2003 Savannah River Biological Monitoring Studies for the Westinghouse Savannah River Company

Report No. F04-06

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THE ACADEMY OF NATURAL SCIENCES

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INTRODUCTION

In 2003, the Academy of Natural Sciences of Philadelphia (ANSP) conducted biological monitoring of the Savannah River for Westinghouse Savannah River Company. The 2003 investigation was the 52nd survey in a series of multiple trophic level biological studies of the river in the vicinity of the Savannah River Site near Augusta, GA by the Academy.

STUDY DESIGN

The methods employed by the Academy to evaluate the conditions of aquatic communities were developed by Dr. Ruth Patrick (1949). Patrick and subsequent biologists have noted that the value of species richness across all the major biological components of an aquatic ecosystem and their relative abundances coupled with known pollution tolerances can provide the strongest, most cost-effective measures of an aquatic environment. These data, along with strong quantitative assessments, provide a broad base for evaluation of river health. Such studies not only permit an assessment of the condition of the aquatic community at the time of the study but can also detect temporal changes.

The major biological components include algae, macroinvertebrates and fishes and span a broad range of ecological roles and trophic levels. This broad assemblage is used because there is no single group that can act as a consistent and reliable measure of every component of ecosystem health due to the ecological complexity of large river systems, and no single group or measure is the best indicator of water quality.

Algae, along with macrophyte communities, are the major constituents of the aquatic flora in riverine environments and are important components of an aquatic ecosystem at the base of the food web. The aquatic flora, through photosynthesis, produces free oxygen, an essential element of most aquatic organisms, and provides shelter and habitat for aquatic organisms. Diatoms (algae with silica-impregnated walls) are used as biological indicator organisms because they represent the predominant periphyton (attached algae) in most water bodies. Macroinvertebrates are an eclectic assemblage that provide the main route of energy flow from the primary producers (algae) and particulate organic matter to higher trophic levels such as fishes. Because of the sedentary or near sedentary nature of many macroinvertebrate species and their wide range of pollution tolerances, they are viewed by state and federal environmental agencies as one of the most important measures of the health of an aquatic ecosystem. In general, the top carnivores in the ecosystem and those species of greatest interest to the public are the fishes. Because of their value and popularity, fish, along with invertebrates, constitute the groups of most concern by regulatory agencies monitoring the health of aquatic ecosystems.

In 2003, the Savannah River biomonitoring program consisted of the following: Diatometer monitoring monthly at Stations 1, 2B, 5 and 6; insect artificial substrates deployed during the spring and late summer periods at Stations 1, 5 and 6 and comprehensive insect collections in late summer at Stations 1 and 6; comprehensive non-insect macroinvertebrates surveys at Stations 1, 5 (mussels only) and 6 in late summer; and fish studies in late summer consisting of boat electrofishing at Stations 1, 5 and 6 and seining at Stations 1 and 6. Only the results of the August/September Diatometer and insect artificial substrate samples from Stations 1 and 6 are reported herein. The remaining samples are archived at the Academy of Natural Sciences and Stroud Water Research Center (SWRC).

LOCATION AND DESCRIPTION OF STATIONS

To assess the impact of a particular effluent upon its receiving waters, sampling must be conducted in ecologically similar habitats in river segments influenced by various tributary streams and/or discharges and in an area unaffected by specific inputs to the river. In this manner, the effects of the discharge on the aquatic community can be isolated from natural variability. Whereas every effort has been made to select the stations as comparable as possible in terms of habitat types, Stations 5 and 6 appear to be more similar physically than the other stations. They occur in a more downriver meandering section of the river and contain nearby oxbows and sloughs as potential sources of biota. Only quantitative algal and insect samples from Stations 1 and 6 were examined for this report, and therefore only those stations are described below. The locations of all the historical stations are depicted in Figure 1.

Station 1 (Fig. 1)
This station comprises a section of the river upstream from Upper Three Runs Creek and any potential impacts of the SRS. The area lies approximately between RM (River Mile) 160.35 and RM 160.85, Burke County, GA and Aiken County, SC. The upper limit of the station is about 1.0 river miles downriver from Shell Bluff Landing, Burke County, GA. Pilings (#78) are present near the upper limit of the station on the left (oriented downriver), or South Carolina, side of the river, and the lower boundary is marked by a rip rap right bank and a small tributary on the Georgia side of the river. Sandy beaches are present among the pilings.

Station 6 (Fig. 1)
The downrivermost Savannah River station, below the confluence of Lower Three Runs Creek, lies in Screven County, GA and Allendale County, SC. The upper end of the station is 1.75 river miles downriver from Johnson's Landing, Allendale County. The station consists of two sections referred to in the 1984 and subsequent studies as reaches. The historical upper reach, located between RM 123.00 and 123.55, contains a large sand beach on the left (South Carolina) bank near its upper end and another sand beach and large backwater along the right (Georgia) bank. The lower reach ranges from RM 122.85 downstream to RM 122.35. The upper limit of this reach includes a large left bank backwater at Ring Jaw Point, and the lower extent is marked by a set of pilings (#42) on the same side of the river. A large sand bar extends out and toward the left bank at Ring Jaw Point. Because of previous damage to the Diatometers at the upper reach, they as well as other study elements were moved to the lower reach in the 1980s. Prior to the 1980s, other groups also, at times, extended their sampling from the upper reach into the backwater behind Ring Jaw Point. Currently, only the fisheries investigation continues to utilize both the upper (seining along the sandy left bank beach) and lower reaches of Station 6.

PERSONNEL AND ACKNOWLEDGMENTS

These studies were performed under the supervision of Dr. Ruth Patrick, Francis Boyer Chair of Limnology, and Dr. David D. Hart, Director, Patrick Center for Environmental Research, ANSP. Dr. Raymond W. Bouchard, Project Leader, was responsible for the professional quality of all field and laboratory work. Robin S. Davis, Scientific Editor, coordinated the data for the report. The direction and implementation of individual project elements were the responsibility of the Principal Scientific Investigators. The following are the personnel who participated in the 2003 Savannah River studies.

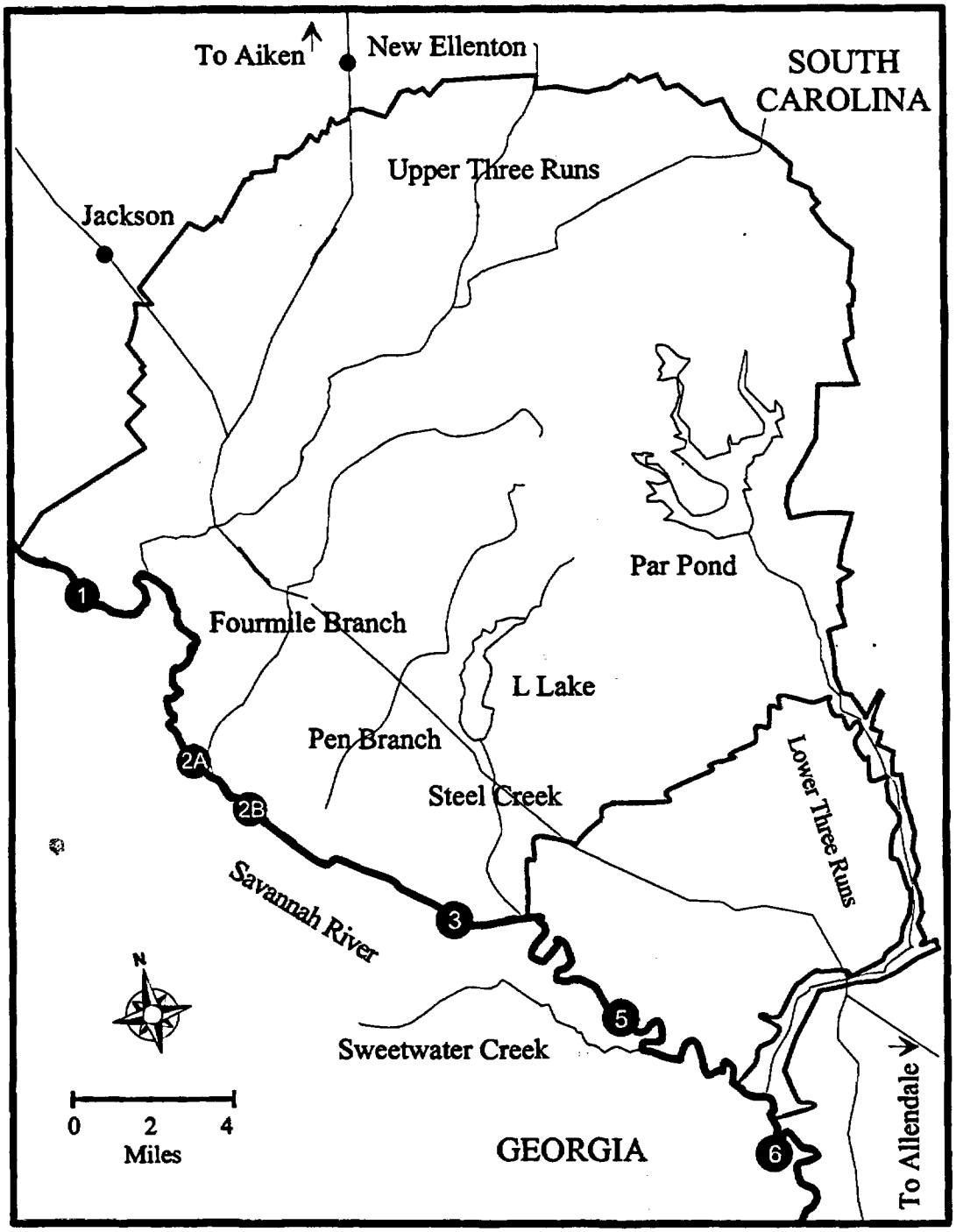

Figure 1. Map of the Savannah River showing the locations of historical sampling stations for ANSP studies.

Diatometer Studies
Supervisor: Frank Acker, M.S.
Principal Scientific Investigators:
Frank Acker, M.S., Raymond W. Bouchard, Ph.D.
and Donald Charles, Ph.D.
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Diatom Analyses and Taxonomy: Eduardo Morales, Ph.D.

Insect Studies
(Stroud Water Research Center)
Supervisor and Principal Scientific Investigator:
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Field Biologists: David H. Funk and
Andrew Byler
Laboratory Biologist: David H. Funk,
Roberta M. Weber, Sally Peirson and Andrew Byler

Macroinvertebrate Studies
Supervisor and Principal Scientific Investigator:
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Quality Assurance
Quality Assurance Officer: Robin S. Davis

Scientific Communications
Scientific Editor: Robin S. Davis
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We wish to thank Mr. Donald Padgett of the Savannah River Site (SRS) for his valuable assistance and the many courtesies extended during the 2003 studies. We also wish to thank Mr. Glenn Laidig, Augusta, GA for access to his launch facilities near Station 1.

DIATOMETER STUDIES

Methods and Procedures

Sampling Method

Diatoms were collected by a device called a Catherwood Diatometer, an apparatus designed to sample the diatom flora in a continuous and nonselective manner. Vertically oriented glass slides serve as artificial substrates for colonization by diatoms. The diatometers are designed to float so that the slides remain just below the water's surface. They are secured to anchors by means of nylon cord and, by adjusting the length of this cord, they are kept afloat at all times, regardless of changing water levels.

Diatometers were deployed at four stations (1, 2B, 5 and 6; Fig. 1) along a 59.9-km (37.2-mi) stretch of the Savannah River in the vicinity of the Savannah River Site (SRS). At each station, two diatometers were placed near the left bank and one diatometer was located near the right bank (by convention, right and left banks are determined by facing downstream). Deployments were made for 12 monthly 2-wk periods. Slides from one diatometer at Stations 1 and 6 were analyzed for the August exposure period. Slides from the other months of 2003 were not analyzed and are stored for future reference. When possible, slides from a diatometer positioned on the side nearest the SRS (left bank) were analyzed. Previous studies (Patrick, Hohn and Wallace 1954) have determined that an exposure period of two weeks is optimal for the collection of a representative growth of diatoms. After exposure, the glass slides were removed from the diatometers and allowed to air dry. The diatometers were replaced by cleaned diatometers and most of the 2003 exposed slides have been shipped to the Academy's laboratory in Philadelphia for retention as part of the Academy's permanent record of the diatom community in the Savannah River since the 1950s.

Laboratory Techniques

The dried slides were first soaked in distilled water, making it possible to remove the diatoms without breakage by scraping the glass slides. The material was then cleaned by a nitric acid digestion procedure (CEM Model 2000 microwave digestor ANSP SOP P-13-42) and, after rinsing by a repeated sedimentation and decanting process, resuspended in 20 ml of distilled water. This procedure removes all organic material from the sample, leaving the empty siliceous shells (frustules) of the diatoms. A known quantity of the cleaned material was placed on an 18 x 18-mm coverslip, air-dried and mounted in Naphrax (a synthetic mounting medium of refractive index 1.6; ANSP SOP P-13-49) on a glass microscope slide.

Identifications and Counts

Specimens on the prepared slides were progressively identified to species and variety, and counted and recorded using a compound microscope with an oil immersion objective and a minimum magnification of 1000x. The detailed reading method (ANSP SOP P-13-39) was employed for the exposure period ending 19 August 2003. In the detailed readings, between 6,000 and 28,000 specimens were counted and identified until the criteria for a lognormal distribution, as described in Patrick, Hohn and Wallace (1954), were met. This method ensured that comparable units of assemblages were compared from station to station.

Data Analysis

The underlying assumption of the reading method is that the relative abundance of diatom species of unpolluted rivers closely follows a lognormal distribution, with a few species very abundant and a few very rare, but the majority of the species represented by populations of moderate abundance. The numbers of species in a hypothetical diatom assemblage are grouped as a function of the numbers of individuals representing each species. The vertical axis identifies the numbers of species whose respective individuals fall within the log-scaled intervals of the horizontal axis. The mode of an extended count needed to produce such a curve is ideally positioned in the third interval. The body of the curve is composed of the majority of species, which are represented by populations of moderate abundance.

In diatom assemblages that might be found in a polluted river, conditions are often indicated by the loss of many species in the system. In this situation, the body of the curve is composed of many fewer species represented by populations of moderate abundances and the tail of the curve is extended as the abundances of the dominant species become relatively greater.

The method used to construct these curves was adapted from procedures described by Patrick, Hohn and Wallace (1954), Cohen (1961) and Hendrickson (1998). The model of a truncated normal curve to express the structure of a natural community of organisms was first used by Preston (1948) to convey the structure of communities of birds and moths. Patrick, Hohn and Wallace (1954) found that this method of analysis was excellent to show the structure of natural diatom communities.

Results from the Structure of the Lognormal Curve

Detailed diatometer readings were carried out for the exposure period ending 19 August 2003. The frequency distributions of diatom species at Stations 1 and 6 are illustrated in Figures 2 and 3.

The results of the detailed diatometer reading at Station 1 (Fig. 2), located upriver from Upper Three Runs and the SRS, but below the city of Augusta, reveal the height of the mode was about 12 diatoms and in the second interval. The curve extended 10 intervals, which lies within the 10 to 12 range for normal conditions (q.v., ANSP, 2003). There were 79 species in the diatom community dominated by *Gomphonema* species 17, *G. lagenula* and *G.* species 14. *Gomphonema* spp. 17 and 14 and *G. lagenula* have been recently distinguished from *Gomphonema parvulum*, the most common and morphologically variable species found in Savannah River studies (q.v., ANSP, 2003). Recognizing these three taxa as separate species better reflects the diversity of the Savannah River diatom community and provides more ecological information because each species has somewhat different environmental tolerances. This should improve the use of diatoms as indicator organisms in Savannah River bioassessments.

Results of the detailed diatometer readings for Station 6 (Fig. 3), located downriver from Lower Three Runs and the SRS, show the height of the mode was about 11 and the curve extended 11 intervals (normal conditions range from 10 to 12). The height of the mode was in interval 2. There were 75 species in the diatom community, which was dominated by *G.* species 14 and *G.* species 17.

The composition of diatom species in the Savannah River up- (Station 1) and downriver (Station 6) from the SRS was similar during the August 2003 study period. The interval of the mode (2 at both stations),

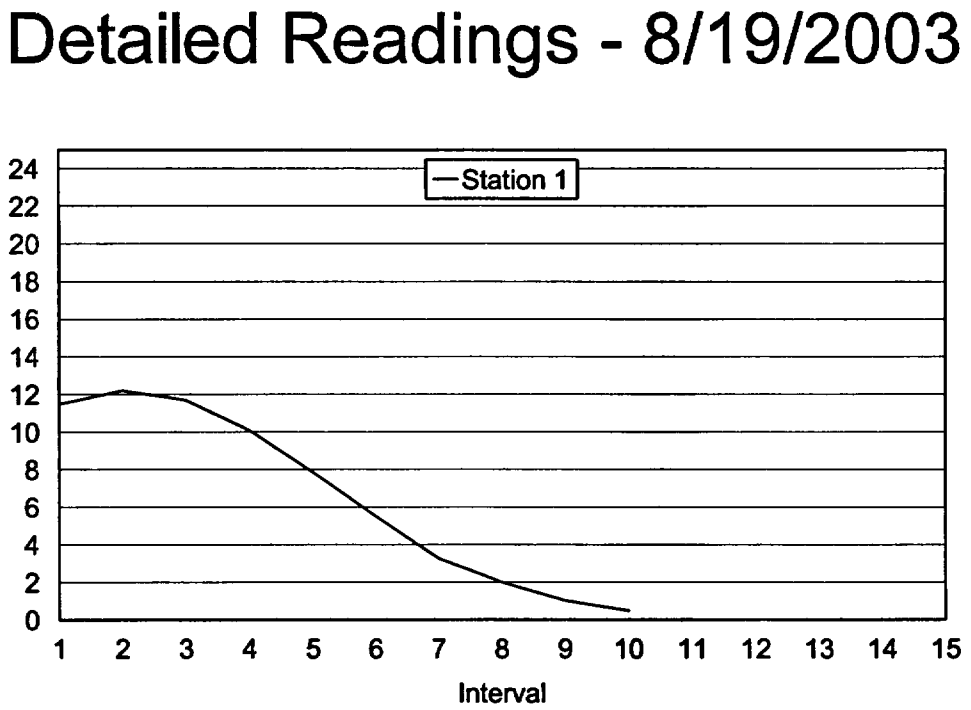

Figure 2. Frequency distribution of diatom species at Station 1 from the detailed reading for the exposure period ending 19 August 2003, Savannah River, South Carolina (number of species is represented in the vertical axis).

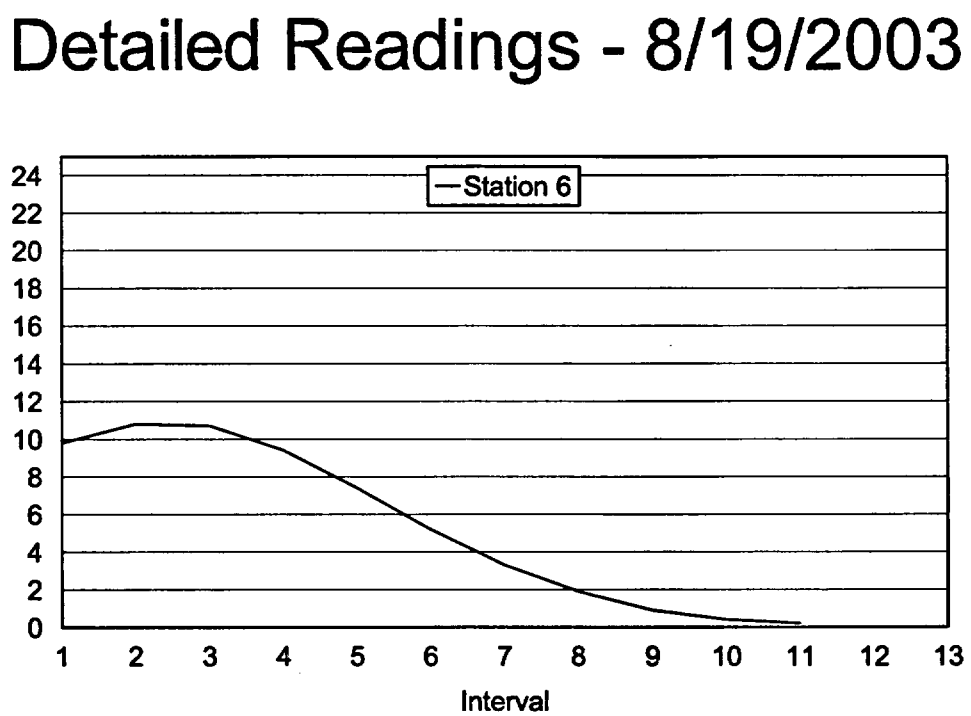

Figure 3. Frequency distribution of diatom species at Station 6 from the detailed reading for the exposure period ending 19 August 2003, Savannah River, South Carolina (number of species is represented in the vertical axis).

height of the mode (12 and 11, at Stations 1 and 6, respectively), extension of the curve (10 and 11) and number of species (79 and 75) were similar for the two stations.

Species composition was similar at the two stations. The overwhelming dominance of a few *Gomphonema* species and the low abundance of the majority of species were also similar. Ecological tolerances of diatom species found on diatometer slides in the Savannah River in the vicinity of the SRS during the 2003 studies, determined from a compilation of diatom literature (Lowe 1974; Beaver 1981; ANSP ecological records), were similar for the dominant species at both stations.

Historically, nearly all of the dominant diatom species in the Savannah River in the region of the SRS have been characteristic of alkaline waters (optimum growth when the pH is greater than 7) with moderately high nutrient concentrations (i.e., eutrophic; Lowe 1974).

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AQUATIC INSECTS

Introduction

In September 2003, qualitative and quantitative aquatic insect collections were made at two stations near the SRS – Stations 1 and 6 (numbered from upstream to downstream; Table 1). Stations 1 and 6 have typically been sampled as part of the Academy's Savannah Cursory and Comprehensive surveys. Fall sampling during all recent surveys (1998-2001) has been completed during the same general time period (6-20 September) due to consistently low flows.

The qualitative sampling area for aquatic insects at Station 1 included all available habitats among the pilings near marker #78 on the left bank (facing downstream) and along the right bank opposite the pilings. In addition, any unique habitats observed within approximately 75 m upstream or downstream of these areas (on either bank) were also sampled. Quantitative sampling of aquatic insects was conducted with floating artificial substrates tied to objects on the left and right sides of the channel at or a little upstream of piling marker #78.

The qualitative sampling area for aquatic insects at Station 6 included all available habitats among the pilings near marker #42 on the left bank (facing downstream) and along the right bank opposite the pilings. In addition, any unique habitats observed within approximately 75 m upstream or downstream of these areas (on either bank) were also sampled. Quantitative sampling of aquatic insects was conducted with floating artificial substrates tied to objects on the left and right sides of the channel near piling marker #42.

Although qualitative and quantitative samples were collected, only quantitative data for September 2003 samples from Stations 1 and 6 were examined for this report. The qualitative samples remain unprocessed and will be archived at the SWRC.

Quantitative Sampling

Floating artificial substrates (insect "traps") were used to provide quantitative samples of insect abundance, even if high flow conditions made qualitative collections difficult. Traps were constructed of 0.64-cm (0.25-in) mesh hardware cloth in the form of a box, with dimensions of 15.2 cm x 20.3 cm x 30.5 cm (6 x 8 x 12 in). Each trap was filled with 9-10 rectangular sheets (approximately 20.3 x 30.5 cm) of Conservation Webbing (3M Company) to provide an interior substrate for aquatic insects. One rectangular piece of Styrofoam was added to the top of each trap for buoyancy because traps that sink tend to fill with silt, contain fewer insects, and can be difficult to retrieve in the field. The traps were tied to tree branches or pilings and left floating in the water. Four traps were placed in the field at the beginning of the colonization period. After colonization, the traps that remained (three to four of the four placed in the field) were removed from the river and placed separately in large plastic tubs. Upon retrieval, current velocities varied among traps (i.e., some traps were retrieved from slow current while others were retrieved from fast current). On shore, the insects were removed from the traps by placing the traps in a water-filled basin (20-gallon) and rinsing each piece of Conservation Webbing with clean river water from a battery powered pump. Slapping the webbing against the side of the basin also

helped dislodge some specimens. Then, each piece of webbing was scrubbed with a large plastic brush and clean river water was sprayed onto the webbing to remove the last of the attached detritus/insects. Finally, the contents of the holding tub and wash basin were poured through a pair of sieves which included a home-made sieve with 1.8 x 1.4-mm rectangular mesh (used in 1997 and earlier years and referred to as the coarse sieve) followed by a standard 0.5 x 0.5-mm mesh sieve (used in 1998-2002 and referred to as the fine sieve). All material (both insects and detritus) retained by the coarse sieve was transferred into a jar containing 10% buffered formalin. All material retained by the fine sieve was transferred into a separate jar which also contained 10% buffered formalin. Material retained by the coarse sieve was kept separate from that retained by the fine sieve in order to examine the potential impact of a reduction in mesh size (from 1.8 x 1.4-mm to 0.5 x 0.5-mm; done at the request of SRS) on the quantitative data and allow samples collected in 2003 to be compared to those collected prior to 1998. Each sample was labeled (with permanent black ink) on the lid and outside of the jar with information concerning river, station, date, and trap number. Notes pertaining to trap placement, conditions, and any other pertinent information were recorded in a field notebook. Samples were transported to the SWRC and stored until processing.

In the laboratory, we processed three trap samples from each site and sampling date. Each trap sample was split into four subsamples (each = 1/4th of a sample unit), one of these subsamples was split again into four subsamples (each = 1/16th of a sample unit), and finally one of these subsamples was split into four subsamples (each = 1/64th of a sample unit). Subsamples from the coarse and fine sieves were then processed (sorted and identified) until the combined material examined totaled over 100-200 individuals. Because macroinvertebrate densities varied among samples, the subsamples represented a greater portion of some samples relative to others. Sample processing involved separating the aquatic insects from the detritus under a dissecting microscope. All specimens were identified to family level when possible. Then, all Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) were taken to the lowest level possible (usually genus/species). The level of identification depended on the size and condition of the individual specimens and the availability of taxonomic keys. Identifications were done with the aid of a dissecting microscope (4-50 X magnification) or compound microscope (40-1000 X magnification). Individuals of each taxon from a given sample were enumerated and most taxa were placed in separate vials and preserved in 80% ETOH for future reference. Selected specimens collected in 2003 have been incorporated into the permanent collections at the SWRC.

The insect identifications from the coarse and fine sieves were combined to generate density estimates for each family and all families combined, and for each EPT genus/species and total EPT density. These estimates are representative of the entire sample (expressed as insects per trap). The number of insects per trap can differ several fold among traps, which can affect the comparability of richness estimates (because some measures of community structure such as richness measures increase as the number of individuals examined increases). Thus, prior to estimating richness (but not density), all samples were standardized. To compensate for this potential bias, we used a computer program that employed a resampling without replacement routine, to standardize samples to a preset number of individuals. In this case, that preset number was 100 because this is a standard number commonly used in water quality monitoring programs. With this correction, differences among richness measures reflect differences in community structure rather than differences in number of individuals examined per trap. EPT Richness does not include redundant taxonomic categories (e.g., Unidentified Ephemeroptera was not counted as a separate taxon if another mayfly family was also identified from that sample).

Results

EPT Richness – We identified a total of 18 species from 11 families (6 Ephemeroptera, 5 Trichoptera) among the 6 samples examined from Stations 1 and 6 (Table 2). Two species that were collected at Station 1, but not at Station 6:

Stenonema modestum
Neuroclipsis spp.

Five species that were collected at Station 6, but not at Station 1:

Caenis nr *hilaris*
Stenonema terminatum
Hydropsyche rossi
Macrostemum carolina
Oxyethira spp.

Neoephemera spp. is possibly the sixth species collected at Station 6 but not at Station 1. It is not clear because a few individuals at both Stations 1 and 6 were small and could only be identified as Neoephemeridae/Caenidae.

EPT Richness averaged 8.0 species per 100 insects at Station 1 and 9.7 species per 100 insects at Station 6 (Table 3).

EPT Density – In September 2003, EPT densities averaged 4067 ± 4244 individuals per trap at Station 1, and 5109 ± 2561 individuals per trap at Station 6 (Table 2). EPT density included only mayflies (Ephemeroptera) and caddisflies (Trichoptera); no stoneflies (Plecoptera) were found among the aquatic insects examined, although some were observed in the qualitative collections at the time of collection (SWRC field notes). % EPT density (EPT as a percent of all aquatic insects) was 68% at Station 1 and 90% at Station 6.

The differences described above have not been evaluated with rigorous statistical analysis as has been done in past surveys. However, a qualitative evaluation of the data resulted in no evidence of degradation in water quality as a result of effluent and runoff from the SRS. Rather, it appears that conditions improve as the water flows from Station 1 to Station 6. More EPT taxa were found at Station 6 relative to Station 1. EPT Richness was 21% higher at Station 6 relative to Station 1. EPT density was 25% higher at Station 6 versus Station 1. % EPT Density was 22% higher at Station 6 versus Station 1. Thus, all four measures of EPT taxa increased between Stations 1 and 6. Because EPT taxa are generally sensitive to pollution, this combined response is an indication of an increase in water quality. This pattern is not unique to 2003 – similar responses have been observed in past surveys of aquatic insects at Stations 1 and 6.

Table 4 represents the 100 individual family level subsamples to be used by SRS staff to generate family-level biometrics.

Table 1. Information concerning the placement, retrieval, and processing of Conservation Webbing traps from four stations (on the Savannah River in the vicinity of the SRS) in 2003. Qualitative collections were made on the same dates as traps were retrieved.

Station	Placement Date	Retrieval Date	Number Placed	Number Retrieved	Number Processed
1	5 August 2003	2 September 2003	4	3	3
6	5 August 2003	3 September 2003	4	4	3

Table 2. Densities (individuals per trap) for EPT (Ephemeroptera, Plecoptera, Trichoptera) species and Total EPT collected from Stations 1 and 6 in September 2003. No Plecoptera were collected in 2003. Unid. = unidentified.

Taxa	Station Number and Trap Location						Station 1		Station 6	
	1LL	1LR	1UR	6LL	6LR	6UR	Mean	Std Err	Mean	Std Err
Ephemeroptera										
Leptohyphidae	0	0	0	64	0	0	0	0	21	37
Trichorythodes spp.	256	464	768	64	48	24	496	257	45	20
Caenidae										
Caenis nr *hilaris*	0	0	0	0	16	64	0	0	27	33
Caenis spp.	0	0	0	0	96	80	0	0	59	51
Baetidae										
Baetis intercalaris	0	64	0	128	80	0	21	37	69	65
Baetis spp.	96	0	192	0	32	16	96	96	16	16
Labiobaetis propinquus grp.	48	136	0	0	16	8	61	69	8	8
Unid. Baetidae	208	72	128	128	0	24	136	68	51	68
Heptageniidae										
Stenonema spp.	32	0	128	64	0	48	53	67	37	33
Stenonema terminatum	0	0	0	64	0	0	0	0	21	37
Stenonema modestum	32	40	0	0	0	0	24	21	0	0
Unid. Heptageniidae	128	112	384	320	128	72	208	153	173	130
Isonychidae										
Isonychia spp.	0	0	128	640	800	816	43	74	752	97
Neoephemeridae										
Neoephemera spp.	0	0	0	64	48	8	0	0	40	29
Neoephemeridae/Caenidae	0	64	0	64	0	88	21	37	51	45
Unid. Ephemeroptera	0	0	0	320	0	200	0	0	173	162
Trichoptera										
Philopotamidae										
Chimarra spp.	0	96	1280	1984	1168	824	459	713	1325	596
Unid. Philopotamidae	0	0	0	512	0	96	0	0	203	272
Hydropsychidae										
Cheumatopsyche spp.	128	248	3392	1920	640	272	1256	1851	944	865
Hydropsyche spp.	0	0	512	512	0	8	171	296	173	293
Hydropsyche mississippiensis	32	64	0	320	64	0	32	32	128	169
Hydropsyche rossi	0	0	0	64	0	0	0	0	21	37
Macrostemum spp.	0	0	0	0	224	232	0	0	152	132
Macrostemum carolina	0	0	0	64	0	0	0	0	21	37
Unid. Hydropsychidae	176	224	1920	576	208	432	773	993	405	185
Hydroptilidae										
Hydroptila spp.	96	32	0	0	0	32	43	49	11	18
Oxyethira spp.	0	0	0	0	32	0	0	0	11	18
Unid. Hydroptilidae	16	0	128	0	16	0	48	70	5	9
Leptoceridae										
Nectopsyche spp.	32	0	0	0	0	0	11	18	0	0
Oecetis spp.	80	40	0	64	96	72	40	40	77	17
Unid. Leptoceridae	0	0	0	64	16	16	0	0	32	28
Polycentropodidae										
Neuroclipsis spp.	0	128	0	0	0	0	43	74	0	0
Unid. Polycentropodidae	0	64	0	64	0	8	21	37	24	35
Unid. Trichoptera	32	0	0	0	0	96	11	18	32	55
EPT Density	1392	1848	8960	8064	3728	3536	4067	4244	5109	2561
% EPT	53	66	85	91	89	90	68	9	90	1

Table 3. Presence and abundance of EPT taxa in a 100 individual subsample drawn at random from each sample. Unid. = unidentified.

	Station 1			Station 6		
Taxon	LL1	LR1	UR1	LL6	LR6	UR6
EPHEMEROPTERA						
Unid. EPHEMEROPTERA	-	-	-	3	-	4
LEPTHYPHIDAE						
TRICORYTHODES SPP.	7	24	7	-	1	-
CAENIDAE						
CAENIS NR.HILARIS	-	-	-	-	-	2
CAENIS SPP.	-	-	-	-	1	-
BAETIDAE						
BAETIS INTERCALARIS	-	1	-	1	-	-
BAETIS SPP.	5	-	2	-	-	-
LABIOBAETIS PROPINQUUSGRP	-	3	-	-	-	1
Unid. BAETIDAE	4	-	-	-	-	-
HEPTAGENIIDAE						
STENONEMA TERMINATUM	-	-	-	1	-	-
STENONEMA MODESTUM	4	1	-	-	-	-
STENONEMA SPP.	5	-	1	-	-	2
Unid. HEPTAGENIIDAE	5	5	5	4	6	3
ISONYCHIDAE						
ISONYCHIA SPP.	-	-	-	7	15	25
NEOEPHEMERIDAE						
NEOEPHEMERA SPP.	-	-	-	2	1	-
NEOEPHEMERIDAE/CAENIDAE	-	1	-	1	-	1
TRICHOPTERA						
Unid. TRICHOPTERA	3	-	-	-	-	1
PHILOPOTAMIDAE						
CHIMARRA SPP.	-	4	10	26	30	25
Unid. PHILOPOTAMIDAE	-	-	-	2	-	3
HYDROPSYCHIDAE						
CHEUMATOPSYCHE SPP.	5	7	40	27	19	5
HYDROPSYCHE SPP.	-	-	6	5	-	-
HYDROPSYCHE MISSISSIPPIENSIS	2	1	-	1	2	-
HYDROPSYCHE ROSSI	-	-	-	2	-	-
MACROSTEMUM SPP.	-	-	-	-	5	6
Unid. HYDROPSYCHIDAE	4	8	18	8	7	8
HYDROPTILIDAE						
HYDROPTILA SPP.	4	1	-	-	-	1
Unid. HYDROPTILIDAE	-	-	-	-	1	-
LEPTOCERIDAE						
NECTOPSYCHE SPP.	1	-	-	-	-	-
OECETIS SPP.	3	-	-	1	1	-
Unid. LEPTOCERIDAE	-	-	-	1	-	-
POLYCENTROPODIDAE						
NEURECLIPSIS SPP.	-	6	-	-	-	-
Unid. POLYCENTROPODIDAE	-	1	-	-	-	1
EPT Richness/100 insects	8	10	6	9	11	9
Mean ± 1 SE		8±1.2			9.7±0.7	

Table 4. Presence and abundance of aquatic insect families in a 100 individual subsample drawn at random from each sample. Family Richness does not include redundant taxonomic categories [e.g., Unidentified (=Unid.) Ephemeroptera was not counted as a separate taxon if another mayfly family was also identified from that sample].

	Station 1			Station 6		
Taxon	LL1	LR1	UR1	LL6	LR6	UR6
ODONATA	-	-	1	-	-	-
MACROMIDAE	-	-	-	-	2	-
Unid ZYGOPTERA	-	-	-	-	2	-
Unid EPHEMEROPTERA	-	-	-	3	-	4
TRICORYTHIDAE	7	24	7	-	1	-
CAENIDAE	-	-	-	-	1	2
BAETIDAE	9	4	2	1	-	1
HEPTAGENIIDAE	14	6	6	5	6	5
SIPHLONURIDAE	-	-	-	7	15	25
NEOEPHEMERIDAE	-	-	-	2	1	-
NEOEPHEMERIDAE/CAENIDAE	-	1	-	1	-	1
Unid TRICHOPTERA	3	-	-	-	-	1
PHILOPOTAMIDAE	-	4	10	28	30	28
HYDROPSYCHIDAE	11	16	64	43	33	19
HYDROPTILIDAE	4	1	-	-	1	1
LEPTOCERIDAE	4	-	-	2	1	-
POLYCENTROPODIDAE	-	7	-	-	-	1
SIMULIIDAE	-	1	-	-	3	2
CHIRONOMIDAE	45	30	10	8	3	10
EMPIDIDAE	3	6	-	-	1	-
Family Richness	9	11	7	10	14	13