90	5.93	6.78	13.04	10.17	24.49	18.03
Percent Dom Taxa	60.66	30.73	45.59	36.30	30.51	42.51	42.37	48.98	50.82
EPT Index	50.00	62.50	68.75	50.00	87.50	81.25	50.00	31.25	62.50
Percent Chironomidae	60.66	3.67	26.82	22.59	30.51	42.51	42.37	48.98	50.82
Shannon-Weiner Diversity Index	57.46	97.08	68.86	69.93	78.56	90.01	83.90	75.71	79.25
Biological Condition Scores									
Taxa Richness	2	4	2	2	4	6	4	2	2
Hilsenhoff Biotic Index	4	4	2	2	2	2	4	4	4
Percent Ephemeroptera	6	6	2	2	2	4	4	4	4
Percent Dominant Taxa	0	2	0	2	2	0	0	0	0
EPT Index	0	0	0	0	4	4	0	0	0
Percent Chironomidae	0	6	2	2	2	0	0	0	0
Shannon-Weiner Diversity Index	4	6	4	4	6	6	6	6	6
Total Biological Score									
Total Biological Score	16	28	12	14	22	22	18	16	16
Percent of Reference	40	70	30	35	55	55	45	40	40
Assessment Designation	Moderately	Slightly	Moderately	Moderately	Slightly	Slightly	Moderately	Moderately	Moderately

Table C2. Summary of Reference Site Analysis Biological Metric Scores and Designations – continued.

Metric Scores	SUSQ 2	SUSQ 3							
	2VBS5	3HD1	3HD2	3HD3	3RBP1	3RBP3	3RS1	3RS2	3RS3
Number of Individuals	41	236	65	152	212	260	326	226	258
Taxa Richness	12	17	15	16	20	25	26	26	27
Hilsenhoff Biotic Index	5.44	5.59	5.32	4.63	5.98	4.96	5.65	4.70	5.72
Percent Ephemeroptera	22.0	26.3	35.4	54.6	43.4	41.2	23.6	53.5	17.1
Percent Dominant Taxa	43.9	49.6	29.2	31.6	17.0	33.5	27.9	22.6	43.8
EPT Index	3	10	8	9	9	12	15	19	17
Percent Chironomidae	43.9	49.6	29.2	13.8	13.7	6.2	27.9	22.6	43.8
Shannon-Weiner Diversity Index	1.88	1.71	2.26	2.21	2.36	2.25	2.25	2.38	2.32
Percent of Reference									
Taxa Richness	42.86	60.71	53.57	57.14	71.43	89.29	92.86	92.86	96.43
Hilsenhoff Biotic Index	73.93	71.89	75.54	86.82	67.28	81.11	71.17	85.49	70.24
Percent Ephemeroptera	21.95	26.27	35.38	54.61	43.40	41.15	23.62	53.54	17.05
Percent Dom Taxa	43.90	49.58	29.23	31.58	16.98	33.46	27.91	22.57	43.80
EPT Index	18.75	62.50	50.00	56.25	56.25	75.00	93.75	118.75	106.25
Percent Chironomidae	43.90	49.58	29.23	13.82	13.68	6.15	27.91	22.57	43.80
Shannon-Weiner Diversity Index	77.40	70.22	92.75	90.84	97.02	92.44	92.34	97.64	95.13
Biological Condition Scores									
Taxa Richness	2	4	2	2	4	6	6	6	6
Hilsenhoff Biotic Index	4	4	4	6	2	4	4	6	4
Percent Ephemeroptera	4	6	6	6	6	6	4	6	4
Percent Dominant Taxa	0	0	4	2	6	2	4	4	0
EPT Index	0	0	0	0	0	2	6	6	6
Percent Chironomidae	0	0	2	4	4	4	2	2	0
Shannon-Weiner Diversity Index	6	4	6	6	6	6	6	6	6
Total Biological Score									
Total Biological Score	16	18	24	26	28	30	32	36	26
Percent of Reference	40	45	60	65	70	75	80	90	65
Assessment Designation	Moderately	Moderately	Slightly	Slightly	Slightly	Slightly	Slightly	Non	Slightly

Table C2. Summary of Reference Site Analysis Biological Metric Scores and Designations – continued.

Metric Scores	SUSQ 3							SUSQ 4		
	3RS4	3RS5	3VBS1	3VBS2	3VBS3	3VBS4	3VBS5	4HD1	4HD2	4HD3
Number of Individuals	251	290	86	237	181	257	244	316	301	276
Taxa Richness	28	21	15	12	14	23	23	18	17	22
Hilsenhoff Biotic Index	5.00	4.95	5.28	4.56	5.48	5.44	5.27	4.48	4.67	4.25
Percent Ephemeroptera	23.9	25.9	22.1	45.6	26.0	12.5	20.9	27.2	24.9	41.3
Percent Dominant Taxa	21.1	26.6	24.4	44.3	28.7	29.2	34.8	20.9	39.9	28.6
EPT Index	14	13	7	5	4	9	13	13	11	16
Percent Chironomidae	7.2	26.6	20.9	17.3	24.3	16.7	34.8	14.9	39.9	28.6
Shannon-Weiner Diversity Index	2.61	2.38	2.05	1.58	1.79	2.31	2.00	2.32	2.02	2.16
Percent of Reference										
Taxa Richness	100.00	75.00	53.57	42.86	50.00	82.14	82.14	64.29	60.71	78.57
Hilsenhoff Biotic Index	80.42	81.26	76.17	88.24	73.37	73.87	76.24	89.80	86.02	94.69
Percent Ephemeroptera	23.90	25.86	22.09	45.57	25.97	12.45	20.90	27.22	24.92	41.30
Percent Dominant Taxa	21.12	26.55	24.42	44.30	28.73	29.18	34.84	20.89	39.87	28.62
EPT Index	87.50	81.25	43.75	31.25	25.00	56.25	81.25	81.25	68.75	100.00
Percent Chironomidae	7.17	26.55	20.93	17.30	24.31	16.73	34.84	14.87	39.87	28.62
Shannon-Weiner Diversity Index	107.00	97.57	84.18	64.80	73.66	95.06	82.20	95.11	82.83	88.85
Biological Condition Scores										
Taxa Richness	6	4	2	2	2	6	6	4	4	4
Hilsenhoff Biotic Index	4	4	4	6	4	4	4	6	6	6
Percent Ephemeroptera	4	6	4	6	6	4	4	6	4	6
Percent Dominant Taxa	4	4	4	0	4	4	2	4	2	4
EPT Index	4	4	0	0	0	0	4	4	0	6
Percent Chironomidae	4	2	4	4	2	4	2	4	0	2
Shannon-Weiner Diversity Index	6	6	6	4	4	6	6	6	6	6
Total Biological Score										
Total Biological Score	32	30	24	22	22	28	28	34	22	34
Percent of Reference	80	75	60	55	55	70	70	85	55	85
Assessment Designation	Slightly	Slightly	Slightly	Slightly	Slightly	Slightly	Slightly	Non	Slightly	Non

Table C2. Summary of Reference Site Analysis Biological Metric Scores and Designations – continued.

Metric Scores	SUSQ 4								SUSQ 5
	4RBP1	4RBP5	4RS1	4RS2	4RS3	4RS4	4RS5	4VBS5	5HD1
Number of Individuals	132	224	245	305	280	286	354	279	255
Taxa Richness	17	16	21	22	22	18	20	20	13
Hilsenhoff Biotic Index	6.17	4.96	5.07	5.18	4.97	5.23	5.40	4.48	3.66
Percent Ephemeroptera	10.6	2.7	29.4	23.9	27.9	21.0	16.7	54.5	41.6
Percent Dominant Taxa	24.2	45.5	19.6	25.2	32.5	45.5	42.7	48.0	26.3
EPT Index	4	5	14	17	15	12	14	10	10
Percent Chironomidae	10.6	12.1	8.2	25.2	32.5	20.6	42.7	9.7	6.7
Shannon-Weiner Diversity Index	2.43	1.69	2.48	2.31	2.06	1.83	1.99	1.56	2.10
Percent of Reference									
Taxa Richness	60.71	57.14	75.00	78.57	78.57	64.29	71.43	71.43	46.43
Hilsenhoff Biotic Index	65.13	81.00	79.39	77.57	80.88	76.82	74.45	89.82	109.90
Percent Ephemeroptera	10.61	2.68	29.39	23.93	27.86	20.98	16.67	54.48	41.57
Percent Dominant Taxa	24.24	45.54	19.59	25.25	32.50	45.45	42.66	48.03	26.27
EPT Index	25.00	31.25	87.50	106.25	93.75	75.00	87.50	62.50	62.50
Percent Chironomidae	10.61	12.05	8.16	25.25	32.50	20.63	42.66	9.68	6.67
Shannon-Weiner Diversity Index	99.89	69.52	102.04	94.84	84.62	75.15	81.54	64.11	86.41
Biological Condition Scores									
Taxa Richness	4	2	4	4	4	4	4	4	2
Hilsenhoff Biotic Index	2	4	4	4	4	4	4	6	6
Percent Ephemeroptera	4	0	6	4	6	4	4	6	6
Percent Dominant Taxa	4	0	6	4	2	0	0	0	4
EPT Index	0	0	4	6	6	2	4	0	0
Percent Chironomidae	4	4	4	2	2	4	0	4	4
Shannon-Weiner Diversity Index	6	4	6	6	6	6	6	4	6
Total Biological Score									
Total Biological Score	24	14	34	30	30	24	22	24	28
Percent of Reference	60	35	85	75	75	60	55	60	70
Assessment Designation	Slightly	Moderately	Non	Slightly	Slightly	Slightly	Slightly	Slightly	Slightly

Table C2. Summary of Reference Site Analysis Biological Metric Scores and Designations – continued.

Metric Scores	5HD2	5RBP1	5RBP5	5RS1	SUSQ 5 5RS2	5RS3	5RS4	SUSQ 6 6HD1	6HD2
Number of Individuals	257	170	218	227	242	245	155	221	46
Taxa Richness	12	16	11	18	20	16	19	4	11
Hilsenhoff Biotic Index	3.57	5.71	6.31	4.22	4.31	4.33	4.56	6.00	4.35
Percent Ephemeroptera	45.1	17.1	5.0	21.1	40.1	29.8	41.3	0.0	13.0
Percent Dominant Taxa	27.6	31.8	43.1	37.0	36.4	29.8	33.5	98.6	21.7
EPT Index	11	6	4	13	14	12	10	1	6
Percent Chironomidae	21.4	6.5	11.9	7.9	36.4	29.8	5.8	98.6	21.7
Shannon-Weiner Diversity Index	1.92	2.22	1.57	1.94	2.29	2.09	2.23	0.09	2.06
Percent of Reference									
Taxa Richness	42.86	57.14	39.29	64.29	71.43	57.14	67.86	14.29	39.29
Hilsenhoff Biotic Index	112.57	70.47	63.71	95.28	93.30	92.94	88.16	66.97	92.49
Percent Ephemeroptera	45.14	17.06	5.05	21.15	40.08	29.80	41.29	0.00	13.04
Percent Dominant Taxa	27.63	31.76	43.12	37.00	36.36	29.80	33.55	98.64	21.74
EPT Index	68.75	37.50	25.00	81.25	87.50	75.00	62.50	6.25	37.50
Percent Chironomidae	21.40	6.47	11.93	7.93	36.36	29.80	5.81	98.64	21.74
Shannon-Weiner Diversity Index	79.04	91.02	64.65	79.49	93.84	86.02	91.46	3.56	84.62
Biological Condition Scores									
Taxa Richness	2	2	0	4	4	2	4	0	0
Hilsenhoff Biotic Index	6	4	2	6	6	6	6	2	6
Percent Ephemeroptera	6	4	2	4	6	6	6	0	4
Percent Dominant Taxa	4	2	0	2	2	4	2	0	4
EPT Index	0	0	0	4	4	2	0	0	0
Percent Chironomidae	2	4	4	4	0	2	4	0	2
Shannon-Weiner Diversity Index	6	6	4	6	6	6	6	0	6
Total Biological Score									
Total Biological Score	26	22	12	30	28	28	28	2	22
Percent of Reference	65	55	30	75	70	70	70	5	55
Assessment Designation	Slightly	Slightly	Moderately	Slightly	Slightly	Slightly	Slightly	Severely	Slightly

Table C2. Summary of Reference Site Analysis Biological Metric Scores and Designations – continued.

Metric Scores	SUSQ6								SUSQ 7
	6HD3	6RBP3	6RS1	6RS3	6RS4	6RS5	6VBS4	6VBS5	7HD3
Number of Individuals	224	288	261	227	297	239	293	134	268
Taxa Richness	19	20	7	20	18	22	21	14	17
Hilsenhoff Biotic Index	4.47	4.72	5.93	5.28	4.45	4.26	4.96	5.21	5.59
Percent Ephemeroptera	38.4	30.6	0.8	13.7	29.6	44.4	23.9	18.7	0.7
Percent Dominant Taxa	29.5	33.7	93.1	39.2	21.5	19.7	30.0	38.1	36.2
EPT Index	11	11	4	12	11	13	11	6	6
Percent Chironomidae	29.5	13.2	93.1	39.2	19.2	17.2	30.0	38.1	35.4
Shannon-Weiner Diversity Index	2.12	2.20	0.32	2.02	2.30	2.47	2.03	1.87	1.62
Percent of Reference									
Taxa Richness	67.86	71.43	25.00	71.43	64.29	78.57	75.00	50.00	60.71
Hilsenhoff Biotic Index	89.89	85.22	67.80	76.19	90.27	94.31	81.14	77.20	71.94
Percent Ephemeroptera	38.39	30.56	0.77	13.66	29.63	44.35	23.89	18.66	0.75
Percent Dominant Taxa	29.46	33.68	93.10	39.21	21.55	19.67	30.03	38.06	36.19
EPT Index	68.75	68.75	25.00	75.00	68.75	81.25	68.75	37.50	37.50
Percent Chironomidae	29.46	13.19	93.10	39.21	19.19	17.15	30.03	38.06	35.45
Shannon-Weiner Diversity Index	86.96	90.16	13.25	82.87	94.52	101.31	83.27	76.67	66.63
Biological Condition Scores									
Taxa Richness	4	4	0	4	4	4	4	2	4
Hilsenhoff Biotic Index	6	6	2	4	6	6	4	4	4
Percent Ephemeroptera	6	6	0	4	6	6	4	4	0
Percent Dominant Taxa	4	2	0	2	4	6	2	2	2
EPT Index	0	0	0	2	0	4	0	0	0
Percent Chironomidae	2	4	0	0	4	4	2	0	0
Shannon-Weiner Diversity Index	6	6	0	6	6	6	6	6	4
Total Biological Score									
Total Biological Score	28	28	2	22	30	36	22	18	14
Percent of Reference	70	70	5	55	75	90	55	45	35
Assessment Designation	Slightly	Slightly	Severely	Slightly	Slightly	Non	Slightly	Moderately	Moderately

Table C2. Summary of Reference Site Analysis Biological Metric Scores and Designations – continued.

Metric Scores	SUSQ7			SUSQ 10					
	7RBP1	7RBP5	7RS5	10HD2	10HD3	10RS1	10RS2	10RS3	10RS5
Number of Individuals	236	212	276	213	151	232	291	267	246
Taxa Richness	18	19	18	17	8	22	20	22	19
Hilsenhoff Biotic Index	6.04	5.38	5.21	4.62	6.07	5.03	5.02	4.95	5.69
Percent Ephemeroptera	2.5	17.5	7.6	27.2	1.3	40.5	26.1	20.2	6.1
Percent Dominant Taxa	29.7	23.1	29.7	26.3	87.4	37.5	35.1	31.8	56.9
EPT Index	4	7	8	11	3	12	13	15	8
Percent Chironomidae	29.7	11.8	25.7	23.5	2.6	37.5	35.1	31.8	4.1
Shannon-Weiner Diversity Index	2.04	2.43	2.01	2.17	0.57	1.99	2.14	2.15	1.70
Percent of Reference									
Taxa Richness	64.29	67.86	64.29	60.71	28.57	78.57	71.43	78.57	67.86
Hilsenhoff Biotic Index	66.60	74.78	77.23	87.13	66.21	80.01	80.09	81.27	70.66
Percent Ephemeroptera	2.54	17.45	7.61	27.23	1.32	40.52	26.12	20.22	6.10
Percent Dominant Taxa	29.66	23.11	29.71	26.29	87.42	37.50	35.05	31.84	56.91
EPT Index	25.00	43.75	50.00	68.75	18.75	75.00	81.25	93.75	50.00
Percent Chironomidae	29.66	11.79	25.72	23.47	2.65	37.50	35.05	31.84	4.07
Shannon-Weiner Diversity Index	83.59	99.88	82.46	89.07	23.49	81.58	87.72	88.30	69.88
Biological Condition Scores									
Taxa Richness	4	4	4	4	0	4	4	4	4
Hilsenhoff Biotic Index	2	4	4	6	2	4	4	4	4
Percent Ephemeroptera	0	4	2	6	0	6	6	4	2
Percent Dominant Taxa	4	4	4	4	0	2	2	2	0
EPT Index	0	0	0	0	0	2	4	6	0
Percent Chironomidae	2	4	2	2	6	0	0	2	6
Shannon-Weiner Diversity Index	6	6	6	6	0	6	6	6	4
Total Biological Score									
Total Biological Score	18	26	22	28	8	24	26	28	20
Percent of Reference	45	65	55	70	20	60	65	70	50
Assessment Designation	Moderately	Slightly	Slightly	Slightly	Moderately	Slightly	Slightly	Slightly	Slightly

Table C3. Summary of Reference Condition Analysis Biological Metric Scores and Designations.

	SUSQ1									
Metric Scores	1HD1	1HD2	1HD3	1RBP1	1RBP2	1RBP3	1RBP4	1RBP5	1RS1	1RS2
Number of Individuals	44	216	59	288	232	283	282	252	166	182
Taxa Richness	15	15	14	24	17	21	18	20	22	22
Hilsenhoff Biotic Index	3.98	3.95	4.25	4.36	4.39	4.13	4.27	4.26	4.57	4.06
Percent Ephemeroptera	45.5	31.5	59.3	18.8	17.7	24.7	15.2	18.7	22.3	45.6
Percent Dominant Taxa	13.6	21.3	22.0	28.1	28.9	30.4	34.4	26.6	32.5	17.6
EPT Index	9	11	10	13	10	11	12	12	13	14
Percent Chironomidae	4.5	8.3	10.2	5.2	6.5	3.2	3.9	3.2	3.6	4.9
Shannon-Weiner Diversity Index	2.56	2.19	2.32	2.56	2.32	2.44	1.98	2.29	2.42	2.60
Percent of Reference										
Taxa Richness	53.57	53.57	50.00	85.71	60.71	75.00	64.29	71.43	78.57	78.57
Hilsenhoff Biotic Index	89.81	90.45	83.96	81.91	81.41	86.47	83.66	83.81	78.12	87.97
Percent Ephemeroptera	45.45	31.48	59.32	18.75	17.67	24.73	15.25	18.65	22.29	45.60
Percent Dominant Taxa	13.64	21.30	22.03	28.13	28.88	30.39	34.40	26.59	32.53	17.58
EPT Index	47.37	57.89	52.63	68.42	52.63	57.89	63.16	63.16	68.42	73.68
Percent Chironomidae	4.55	8.33	10.17	5.21	6.47	3.18	3.90	3.17	3.61	4.95
Shannon-Weiner Diversity Index	98.19	84.02	89.17	98.38	89.08	93.77	75.82	87.87	92.91	99.90
Biological Condition Scores										
Taxa Richness	2	2	2	6	4	4	4	4	4	4
Hilsenhoff Biotic Index	6	6	4	4	4	6	4	4	4	6
Percent Ephemeroptera	6	6	6	4	4	4	4	4	4	6
Percent Dominant Taxa	6	4	4	4	4	2	2	4	2	6
EPT Index	0	0	0	0	0	0	0	0	0	2
Percent Chironomidae	6	4	4	4	4	6	6	6	6	6
Shannon-Weiner Diversity Index	6	6	6	6	6	6	6	6	6	6
Total Biological Score										
Total Biological Score	32	28	26	28	26	28	26	28	26	36
Percent of Reference	76	67	62	67	62	67	62	67	62	86
Assessment Designation	Slightly	Slightly	Slightly	Slightly	Slightly	Slightly	Slightly	Slightly	Slightly	Non

Table C3. Summary of Reference Condition Analysis Biological Metric Scores and Designations – continued.

Metric Scores	SUSQ 1								SUSQ 2	
	1RS3	1RS4	1RS5	1VBS1	1VBS2	1VBS3	1VBS4	1VBS5	2HD1	2HD2
Number of Individuals	236	260	203	197	237	247	249	228	294	278
Taxa Richness	21	18	23	20	28	17	23	24	15	17
Hilsenhoff Biotic Index	4.00	4.22	3.58	4.57	4.02	4.07	4.21	3.89	5.53	4.79
Percent Ephemeroptera	29.7	20.8	70.9	13.7	34.2	39.7	22.1	25.4	19.4	23.4
Percent Dominant Taxa	17.4	24.6	23.6	31.5	22.8	32.4	37.3	28.1	51.0	44.6
EPT Index	14	11	15	10	16	9	14	12	10	12
Percent Chironomidae	7.6	12.3	5.9	3.6	3.0	1.6	5.6	3.1	51.0	16.2
Shannon-Weiner Diversity Index	2.43	2.17	2.41	2.04	2.44	1.96	2.24	2.29	1.63	1.72
Percent of Reference										
Taxa Richness	75.00	64.29	82.14	71.43	100.00	60.71	82.14	85.71	53.57	60.71
Hilsenhoff Biotic Index	89.21	84.66	99.74	78.19	88.83	87.79	84.79	91.82	64.59	74.55
Percent Ephemeroptera	29.66	20.77	70.94	13.71	34.18	39.68	22.09	25.44	19.39	23.38
Percent Dominant Taxa	17.37	24.62	23.65	31.47	22.78	32.39	37.35	28.07	51.02	44.60
EPT Index	73.68	57.89	78.95	52.63	84.21	47.37	73.68	63.16	52.63	63.16
Percent Chironomidae	7.63	12.31	5.91	3.55	2.95	1.62	5.62	3.07	51.02	16.19
Shannon-Weiner Diversity Index	93.30	83.37	92.35	78.40	93.48	75.42	85.88	87.88	62.39	66.03
Biological Condition Scores										
Taxa Richness	4	4	6	4	6	4	6	6	2	4
Hilsenhoff Biotic Index	6	4	6	4	6	6	4	6	2	4
Percent Ephemeroptera	6	4	6	4	6	6	4	6	4	4
Percent Dominant Taxa	6	4	4	2	4	2	2	4	0	0
EPT Index	2	0	2	0	4	0	2	0	0	0
Percent Chironomidae	4	4	4	6	6	6	4	6	0	4
Shannon-Weiner Diversity Index	6	6	6	6	6	6	6	6	4	4
Total Biological Score										
Total Biological Score	34	26	34	26	38	30	28	34	12	20
Percent of Reference	81	62	81	62	90	71	67	81	29	48
Assessment Designation	Non	Slightly	Non	Slightly	Non	Slightly	Slightly	Non	Moderately	Slightly

Table C3. Summary of Reference Condition Analysis Biological Metric Scores and Designations – continued.

Metric Scores	SUSQ 2							
	2HD3	2RBP5	2RS1	2RS2	2RS3	2RS5	2VBS1	2VBS2
Number of Individuals	211	218	261	270	236	207	118	49
Taxa Richness	15	21	15	14	20	25	21	14
Hilsenhoff Biotic Index	5.40	4.89	6.65	5.81	6.03	5.94	5.42	5.22
Percent Ephemeroptera	26.5	56.0	6.9	5.9	6.8	13.0	10.2	24.5
Percent Dominant Taxa	60.7	30.7	45.6	36.3	30.5	42.5	42.4	49.0
EPT Index	8	10	11	8	14	13	8	5
Percent Chironomidae	60.7	3.7	26.8	22.6	30.5	42.5	42.4	49.0
Shannon-Weiner Diversity Index	1.40	2.36	1.68	1.70	1.91	2.19	2.04	1.84
Percent of Reference								
Taxa Richness	53.57	75.00	53.57	50.00	71.43	89.29	75.00	50.00
Hilsenhoff Biotic Index	66.11	73.12	53.73	61.47	59.20	60.16	65.96	68.37
Percent Ephemeroptera	26.54	55.96	6.90	5.93	6.78	13.04	10.17	24.49
Percent Dominant Taxa	60.66	30.73	45.59	36.30	30.51	42.51	42.37	48.98
EPT Index	42.11	52.63	57.89	42.11	73.68	68.42	42.11	26.32
Percent Chironomidae	60.66	3.67	26.82	22.59	30.51	42.51	42.37	48.98
Shannon-Weiner Diversity Index	53.71	90.74	64.36	65.37	73.43	84.14	78.43	70.77
Biological Condition Scores								
Taxa Richness	2	4	2	2	4	6	4	2
Hilsenhoff Biotic Index	2	4	2	2	2	2	2	2
Percent Ephemeroptera	6	6	2	2	2	4	4	4
Percent Dominant Taxa	0	2	0	2	2	0	0	0
EPT Index	0	0	0	0	2	0	0	0
Percent Chironomidae	0	6	2	2	2	0	0	0
Shannon-Weiner Diversity Index	4	6	4	4	4	6	6	4
Total Biological Score								
Total Biological Score	14	28	12	14	18	18	16	12
Percent of Reference	33	67	29	33	43	43	38	29
Assessment Designation	Moderately	Slightly	Moderately	Moderately	Moderately	Moderately	Moderately	Moderately

Table C3. Summary of Reference Condition Analysis Biological Metric Scores and Designations – continued.

Metric Scores	SUSQ 2		SUSQ 3						
	2VBS3	2VBS5	3HD1	3HD2	3HD3	3RBP1	3RBP3	3RS1	3RS2
Number of Individuals	61	41	236	65	152	212	260	326	226
Taxa Richness	16	12	17	15	16	20	25	26	26
Hilsenhoff Biotic Index	5.64	5.44	5.59	5.32	4.63	5.98	4.96	5.65	4.70
Percent Ephemeroptera	18.0	22.0	26.3	35.4	54.6	43.4	41.2	23.6	53.5
Percent Dominant Taxa	50.8	43.9	49.6	29.2	31.6	17.0	33.5	27.9	22.6
EPT Index	10	3	10	8	9	9	12	15	19
Percent Chironomidae	50.8	43.9	49.6	29.2	13.8	13.7	6.2	27.9	22.6
Shannon-Weiner Diversity Index	1.93	1.88	1.71	2.26	2.21	2.36	2.25	2.25	2.38
Percent of Reference									
Taxa Richness	57.14	42.86	60.71	53.57	57.14	71.43	89.29	92.86	92.86
Hilsenhoff Biotic Index	63.34	65.67	63.86	67.10	77.12	59.77	72.05	63.22	75.94
Percent Ephemeroptera	18.03	21.95	26.27	35.38	54.61	43.40	41.15	23.62	53.54
Percent Dominant Taxa	50.82	43.90	49.58	29.23	31.58	16.98	33.46	27.91	22.57
EPT Index	52.63	15.79	52.63	42.11	47.37	47.37	63.16	78.95	100.00
Percent Chironomidae	50.82	43.90	49.58	29.23	13.82	13.68	6.15	27.91	22.57
Shannon-Weiner Diversity Index	74.08	72.35	65.64	86.70	84.91	90.69	86.41	86.31	91.27
Biological Condition Scores									
Taxa Richness	2	2	4	2	2	4	6	6	6
Hilsenhoff Biotic Index	2	2	2	2	4	2	4	2	4
Percent Ephemeroptera	4	4	6	6	6	6	6	4	6
Percent Dominant Taxa	0	0	0	4	2	6	2	4	4
EPT Index	0	0	0	0	0	0	0	2	6
Percent Chironomidae	0	0	0	2	4	4	4	2	2
Shannon-Weiner Diversity Index	4	4	4	6	6	6	6	6	6
Total Biological Score									
Total Biological Score	12	12	16	22	24	28	28	26	34
Percent of Reference	29	29	38	52	57	67	67	62	81
Assessment Designation	Moderately	Moderately	Moderately	Slightly	Slightly	Slightly	Slightly	Slightly	Non

Table C3. Summary of Reference Condition Analysis Biological Metric Scores and Designations – continued.

Metric Scores	SUSQ 3								SUSQ 4	
	3RS3	3RS4	3RS5	3VBS1	3VBS2	3VBS3	3VBS4	3VBS5	4HD1	4HD2
Number of Individuals	258	251	290	86	237	181	257	244	316	301
Taxa Richness	27	28	21	15	12	14	23	23	18	17
Hilsenhoff Biotic Index	5.72	5.00	4.95	5.28	4.56	5.48	5.44	5.27	4.48	4.67
Percent Ephemeroptera	17.1	23.9	25.9	22.1	45.6	26.0	12.5	20.9	27.2	24.9
Percent Dominant Taxa	43.8	21.1	26.6	24.4	44.3	28.7	29.2	34.8	20.9	39.9
EPT Index	17	14	13	7	5	4	9	13	13	11
Percent Chironomidae	43.8	7.2	26.6	20.9	17.3	24.3	16.7	34.8	14.9	39.9
Shannon-Weiner Diversity Index	2.32	2.61	2.38	2.05	1.58	1.79	2.31	2.00	2.32	2.02
Percent of Reference										
Taxa Richness	96.43	100.00	75.00	53.57	42.86	50.00	82.14	82.14	64.29	60.71
Hilsenhoff Biotic Index	62.40	71.44	72.19	67.66	78.39	65.17	65.62	67.72	79.77	76.42
Percent Ephemeroptera	17.05	23.90	25.86	22.09	45.57	25.97	12.45	20.90	27.22	24.92
Percent Dominant Taxa	43.80	21.12	26.55	24.42	44.30	28.73	29.18	34.84	20.89	39.87
EPT Index	89.47	73.68	68.42	36.84	26.32	21.05	47.37	68.42	68.42	57.89
Percent Chironomidae	43.80	7.17	26.55	20.93	17.30	24.31	16.73	34.84	14.87	39.87
Shannon-Weiner Diversity Index	88.93	100.02	91.20	78.68	60.57	68.85	88.86	76.84	88.90	77.43
Biological Condition Scores										
Taxa Richness	6	6	4	2	2	2	6	6	4	4
Hilsenhoff Biotic Index	2	4	4	2	4	2	2	2	4	4
Percent Ephemeroptera	4	4	6	4	6	6	4	4	6	4
Percent Dominant Taxa	0	4	4	4	0	4	4	2	4	2
EPT Index	4	2	0	0	0	0	0	0	0	0
Percent Chironomidae	0	4	2	4	4	2	4	2	4	0
Shannon-Weiner Diversity Index	6	6	6	6	4	4	6	6	6	6
Total Biological Score										
Total Biological Score	22	30	26	22	20	20	26	22	28	20
Percent of Reference	52	71	62	52	48	48	62	52	67	48
Assessment Designation	Slightly	Slightly	Slightly	Slightly	Slightly	Slightly	Slightly	Slightly	Slightly	Slightly

Table C3. Summary of Reference Condition Analysis Biological Metric Scores and Designations – continued.

Metric Scores	SUSQ 4								
	4HD3	4RBP1	4RBP5	4RS1	4RS2	4RS3	4RS4	4RS5	4VBS5
Number of Individuals	276	132	224	245	305	280	286	354	279
Taxa Richness	22	17	16	21	22	22	18	20	20
Hilsenhoff Biotic Index	4.25	6.17	4.96	5.07	5.18	4.97	5.23	5.40	4.48
Percent Ephemeroptera	41.3	10.6	2.7	29.4	23.9	27.9	21.0	16.7	54.5
Percent Dominant Taxa	28.6	24.2	45.5	19.6	25.2	32.5	45.5	42.7	48.0
EPT Index	16	4	5	14	17	15	12	14	10
Percent Chironomidae	28.6	10.6	12.1	8.2	25.2	32.5	20.6	42.7	9.7
Shannon-Weiner Diversity Index	2.16	2.43	1.69	2.48	2.31	2.06	1.83	1.99	1.56
Percent of Reference									
Taxa Richness	78.57	60.71	57.14	75.00	78.57	78.57	64.29	71.43	71.43
Hilsenhoff Biotic Index	84.12	57.85	71.95	70.52	68.91	71.85	68.24	66.13	79.79
Percent Ephemeroptera	41.30	10.61	2.68	29.39	23.93	27.86	20.98	16.67	54.48
Percent Dominant Taxa	28.62	24.24	45.54	19.59	25.25	32.50	45.45	42.66	48.03
EPT Index	84.21	21.05	26.32	73.68	89.47	78.95	63.16	73.68	52.63
Percent Chironomidae	28.62	10.61	12.05	8.16	25.25	32.50	20.63	42.66	9.68
Shannon-Weiner Diversity Index	83.05	93.38	64.99	95.39	88.66	79.10	70.25	76.22	59.93
Biological Condition Scores									
Taxa Richness	4	4	2	4	4	4	4	4	4
Hilsenhoff Biotic Index	4	2	4	4	2	4	2	2	4
Percent Ephemeroptera	6	4	0	6	4	6	4	4	6
Percent Dominant Taxa	4	4	0	6	4	2	0	0	0
EPT Index	4	0	0	2	4	2	0	2	0
Percent Chironomidae	2	4	4	4	2	2	4	0	4
Shannon-Weiner Diversity Index	6	6	4	6	6	6	4	6	4
Total Biological Score									
Total Biological Score	30	24	14	32	26	26	18	18	22
Percent of Reference	71	57	33	76	62	62	43	43	52
Assessment Designation	Slightly	Slightly	Moderately	Slightly	Slightly	Slightly	Moderately	Moderately	Slightly

Table C3. Summary of Reference Condition Analysis Biological Metric Scores and Designations – continued.

Metric Scores	SUSQ 5								SUSQ 6
	5HD1	5HD2	5RBP1	5RBP5	5RS1	5RS2	5RS3	5RS4	6HD1
Number of Individuals	255	257	170	218	227	242	245	155	221
Taxa Richness	13	12	16	11	18	20	16	19	4
Hilsenhoff Biotic Index	3.66	3.57	5.71	6.31	4.22	4.31	4.33	4.56	6.00
Percent Ephemeroptera	41.6	45.1	17.1	5.0	21.1	40.1	29.8	41.3	0.0
Percent Dominant Taxa	26.3	27.6	31.8	43.1	37.0	36.4	29.8	33.5	98.6
EPT Index	10	11	6	4	13	14	12	10	1
Percent Chironomidae	6.7	21.4	6.5	11.9	7.9	36.4	29.8	5.8	98.6
Shannon-Weiner Diversity Index	2.10	1.92	2.22	1.57	1.94	2.29	2.09	2.23	0.09
Percent of Reference									
Taxa Richness	46.43	42.86	57.14	39.29	64.29	71.43	57.14	67.86	14.29
Hilsenhoff Biotic Index	97.63	100.00	62.60	56.59	84.64	82.88	82.56	78.31	59.49
Percent Ephemeroptera	41.57	45.14	17.06	5.05	21.15	40.08	29.80	41.29	0.00
Percent Dominant Taxa	26.27	27.63	31.76	43.12	37.00	36.36	29.80	33.55	98.64
EPT Index	52.63	57.89	31.58	21.05	68.42	73.68	63.16	52.63	5.26
Percent Chironomidae	6.67	21.40	6.47	11.93	7.93	36.36	29.80	5.81	98.64
Shannon-Weiner Diversity Index	80.77	73.89	85.08	60.43	74.31	87.72	80.41	85.49	3.33
Biological Condition Scores									
Taxa Richness	2	2	2	0	4	4	2	4	0
Hilsenhoff Biotic Index	6	6	2	2	4	4	4	4	2
Percent Ephemeroptera	6	6	4	2	4	6	6	6	0
Percent Dominant Taxa	4	4	2	0	2	2	4	2	0
EPT Index	0	0	0	0	0	2	0	0	0
Percent Chironomidae	4	2	4	4	4	0	2	4	0
Shannon-Weiner Diversity Index	6	4	6	4	4	6	6	6	0
Total Biological Score									
Total Biological Score	28	24	20	12	22	24	24	26	2
Percent of Reference	67	57	48	29	52	57	57	62	5
Assessment Designation	Slightly	Slightly	Slightly	Moderately	Slightly	Slightly	Slightly	Slightly	Severely

Table C3. Summary of Reference Condition Analysis Biological Metric Scores and Designations – continued.

Metric Scores	SUSQ6								
	6HD2	6HD3	6RBP3	6RS1	6RS3	6RS4	6RS5	6VBS4	6VBS5
Number of Individuals	46	224	288	261	227	297	239	293	134
Taxa Richness	11	19	20	7	20	18	22	21	14
Hilsenhoff Biotic Index	4.35	4.47	4.72	5.93	5.28	4.45	4.26	4.96	5.21
Percent Ephemeroptera	13.0	38.4	30.6	0.8	13.7	29.6	44.4	23.9	18.7
Percent Dominant Taxa	21.7	29.5	33.7	93.1	39.2	21.5	19.7	30.0	38.1
EPT Index	6	11	11	4	12	11	13	11	6
Percent Chironomidae	21.7	29.5	13.2	93.1	39.2	19.2	17.2	30.0	38.1
Shannon-Weiner Diversity Index	2.06	2.12	2.20	0.32	2.02	2.30	2.47	2.03	1.87
Percent of Reference									
Taxa Richness	39.29	67.86	71.43	25.00	71.43	64.29	78.57	75.00	50.00
Hilsenhoff Biotic Index	82.16	79.85	75.70	60.23	67.68	80.19	83.78	72.08	68.57
Percent Ephemeroptera	13.04	38.39	30.56	0.77	13.66	29.63	44.35	23.89	18.66
Percent Dominant Taxa	21.74	29.46	33.68	93.10	39.21	21.55	19.67	30.03	38.06
EPT Index	31.58	57.89	57.89	21.05	63.16	57.89	68.42	57.89	31.58
Percent Chironomidae	21.74	29.46	13.19	93.10	39.21	19.19	17.15	30.03	38.06
Shannon-Weiner Diversity Index	79.10	81.28	84.28	12.38	77.46	88.35	94.70	77.84	71.67
Biological Condition Scores									
Taxa Richness	0	4	4	0	4	4	4	4	2
Hilsenhoff Biotic Index	4	4	4	2	2	4	4	4	2
Percent Ephemeroptera	4	6	6	0	4	6	6	4	4
Percent Dominant Taxa	4	4	2	0	2	4	6	2	2
EPT Index	0	0	0	0	0	0	0	0	0
Percent Chironomidae	2	2	4	0	0	4	4	2	0
Shannon-Weiner Diversity Index	6	6	6	0	6	6	6	6	4
Total Biological Score									
Total Biological Score	20	26	26	2	18	28	30	22	14
Percent of Reference	48	62	62	5	43	67	71	52	33
Assessment Designation	Slightly	Slightly	Slightly	Severely	Moderately	Slightly	Slightly	Slightly	Moderately

Table C3. Summary of Reference Condition Analysis Biological Metric Scores and Designations – continued.

Metric Scores	SUSQ7				SUSQ 10			
	7HD3	7RBP1	7RBP5	7RS5	10HD2	10HD3	10RS1	10RS2
Number of Individuals	268	236	212	276	213	151	232	291
Taxa Richness	17	18	19	18	17	8	22	20
Hilsenhoff Biotic Index	5.59	6.04	5.38	5.21	4.62	6.07	5.03	5.02
Percent Ephemeroptera	0.7	2.5	17.5	7.6	27.2	1.3	40.5	26.1
Percent Dominant Taxa	36.2	29.7	23.1	29.7	26.3	87.4	37.5	35.1
EPT Index	6	4	7	8	11	3	12	13
Percent Chironomidae	35.4	29.7	11.8	25.7	23.5	2.6	37.5	35.1
Shannon-Weiner Diversity Index	1.62	2.04	2.43	2.01	2.17	0.57	1.99	2.14
Percent of Reference								
Taxa Richness	60.71	64.29	67.86	64.29	60.71	28.57	78.57	71.43
Hilsenhoff Biotic Index	63.90	59.16	66.43	68.61	77.40	58.82	71.07	71.15
Percent Ephemeroptera	0.75	2.54	17.45	7.61	27.23	1.32	40.52	26.12
Percent Dominant Taxa	36.19	29.66	23.11	29.71	26.29	87.42	37.50	35.05
EPT Index	31.58	21.05	36.84	42.11	57.89	15.79	63.16	68.42
Percent Chironomidae	35.45	29.66	11.79	25.72	23.47	2.65	37.50	35.05
Shannon-Weiner Diversity Index	62.28	78.14	93.36	77.08	83.26	21.96	76.26	82.00
Biological Condition Scores								
Taxa Richness	4	4	4	4	4	0	4	4
Hilsenhoff Biotic Index	2	2	2	2	4	2	4	4
Percent Ephemeroptera	0	0	4	2	6	0	6	6
Percent Dominant Taxa	2	4	4	4	4	0	2	2
EPT Index	0	0	0	0	0	0	0	0
Percent Chironomidae	0	2	4	2	2	6	0	0
Shannon-Weiner Diversity Index	4	6	6	6	6	0	6	6
Total Biological Score								
Total Biological Score	12	18	24	20	26	8	22	22
Percent of Reference	29	43	57	48	62	19	52	52
Assessment Designation	Moderately	Moderately	Slightly	Slightly	Slightly	Moderately	Slightly	Slightly

Table C3. Summary of Reference Condition Analysis Biological Metric Scores and Designations – continued.

Metric Scores	SUSQ 10	
	10RS3	10RS5
Number of Individuals	267	246
Taxa Richness	22	19
Hilsenhoff Biotic Index	4.95	5.69
Percent Ephemeroptera	20.2	6.1
Percent Dominant Taxa	31.8	56.9
EPT Index	15	8
Percent Chironomidae	31.8	4.1
Shannon-Weiner Diversity Index	2.15	1.70
Percent of Reference		
Taxa Richness	78.57	67.86
Hilsenhoff Biotic Index	72.20	62.77
Percent Ephemeroptera	20.22	6.10
Percent Dominant Taxa	31.84	56.91
EPT Index	78.95	42.11
Percent Chironomidae	31.84	4.07
Shannon-Weiner Diversity Index	82.54	65.32
Biological Condition Scores		
Taxa Richness	4	4
Hilsenhoff Biotic Index	4	2
Percent Ephemeroptera	4	2
Percent Dominant Taxa	2	0
EPT Index	2	0
Percent Chironomidae	2	6
Shannon-Weiner Diversity Index	6	4
Total Biological Score		
Total Biological Score	24	18
Percent of Reference	57	43
Assessment Designation	Slightly	Moderately