

# **Watershed Assessment of the Lower Crum Creek: Decision Support for a Community-Based Partnership**

**Final Report:  
Nonpoint Source Management and  
Watershed Restoration and Assistance Program Project**

**October 31, 2001**

Arthur E. McGarity  
Department of Engineering  
Swarthmore College  
Swarthmore Pennsylvania

Project Sponsor: Swarthmore College

Other Sponsors:

Chester-Ridley-Crum Watersheds Association  
Swarthmore Borough Environmental Advisory Council  
Nether Providence Township Environmental Advisory Council  
Springfield Township Environmental Advisory Council

Funding Sponsor

This project was funded through the **U.S. Environmental Protection Agency's Section 319 Program** administered by the **Pennsylvania Department of Environmental Protection Nonpoint Source Management Program**, Project Number ME# 359457.

## Acknowledgements

The following report was written primarily by the Project Director, **Arthur E. McGarity**, with assistance in preparation and writing from the project staff, listed below.

1. **Frank Dowman**, summer Laboratory Manager at Swarthmore College and science teacher, Sun Valley High School
2. **Kristin Chadderton**, summer Data Manager, GIS Analyst, and engineering graduate of Swarthmore College, class of 2001
3. **Marc Jeuland**, summer QA/QC Program Developer and engineering honors graduate of Swarthmore College, class of 2001
4. **Michelle Mizumori**, summer Watershed Modeler and engineering graduate of Swarthmore College, class of 2001
5. **Clara Fuchsman**, summer Metals Analyst and biochemistry honors graduate of Swarthmore College, class of 2001
6. **Elaine Lennox**, summer Howard Hughes Medical Institute (HHMI) research participant and science teacher, Ridley High School
7. **Emily Ford**, summer HHMI research participant, Strath Haven High School
8. **Ericka Beverly**, summer HHMI research participant, Chester Academy
9. **Andrew Combs**, summer HHMI research participant, Strath Haven High School
10. **Chris Fabiano**, summer HHMI research participant, Ridley High School
11. **Part-time monitoring and work crew**: Nick Childers, Gordon Davis, Will Eckenhoff, Bill Gross, Richard Hall, Mike McGarity, Owen McGarity, Sam McGarity, Seth Miran

This project was funded through the **U.S. Environmental Protection Agency's Section 319 Program** administered by the **Pennsylvania Department of Environmental Protection Nonpoint Source Management Program**, ME# 359457.

# **Watershed Assessment of Crum Creek: Decision Support for a Community-Based Partnership**

**Final Report  
October 31, 2001**

## **Executive Summary**

This report presents results from a two-year watershed assessment study of conservation and restoration options for the lower reaches of the Crum Creek watershed, located in the heavily developed western suburbs of Philadelphia, Pennsylvania. This stream is stressed in its lower reaches by wet-weather flows of nutrient rich and sediment-laden stormwater, bank erosion, and leaks from sanitary sewer systems, and is listed on the USEPA's 303(d) list of impaired waterways.

The assessment project has made significant progress in five areas: (1) watershed partnership development and growth, (2) public awareness of problems in the watershed and potential solutions through two conference/workshops, (3) growing involvement of Swarthmore College in local watershed studies and protection activities, (4) monitoring of water quality with database development, and (5) developing proposals and preliminary designs for implementation projects that will begin the process of watershed restoration.

Results in each of these areas are reported in separate sections of this report. Especially significant are results relating to the successful creation of a watershed-wide partnership of municipalities, businesses, and institutions in the Crum Creek watershed which now includes representatives from virtually all of the municipalities in the watershed, from the headwaters in Chester County and through the middle and lower sections in Delaware County to the confluence with the Delaware River. The Crum Creek Watershed Partnership (CCWP) contributed to the development of a successful proposal to Pennsylvania's Growing Greener program to perform assessment of the upper reaches of the watershed. CCWP has also submitted a proposal to the Growing Greener program to begin high priority restoration projects in the lower watershed.

Selection of restoration projects was assisted by the monitoring and modeling activities conducted at Swarthmore College by the faculty and students involved in the project which helped to identify "hot spots" requiring immediate corrective action by municipalities and "restoration opportunities" that generated proposals for implementation of best management practices (BMP's). The project has successfully integrated watershed assessment and partnership building activities into the environmental studies and engineering curricula at the College. Students in three different courses participated in the project over two academic years. Senior engineering design students developed preliminary designs for BMP projects and constructed an experimental constructed wetland facility for treating a portion of the College's stormwater runoff flow.

The main recommendations of this project are (1) that efforts be continued in support of the partnership approach to protection and restoration of the watershed, (2) that the proposed restoration projects be funded and implemented, (3) that the performance of the projects be monitored for an extended period after completion, and (4) that the methodology developed for this project be used throughout the Crum Creek watershed to assess potential sites for restoration and protection projects and to work through the Crum Creek Watershed Partnership to prioritize projects and to develop feasible and economical implementation plans.

## **1. Background**

The Crum Creek watershed is located in the heavily developed suburbs of Philadelphia, Pennsylvania. The watershed's Hydrologic Unit Code (HUC) is 2040202. The lower reaches of the stream appear in the Section 303 listing of impaired waterways based on data from the Surface Water Monitoring Program. The watershed drains an area of about 40 square miles in the southern edge of the Piedmont region, flowing from north to south through a ridge-valley system that merges at its southern end with the Atlantic coastal plain and the Delaware River estuary. The creek's headwaters are just south of the east-west "mainline" ridge where U.S. Highway 30 emerges from Philadelphia. Its middle reaches are crossed by another major east-west commuter highway, Pennsylvania Route 3. South of Route 3, the creek forms Springton Lake, a storage reservoir owned by the Philadelphia Suburban Water Company (PSWC), which is an investor owned water utility serving most of Philadelphia's northern and western suburbs. The PSWC controls the flow downstream of the reservoir so as to keep its intake pond full. The intake supplies a filtration plant that purifies the water for distribution to residences and businesses in the area. During low-flow periods, the PSWC has the legal right to take the entire flow of the stream.

Figure A-1, in Appendix A, shows a map of the entire Crum Creek watershed. The creek and its major tributaries are shown. Sections that have been designated "attained use" are shown in blue, indicating that water quality requirements are currently satisfied for the designated uses of those sections. Sections that have been designated "impaired" are shown in red, indicating that some kind of corrective measure will be necessary to restore these sections in order to attain federal and state water quality goals. Only a small section of the stream in the tidal zone at Eddystone Borough is still unassessed.

U.S. Highway 1 crosses the stream just above the water supply intake pond and Interstate Highway 476 (I-476) passes just to the east of the pond. I-476 was constructed in the late 1980's on a controversial route (called the "Blue Route") that involves multiple crossings of the stream. The map shows these crossings, as well as three major intersections that I-476 makes with other highways: with U.S. 1 just above the intake pond, with Baltimore Pike near the center of the map, and with Interstate Highway 95, at the bottom center of the photo. I-476 connects I-95 with the Pennsylvania Turnpike, and it is heavily used for commuter traffic and interstate travel and commerce since it serves as the primary bypass route to the west of Philadelphia.

Large single-family homes and commercial establishments near the highways characterize development in the upper reaches of the watershed. There is some commercial agriculture in this area. The lower reaches are more densely settled in the communities of Springfield, Nether Providence, Swarthmore, and Ridley. There is intense pressure to develop for residential and commercial use the remaining wooded areas and green space over the entire the watershed. The stream is particularly stressed in the lower reaches by wet-weather flows of sediment-laden stormwater, bank erosion, and sanitary sewer leaks. The stream is also stressed during dry weather because of withdrawals from the stream at the PSWC intake pond that are necessary to meet the demands for water in the region. The problems on the Crum Creek watershed are typical of many watersheds in urban/suburban regions. Thus, the results of this project and the successful creation of a watershed-wide partnership for restoration and protection of the watershed can serve as an example for similarly stressed watersheds in other urban areas in the Commonwealth and around the nation.

## **2. Partnership Development and Growth**

There are many diverse groups and agencies with interests in the health of the Crum Creek watershed including the Chester-Ridley-Crum Watersheds Association (CRCWA), municipal governments and their Environmental Advisory Councils, volunteer monitoring organizations, sporting clubs and public park advocates, two land conservation trusts, the Philadelphia Suburban Water Company (PSWC), a large water utility company with a reservoir and filtration plant on the stream, and land owners including a major shopping mall and Swarthmore College. A partnership among certain of these groups in the lower reaches of the watershed was formed in 1999 with the goals of reducing nonpoint source pollution in the watershed and restoring the watershed so that it will meet the nation's water quality goals. The initial, "core" members of the partnership included the Borough of Swarthmore, the Townships of Nether Providence and Springfield, the CRCWA, and Swarthmore College. This initial, loosely organized group provided impetus and support for the proposal that resulted in funding for this assessment project.

During the course of the project, the partnership has become solidly organized and has grown substantially, as indicated by the affiliations of the members of its steering committee. As of March, 2000, the Townships of Marple, Ridley, and Upper Providence and the Borough of Ridley Park had designated persons to serve on the partnership steering committee, for a total of seven municipalities, and the Philadelphia Suburban Water Company was regularly sending a representative to steering committee meetings. The Lower Crum Creek Watershed Partnership, as it was then called, helped to organize the Crum Creek 2000 Conference and Workshop held at Swarthmore College in March, 2000 (details on this conference and the March 2001 conference are included in Section 3 below).

The Crum Creek 2000 conference was publicized widely throughout the watershed, and it attracted many attendees from the middle and upper reaches of the

watershed as well as the lower reaches represented in the partnership. During the discussion sessions held during the workshop, attendees expressed strong sentiment for the idea of expanding the partnership to include the entire watershed. Ongoing discussions after the conference led to the recruitment of representatives from several more municipalities and two nongovernmental organizations. The staff of the Willistown Conservation Trust were particularly helpful in facilitating the growth of the partnership through their extensive network of contacts in the upper reaches of the watershed. In April, 2000, the partnership was renamed the Crum Creek Watershed Partnership (CCWP) when the Townships of Edgmont and Newtown in Delaware County and the Townships of Easttown, and Willistown and the Borough of Malvern in Chester County designated persons to serve on the steering committee. The Natural Lands Trust and the Willistown Conservation Trust were also represented. At the April 2000 meeting, Arthur McGarity of Swarthmore College and Mary McLoughlin of the Willistown Conservation Trust were designated Chair and Vice Chair, respectively, of the steering committee.

At the June, 2000 meeting of the steering committee, the following mission statement was adopted:

The mission of the Crum Creek Watershed Partnership is to improve and protect the Crum Creek watershed including its tributaries, groundwater, and forested valleys to assure the longevity of this precious and vital natural resource for the enjoyment and benefit of current and future generations. To this end, we provide a collaborative framework for representatives from municipalities, institutions, businesses, and communities who share responsibility as stewards of the stream's water quality, supply, and ability to function as a healthy ecosystem.

In March, 2001, Tredyffrin Township (in the upper headwaters of the watershed in Chester County) designated a representative to the steering committee, and a group of "Crum Creek Watershed Associates" was assembled representing government agencies including PADEP, the Conservation Districts of both Chester and Delaware counties (county watershed coordinators), the Chester County Water Resources Authority, plus Schnabel Engineering Associates (contractors on the Crum Creek source water protection study), the Pennsylvania Environmental Council and Eddystone Township (at the mouth of Crum Creek in Delaware County). The Associates receive meeting announcements and minutes and are welcome to attend meetings of the steering committee. On March 24, 2001, the CCWP organized the Crum Creek 2001 Conference and Workshop, held at Swarthmore College. A panel discussion was led by members of the steering committee to discuss the current projects and future plans of the partnership.

The partnership steering committee holds regular bimonthly meetings, and occasionally meets more frequently, when necessary. In addition to sponsoring the two conferences, the committee developed a detailed questionnaire for municipalities to identify problem areas or "hot spots" in the watershed. The results of the questionnaire provide a valuable guide for setting priorities for protection and restoration of the watershed. Representatives from municipalities have interviewed municipal managers

and work crew supervisors to determine the locations of problems such as excessive erosion, leaking or surcharging sewers, flooding problems, etc. In the lower watershed, where the research team at Swarthmore College has been conducting “targeted monitoring” of suspected hot spots (described in detail in Section 5 below), there has been useful interaction between the research team and the municipalities to identify potential sites for monitoring and to determine the sources of nonpoint pollution when hot spots are detected by the monitoring.

Perhaps the most important function of the partnership is facilitating cooperation among municipalities, businesses, educational institutions, and other landowners in the watershed in developing and implementing projects to protect and restore Crum Creek. Regular discussions among committee members about stresses and threats to water quality in the watershed coupled with high quality monitoring data and scientific analysis of problem sites is helping to create consensus regarding priorities to assign to project ideas that require funding to implement. This process resulted in the submission of a proposal to the PADEP Growing Greener Program in March, 2001 for funding to support three restoration projects in four municipalities in the lower Crum Creek drainage area. Rather than competing for limited funds, the Townships of Nether Providence, Ridley, and Springfield and the Borough of Swarthmore worked together under the auspices of the CCWP to develop the project ideas, and Swarthmore College made commitments to sponsor the project and to provide scientific facilities and expertise necessary to monitor the performance of the projects after they are installed. Details on these project proposals are given in Section 6, below. Notification was received from PADEP in late July, 2001 that this proposal will be funded.

The next challenge ahead for the partnership is to obtain recognition and endorsements from the elected governing councils of the municipalities. The steering committee is currently developing a model resolution that will be presented to borough councils and township commissioners. The resolution will contain an endorsement of the partnership’s mission statement and a pledge to support the involvement of the municipality’s partnership representative in the work of the steering committee. As restoration and protection implementation projects are developed, the partnership will be available to play a central role in evaluating and ranking projects, and will be particularly helpful in assisting with joint projects that cross municipal boundaries.

A World-Wide-Web internet site has been created to serve the partnership which is hosted by the web server at Swarthmore College. Meeting announcements, steering committee meeting minutes, and useful watershed links are posted on the site, which has the internet address: <http://watershed.swarthmore.edu>.

### **3. Crum Creek Watershed Conferences**

Two successful conferences were held during the assessment study that benefited the project in many ways. Both conferences were held on the campus of Swarthmore College, and each one attracted more than 100 participants. Residents, municipal leaders, and business leaders from throughout the Crum Creek watershed participated in

the conferences. Also, watershed professionals, land trust staff, and college students attended from throughout the entire Delaware Valley region and from as far away as Harrisburg. Publicity was achieved through press releases and direct mailings based on lists from watershed associations. The first conference (March, 2000) built public awareness of many of the problems facing the watershed, emphasized partnership building, and provided opportunities for persons with concerns about specific problem sites in the watershed to alert the watershed professionals. At the second conference (March 2001), preliminary results of assessment studies were reported, ideas for implementation projects to restore and protect the watershed were discussed and critiqued, and the role of the watershed-wide partnership in implementing these projects was solidified.

The Crum Creek 2000 Conference and Workshop featured an early-morning plenary session, three late-morning concurrent sessions, a networking lunch that encouraged groupings according to sub-watershed, exhibitors' presentations, afternoon breakout group discussions followed by breakout group reporting and open discussion among all conference participants.

The theme of the plenary session was "Watershed Protection, Partnerships, and Stewardship." The concurrent sessions covered three areas: "Watershed Case Studies," "Best Management Practices," and "Watershed Management Tools." Breakout discussion groups were formed according to six different interest areas: (1) Problems and concerns of residents of neighborhoods that adjoin the banks of Crum Creek and its tributaries, (2) Municipal codes and ordinances affecting stormwater runoff into Crum Creek, (3) Water quality: drinking water protection and preservation of ecology and habitat, (4) Commercial and residential land development and business opportunities in the watershed, (5) Fishing, hiking, and other recreation in Crum Creek and adjacent woodlands and parks, and (6) Use of watershed management tools to benefit Crum Creek, including water quality monitoring, databases, and geographic information systems. All sessions were video taped and notes on the discussions in each breakout group were recorded by the group leaders. A copy of the program guide showing details of the entire program and abstracts of the presentations are provided in Appendix G. A conference evaluation form was distributed to all participants to solicit comments on the conference and suggestions for improvement, which were helpful in planning the 2001 conference.

The Crum Creek 2001 Conference and Workshop featured an early morning plenary session with presentations on three different assessment studies underway in the Crum Creek watershed: (1) the Chester County Watershed Conservation Plan being developed by the Chester County Water Resources Authority, (2) the Upper Crum Creek Source Water Protection project sponsored by the Delaware County Conservation District and conducted by Schnabel Engineering Associates and the Philadelphia Suburban Water Company, and (3) the Lower Crum Creek Watershed Assessment Project conducted by Swarthmore College. Morning concurrent sessions were held on "Nonpoint Pollution Control and Stream Restoration" and "Government Programs, Community Organizing and Partnerships." A networking lunch featured poster presentations by Swarthmore College senior engineering students on their design projects related to design of best management practices for nonpoint pollution control and on water quality modeling for



support of watershed management. More details on the student projects are presented in Section 4 below. Afternoon concurrent sessions were held on “Watershed Assessment Tools and Methods” and “Developments on Neighboring Watersheds.” Late afternoon sessions included site visits to stormwater management demonstration and experimentation sites on the Swarthmore College campus, and the conference concluded with a panel discussion “What’s Next for Crum Creek?” - a panel discussion with audience participation on future implementation projects in the watershed led by members of the Crum Creek Watershed Partnership Steering Committee. A copy of the program guide showing details of the entire program and abstracts of the presentations are provided in Appendix G.

#### **4. Curriculum Developments and Institutional Support at Swarthmore College**

The assessment project has heavily involved students, faculty, administrators and facilities of Swarthmore College, which owns substantial land in the watershed on both banks of the creek. Swarthmore is a selective liberal arts and engineering college that is nationally recognized for excellence in undergraduate education, and it attracts students from all regions of the U.S. and many foreign countries. This project has helped to establish mutually beneficial links between the College and local municipalities, government agencies, and other landowners and residents in the watershed.

The Crum Creek watershed provides a case study of a stressed stream in an urbanized setting that is threatened and impaired by nonpoint pollution runoff. Thus, it provides a context for field studies and research as well as opportunities for local community-based learning and service. Moreover, the Crum Woods sections of the College campus provide a wide range of benefits including field sites for ecological field studies of rare and threatened plant and animal species, serene wooded landscapes inspiring artistic expression, and hiking trails for exercise and escape from the intense academic atmosphere. In recognition of the benefits the College receives from its proximity to Crum Creek, the College has made a commitment to support involvement by its students and faculty in scientific studies and service projects and to promote stewardship of the watershed on its own properties.

Student involvement in this assessment project has been substantial. Direct contact in the environmental studies and engineering curriculum with watershed topics has occurred in three different courses: (1) the Environmental Studies Capstone Seminar, required of all students concentrating in Environmental Studies, (2) “Water Quality and Pollution Control,” an elective for environmental engineers in the College’s accredited engineering program, and (3) Engineering Design, a required course for all engineering majors.

During the Spring 2000 semester, senior Environmental Studies students participated in a capstone seminar course on the topic “Water and Watershed Studies.” This seminar focused on the Crum Creek as a case study. The students had a significant role in planning and organizing the Crum Creek 2000 conference. Their research prior to the conference on issues of concern to watershed residents assisted the definition of the workshop breakout groups. The students helped to conduct the conference by chairing

sessions, introducing speakers, leading breakout groups and recording notes on the discussions. The seminar students also conducted team projects involving the Crum Creek watershed including (1) incorporating monitoring data into a computer-based geographic information system (GIS) program, (2) developing an internet web site for watershed studies and the Crum Creek Watershed Partnership ( internet address: <http://watershed.swarthmore.edu>), (3) creating a video for a high school audience on stewardship of Crum Creek, and (4) researching and writing a pamphlet on persons who have made significant contributions to improving the quality of Crum Creek. The pamphlet, called A Sense of Place was published by the College and distributed at the Crum Creek 2001 conference.

In the Fall of 2000, environmental engineering students in Engineering 63: “Water Quality and Pollution Control” learned about the fundamentals of water quality measurement including quality assurance and quality control protocols for sampling and laboratory analysis. Sites on Crum Creek were frequently used to obtain samples for lab exercises. Group projects in the course included (1) measurements of the effectiveness during rain events of a vegetated swale called the “Biostream” on campus that is used for partial treatment of stormwater runoff, (2) macroinvertebrate water quality assessment of sites on Crum Creek, and (3) evaluation of the GWLF computer model for use in future nonpoint pollution studies.

Several senior engineering majors in the classes of 2000 and 2001 also participated in the assessment project through the required engineering design projects. A senior biochemistry major worked with the engineering students for her senior thesis research. These projects were supervised and critiqued by science and engineering faculty. The results were presented to faculty and students in public forums in May, 2000 and May, 2001, and copies of their reports have been published by Swarthmore College and are available to the public in the college library. Two design projects involved the development of operations research models that can be used by the Crum Creek Watershed Partnership to help prioritize watershed restoration projects. Another project involved development of a database to store and categorize water quality monitoring data and a GIS interface for the data enabling display and analysis of summary statistics in ArcView standard GIS software. The Biochemistry honors thesis involved a study of the bioavailability and potential toxicity of heavy metals contamination in the sediments of Crum Creek. Results of these four projects are discussed further in Section 5, below.

Two senior design projects involved the design of BMP’s for reduction of nonpoint nutrient and metals pollution at specific sites on the Swarthmore College campus. One project, a paper design study, developed specifications for a wet retention pond to treat runoff from the eastern half of the campus including academic buildings, dormitories, and parking lots. The other project involved design *and construction* of an experimental constructed wetland for treatment of stormwater runoff. Details on these two projects are provided in Section 6, below.

A student-run volunteer organization at Swarthmore College called the Crum Creek Monitoring Project (CCMP) has been using simple test kits to obtain

measurements of chemical water quality parameters since 1995. Students working on this assessment project who were trained in proper QA/QC protocols provided new leadership to the organization during the 2000-2001 academic year. Volunteers were trained to operate some laboratory instrumentation, and they were taught standard procedures for sampling and analysis. Thus, high quality monitoring data were generated by this group during the past academic year. These data, and results from previous years of monitoring have been incorporated into the main computer database for the project, as discussed further in Section 5 below.

Another development at Swarthmore College closely associated with this project has been the formation of the Crum Woods Stewardship Committee. This committee was formed in the Fall of 2000, and its goals statement is given below.

The goal of the Crum Woods Stewardship Committee is to create a protection, restoration, and stewardship plan for Crum Woods. The planning effort will begin with an evaluation of biodiversity, teaching and recreational resources in the context of the College's educational mission and its commitment to social responsibility. The committee will develop the plan in collaboration with College faculty, staff, and students as well as stakeholders in surrounding communities, and will engage the services of professional experts.

The committee includes members of the faculty and the senior administrative staff, and it has two representatives from the student body. A request for proposals for professional services to assist in developing a master plan was issued in February, 2001. The Natural Lands Trust was selected to conduct the study, which is currently underway. The study is funded internally by the Office of the President of the College.

Finally, it should be noted that Swarthmore College has provided substantial in-kind and cash support to this assessment project. Meeting room and conference facilities have been provided without charge for partnership steering committee meetings and for both Crum Creek conferences. Laboratory facilities, computing hardware and software, laboratory and field sampling equipment, secretarial services, and grant administration services have been provided, and the overhead charges normally assessed by the College to cover these expenses have been waived. Moreover, the College has allocated significant cash contributions to the project from its grants supporting undergraduate research participation funded by the Howard Hughes Medical Institute (HHMI). HHMI funds have also supported the participation of local high school teachers and students from Ridley, Strath Haven, and Ridley High Schools in the project. In addition, funds from the Swarthmore Foundation have supported involvement by the Advanced Placement Chemistry class (teacher and students) from Chester High School.

## **5. Monitoring and Database Management**

An important objective of this study is identification of “hot spots” in the impaired lower reaches of the Crum Creek watershed where significant sources of nonpoint pollution are generated and where sites for BMP implementation and restoration projects should be considered. Also, a decision support methodology based on operations research computer models was used to evaluate and prioritize nonpoint pollution reduction projects.

A targeted monitoring program was established during the summer of 2000 with the goal of measuring pollutant loadings generated by storm events. This effort differs significantly from previous monitoring activities on Crum Creek because it focuses on stormwater outfalls and measurement of pollution *loadings* (pollutant mass flow per time) as well as pollutant concentrations. Measurement of baseline pollutant concentrations in the creek at established monitoring locations was continued as well.

During the course of this project, the procedures for field sampling and laboratory analysis of monitoring data used in Swarthmore College’s Environmental Laboratory were scrutinized and revised to assure that the quality of data generated would be sufficient for the needs of the project. Data quality objectives for each type of measurement were specified and the sampling protocols, laboratory methods, and data analysis procedures were prescribed so as to achieve the necessary quality of data. Moreover, quality assurance and quality control (QA/QC) measures were implemented to verify that the data quality objectives were met. A *QA/QC Project Plan* was written and submitted to the U.S. Environmental Protection Agency’s Region III Project Manager, and approval of the plan was obtained. Appendix E presents excerpts from the plan, including a copy of the title page signed by the authorized official at USEPA Region III.

Walking surveys of the creek identified all outfalls in three reaches of the main stem of the creek covering a distance of 3 miles of stream bed in a section of the stream where it forms the boundary between Springfield Township, Nether Providence Township, and Swarthmore Borough. The three reaches were named “Strath Haven” (the southern most reach in the vicinity of the Strath Haven Condominiums), “Swarthmore College” (the middle reach near the main part of the campus), and “Smedley Park” (the northern-most reach located in the Delaware County park having the same name). Monitoring sites were also designated in the tributaries of Dicks Run (Nether Providence Township, Strath Haven reach) and Whiskey Run (Springfield Township, Smedley Park reach). Sites in the major sub-watershed of Little Crum Creek, which drains most of Swarthmore Borough and much of Ridley Township, were identified in previous research studies conducted by Swarthmore College, and the previously designated sites were adopted for use in this study. Finally, a substantial amount of historical data was obtained from the reports of the environmental monitor contracted by the Pennsylvania Department of Transportation during the construction of Interstate 476. These data were entered into our database and have been valuable for relative comparisons of chemical data from our monitoring studies.

Maps showing the locations of the monitoring sites are included in Appendix A. Figure A-2 shows a map of the upper portion of Little Crum Creek with its monitoring sites designated. Figure A-3 shows a map of the lower main stem of the creek with monitoring sites designated. Figure A-4 shows a map with the Interstate 476 construction monitoring sites. Photographs of several of the monitoring sites are shown in Appendix B. Geographic coordinates and associated monitoring data are presented in Appendix C. The discussion here focuses on potential problem sites and observations drawn from our monitoring and site visits.

#### 5.1 Sites in the Strath Haven Reach of the Main Stem

In the Strath Haven reach (sites labels beginning with “H”), site H10 has the most severe problems caused by a continuous discharge of what appears to be leaking sewage. Measurements of fecal coliform, phosphate, and ammonia strongly suggest that the flow coming from a plastic pipe that appears to have been installed during the construction of Interstate Highway 476 during the late 1980’s. Fecal coliform levels are extremely high at this discharge point, and there is a distinct odor. Readings from July, 2000 and June and July of 2001 range from **31,000 to 130,000 E. coli bacteria per 100 mL** with a geometric mean of **73,451 E. coli per 100 mL** based on five samples collected on different days. According to the Pennsylvania Code: *Title 25. Environmental Protection*, “(d)uring the swimming season (May 1 through September 30), the maximum fecal coliform level shall be a geometric mean of **200 per 100 ml** based on five consecutive samples, each sample collected on different days.” Thus, the measured bacteria levels flowing in the small unnamed tributary at site H10 are more than 300 times greater than the maximum specified for surface waters in Pennsylvania. In the main stem of Crum Creek, the flow is diluted by water from upstream, so the bacteria levels are lower. However, the standard is most likely exceeded in the main stem as well. In June 2001, we took samples in the main stem upstream and downstream of the discharge from site H10. On a day when the E. coli count in the discharge was 130,000 per 100 ml., the upstream count was 270 per 100 ml and the downstream count was 10,000 per 100 ml.

The data for this site has been summarized and presented to the Nether Providence representative to the Crum Creek Watershed Partnership, who has alerted the Township Manager (see Appendix F). At present, tests are being conducted on the sewer lines in the vicinity of site H10 in order to locate and eliminate the source of the problem. A temporary rubber cap has been installed on the plastic pipe which has stopped the flow. Note that the "Blue Route" monitoring site CC-4, which is just upstream from site H10 frequently shows extremely high fecal coliform values as far back as 1985, indicating that this problem may have existed for quite some time.

Another site of potential concern is site H30, the southern-most point of Dicks Run just before its confluence with Crum Creek. A high fecal coliform

measurement during a rain event indicates that there may be a sanitary sewer line in the part Nether Providence drained this tributary that overflows during rain storms as a result of excessive infiltration.

## 5.2 Sites in the Swarthmore College Reach of the Main Stem

Sites in the Swarthmore College Reach begin with “C”. Site C40 is one of the main stormwater discharge points for the Swarthmore College campus. It is located behind the Ware Swimming Pool and the new Mullan Tennis Center. It drains the eastern half of the campus as well as residential neighborhoods, the SEPTA train station and its parking lot, and a section of Pennsylvania Route 320 including the underpass underneath the SEPTA station. Prior to this assessment study, visible evidence of heavy oil was frequently present in this discharge. The source was determined to be number 6 fuel oil that had leaked into the groundwater from one of the College’s heating fuel tanks. The tank was replaced and an oil recovery system was installed which operated for several years prior to this study and which is still in operation. Very little evidence of continued oil discharge was found during the monitoring program indicating that the oil recovery system is working well enough to keep the oil from reaching the outfall.

However, other nonpoint pollution problems were detected during rain events that are typical of stormwater outfalls in urbanized areas. Significant nutrient pollution loadings were measured during our targeted monitoring of rain events, including excess nitrate nitrogen and orthophosphate. We also measured significant loading of two metals: zinc and copper. On the basis of these measurements, senior engineering design students selected this site for further study including two BMP design projects, discussed in Section 6 below.

The western half of the campus is drained by storm sewers that discharge at site C50, which is just down the bank from the Lang Music Building. A large deposit of sediment has been deposited in the main stem of Crum Creek at this site. We selected C50 as the location for sediment sampling and toxicity evaluation. A senior Biochemistry honors thesis investigated the measurement of acid volatile sulfide and simultaneously extracted metals in the sediments at site C50. The results are in a gray range indicating possible, but not conclusive elevated toxicity to macroinvertebrates in the stream resulting from metals contamination of the sediments. This project serves as an initial investigation of sediment toxicity in Crum Creek, and future studies will build on the results.

Site C60 drains a residential neighborhood on Elm Avenue in Swarthmore Borough, just north of the college campus. During the summer of 2001, unusually high nitrate-nitrogen concentrations were detected. Regular

monitoring is being conducted to better characterize this potential source of significant nutrient loading.

### 5.3 Sites in the Smedley Park Reach of the Main Stem

Sites in the Smedley Park reach begin with “P”. Site P40 is in Whiskey Run just before its confluence with the main stem. Whiskey Run drains much of the western portions of Springfield Township which includes residential neighborhoods and many commercial establishments, including a regional shopping mall, Springfield Mall. The parking lots and roof drains of Springfield Mall discharge directly into Whiskey Run on the south bank. Also, just behind the mall on the north bank for Whiskey Run, a major construction project has been underway during the period of this assessment study which has added substantially to size of Springfield Hospital through the addition of a large exercise and health complex. Also, a large number of new multifamily residences were built on the upper portions of the Whiskey Run valley. Thus, this site has experienced substantial development during the two-year project period which produced short-term construction site runoff and is likely to create long-term increased runoff and nonpoint pollution loading. Our monitoring data indicates elevated fecal coliform levels at site P40 during rain events, indicating possible leaking sanitary sewers upstream on Whiskey Run in Springfield Township.

Site P70 is a landfill leachate discharge from a closed landfill in Springfield Township. It is a permitted discharge listed by PADEP. Our monitoring indicates the possibility of elevated concentrations of orthophosphate, zinc, and copper at this site.

### 5.4 Sites in the Little Crum Creek Subwatershed

Sites in the Little Crum Creek subwatershed begin with “LC”. Several sites on this stream have been monitored by Swarthmore College and Ridley High School since 1995. This stream is designated as impaired over its entire 3.68 miles. It drains an area of 3.3 square miles, with branches originating in heavily commercially developed sections of Springfield Township and in residential sections Swarthmore Borough. It flows through Ridley Township and Ridley Park Borough, and it joins the main stem of Crum Creek just before it joins the Delaware Estuary.

This stream was designated by the Steering Committee of the Crum Creek Watershed Partnership as a high priority location for restoration because of the many obvious problems such as high storm flows, bank erosion, and poor biological indicators. Monitoring has revealed severe fecal coliform contamination of the stream during storm events. E. Coli levels in the stream consistently violate PADEP standards during rain events. A December 1998 study by students at Swarthmore College showed the E. Coli bacteria count

jump from 700 per 100 ml to 112,000 per 100 ml in a one-hour period at the beginning of a rainstorm.

Two sites in the Little Crum Creek subwatershed have been selected by the CCWP for implementation of restoration projects. Preliminary designs have been developed, and funding has been requested, as described in Section 6, below.

### 5.5 Macroinvertebrate Biological Monitoring

Results from macroinvertebrate biological monitoring of sites in the lower Crum Creek watershed are reported here to enable comparison among the different sites. Macrobiological surveys were performed at selected sites along Crum Creek during the summers of 1999, 2000 and 2001. These surveys determined the species and numbers of visible invertebrate organisms found at the selected creek sites. These organisms include insect nymphs, larvae, crustaceans, mollusks and worms. Organisms were collected and classified. These organisms are used universally as indicators of the biological health of the stream. Using the data on numbers and types of organisms, various indices (Simpson Diversity, Pollution Tolerance, and Shannon Weaver) were calculated to estimate levels of pollution present.

Macrobiological surveys were also performed on Ridley Creek, at the base of the falls in Ridley Creek State Park. The section of the Ridley Creek watershed in which this site is located is relatively pristine, while the section of the Crum Creek watershed that has been monitored is heavily developed. The two watersheds run parallel to each other, and are often subjected to the same runoff. The major variability between the two watersheds is their level of development. Because of these factors, the Ridley Creek site was used as a control to help evaluate the impact of development on stream health. The 1997 data on this site were collected by high school students, under the supervision of Mr. Frank Dowman, an environmental education teacher and laboratory manager at the Swarthmore College Environmental Lab.

Macrobiological surveys are not used to formulate definite conclusions on water quality, but they provide strong general information about stream conditions. When performed at the same sites over several years, they can indicate long-term changes in water quality. The data tables that follow suggest the following conclusions concerning changes in stream health over time on Crum Creek:

1. All of the sites, with the exception of the site downstream of Swarthmore College (H55), exhibit deterioration in stream health, as shown by all three indices used.
2. All of the sites from Victoria Mills Bridge (P15) upstream – P40-1, P40-2, and P50 – currently classify as either polluted or very polluted,



though most of these sites were in the unpolluted to mildly polluted range two years ago.

3. At the sites that exhibit a decrease in the total number of organisms collected, an overall decrease in population diversity was observed. At the sites at which the total organisms collected increased, a decrease in diversity was still observed. The reason for the increases in populations was found to be increases in the numbers of one or two species.
  - a. Examples of Point #3: At P50, the total number of organisms collected decreased by only 12 between 1999 and 2001. In 2001, however, six species that had been found at the site in 1999 were no longer found. This trend also appeared at site P40-1. In 1999, eight species were found at the site, as opposed to two species in 2001.
  - b. Conversely, at site C55, the total number of organisms collected increased substantially between 1999 and 2001. This was primarily caused, however, by a dramatic increase in the populations of caddisflies and sideswimmers. Five other species that were found in 1999 were not found in 2001, including such pollution-sensitive organisms as riffle beetles and dragonflies.
4. Over a longer time period, the Ridley Creek site has indicated either stable or improving stream health. This suggests that overall deterioration in stream health is confined to the Crum Creek watershed, although more sites on Ridley Creek should be tested to confirm this hypothesis.

During the summer of 2001, monitoring also began at three sites on Little Crum Creek. Little Crum Creek has been designated as an impaired stream by the PADEP. The data verify this conclusion, because all three indices calculated for each of these sites indicate that the sites are either polluted or very polluted.

## 5.6 Data Management and Geographic Information System Analysis

A significant component of this project has been the development of a comprehensive database for managing the large amount of data generated by the monitoring and for incorporating data from other sources such as volunteer monitors and the data collected by the Pennsylvania Department of Transportation's (PADOT) environmental monitor during the construction of Interstate 476 during the late 1980's and early 1990's. An innovative aspect of this database is the inclusion of a "data quality index" which indicates how reliable each data record is expected to be. Data from volunteer monitors have the greatest potential for error whereas data from our USEPA approved program and from the PADOT environmental monitors have the least potential error. This index enables the analyst to select data having only the

highest quality for certain evaluations while enabling other evaluations to use all of the data available.

A geographic information system (GIS) based on the ESRI ArcView standard GIS platform has been developed to display summary data from all of our monitoring sites. Starting with GIS layers developed by the Philadelphia Academy of Natural Sciences for the Philadelphia Suburban Water Company, we have added additional layers for displaying monitoring data and for conducting analyses. For example, we can set up a display that automatically shows sites having different ranges of pollutant concentrations in different colors, to make it easy to recognize “hot spots.”

Most of the database and GIS system development was done as part of a senior engineering design project. An abstract of this project containing more details is presented in Appendix F.

## **6. Selection and Design of Restoration Projects and Best Management Practices**

One of the main goals of this project has been to identify potential stream restoration projects and sites for implementation of best management practices (BMP's). All of the components of the project described in the previous sections of this report support this goal. In this section, five different proposed projects resulting from this study are described, and the methodology used to select these projects is discussed.

### **6.1 Operations Research Models for Decision Support**

A large amount of information in a variety of different forms has been generated in the course of this assessment study. A rational decision-making framework is necessary to enable the information to be used in an effective manner to determine which potential watershed improvement projects should be given high priority. This project has included the use of a decision support methodology based on computer modeling tools from the field of Operations Research. Three different models have been developed as part of two senior engineering design projects at Swarthmore College. Details on these models are provided in the report abstracts, which appear in Appendix D.

The first model, called the “goal programming” model uses a well known Operations Research technique (Hillier and Lieberman, 2000) to prioritize projects based on the overall goals and specific objectives of water quality managers and watershed stakeholders. A survey of several such persons contacted through the early partnership group was conducted to obtain their views on the relative importance of different water quality goals and priorities

for stream restoration. The survey also generated information on specific problem sites in the watershed, and expert views on the effectiveness of various BMP's for the problems existing at the different sites. Estimates of relative costs and pollutant removal efficiencies were also introduced into the analysis. This model enabled an initial assessment of potential projects in the watershed, but it had the shortcoming of relying heavily on the opinions expressed by the survey participants rather than hard cost and performance data.

The second and third decision support models build on the progress made in developing the first model. They use data on costs and performance of actual stream restoration projects and BMP implementations. The second model is called the "watershed model" because it can be applied to multiple sub-watersheds simultaneously, including the entire watershed if necessary. The objective of the watershed model is to determine optimal targets for nonpoint pollutant loading reduction in each sub-watershed that enable water quality goals to be achieved at minimum total cost to the entire watershed. Sub-watershed delineations for the Crum Creek watershed developed by Schabel Engineering Associates for the Delaware County Conservation District were adopted for use in this model.

Land use data for each sub-watershed were obtained from the ArcView GIS model discussed in Section 5, above. Export coefficients for nonpoint pollutants from each land use category were obtained for each of the three pollutants examined: total nitrogen, total phosphorous, and total suspended solids. Realistic cost functions were developed by assuming that the least expensive BMP options per unit of pollution reduction will be selected first, followed by options with higher and higher marginal costs. Very expensive options are selected only if absolutely necessary to achieve water quality goals. Reduction of pollutant discharges in a sub-watershed can affect total pollutant loadings in downstream sub-watersheds. The stream water quality model QUAL2E, which is distributed with the BASINS software package from USEPA, was used to calculate pollutant transfer coefficients between sub-watersheds for each pollutant.

The third model is called the "subwatershed model." It is applied to a single subwatershed at a time. It enables a budget to be specified which applies to all watershed restoration and BMP implementation projects in the subwatershed. It then determines the optimal combination of projects so as to achieve the maximum nonpoint pollution loading reduction that can be obtained for the budgeted amount of money. For each potential BMP site in the subwatershed, multiple types of BMP's can be selected simultaneously, and it is possible to specify both "requisite BMP's" (those that must be already in place at the site before a particular BMP can be implemented) and "mutually exclusive BMP's" (other BMP's that are incompatible in the same site with a particular BMP). Whereas the watershed model is used to establish

broad goals for each subwatershed so that future projects fit well into an overall watershed-wide plan, the subwatershed model is useful for setting priorities for projects within a subwatershed when the amount of funds available for restoration projects is fixed.

#### 6.2 Design of a Wet Retention Pond for the Swarthmore College Campus

During the 1999-2000 academic year, a senior engineering design student developed design specifications for a wet retention pond to remove nonpoint pollution from the College's main stormwater outfall, designated site C40 in Section 5, above. The site for the pond is in a low-lying area in the southeastern part of the campus, just north of the SEPTA railroad station and adjacent to the storm sewer main conduit. Stormwater first flows through a sediment fore-bay where the larger suspended solids are removed. The water then flows into a vegetated pond where nutrients are removed.

The College administration has indicated significant interest in implementing this design after further evaluation and integration with plans for a new dormitory building near the proposed site.

#### 6.3 Design and Construction of an Experimental Constructed Wetland

During the 2000-2001 academic year, a senior engineering design student designed and built an experimental constructed wetland below site C40 in the Crum Woods on the Swarthmore College campus. A portion of the flow from the College's storm sewer outfall is diverted through the experimental facility which consists of two trenches filled with gravel, each 50 feet long, 15 inches wide, and 20 inches deep. Native wetland plant species are planted in one of the trenches and the other trench is not planted so that it can serve as an experimental control. The facility is designed so that experiments can be conducted operating the system in either the below surface flow or above surface flow modes. Pollutant inflow loadings and removal efficiencies will be determined through field sampling and laboratory measurements. Results from the experiments will be used to refine models of pollutant removal efficiency in constructed wetlands and to develop guidelines for their optimal operation. An abstract of the design project report is provided in Appendix D.

#### 6.4 Restoration of a Natural Wetland in Little Crum Creek Park, Swarthmore Borough

The Crum Creek Watershed Partnership has selected three projects in the lower Crum Creek watershed as high priority initial implementation projects for the partnership to take on. Plans for these projects emerged from steering committee deliberations in January and February of 2001, and a proposal was submitted to the PADEP Growing Greener program in March, 2001. The first project involves restoration of a natural wetland in the Little Crum Creek

subwatershed. The site is located in Little Crum Creek Park in Swarthmore Borough where three branches of the creek merge. The wetland is fed by a spring, and for many years, the Borough work crews have attempted to keep the land drained, mowed, and planted in lawn grass. However, drain pipes have frequently clogged, and use of this portion of the park by visitors has been severely limited. The proposed project will involve removing drain pipes and planting the area with native wetland species so that the natural function of the wetland is restored and the quality of water in Little Crum Creek is thereby enhanced. Details of the preliminary design for this project are provided in Appendix A, Figure A-6.

#### 6.5 Riparian Zone Restoration on Little Crum Creek at Ridley High School

The second project selected by the CCWP for implementation involves restoration of the banks of Little Crum Creek behind Ridley High School in Ridley Township. The school district has recently constructed a new high school building at the site, and has added a new stormwater outfall that discharges directly onto the riparian zone of the stream banks. Only riprap was installed to reduce the impacts of the new stormwater flow. Significant new erosion of the bank is already apparent. This project will design a vegetated stormwater buffer zone through which the water will pass. Sediment and nutrient removal will be achieved and erosion will be minimized. Paths will be installed to enable environmental science students from the high school to gain access to the site for observation and monitoring. New curriculum units on the role of riparian buffers for water quality enhancement will be developed by science faculty that make use of the project as a laboratory. Details of the preliminary design for this project are provided in Appendix A, Figure A-5.

#### 6.6 Stormwater Inlet Labeling in Nether Providence and Springfield Townships

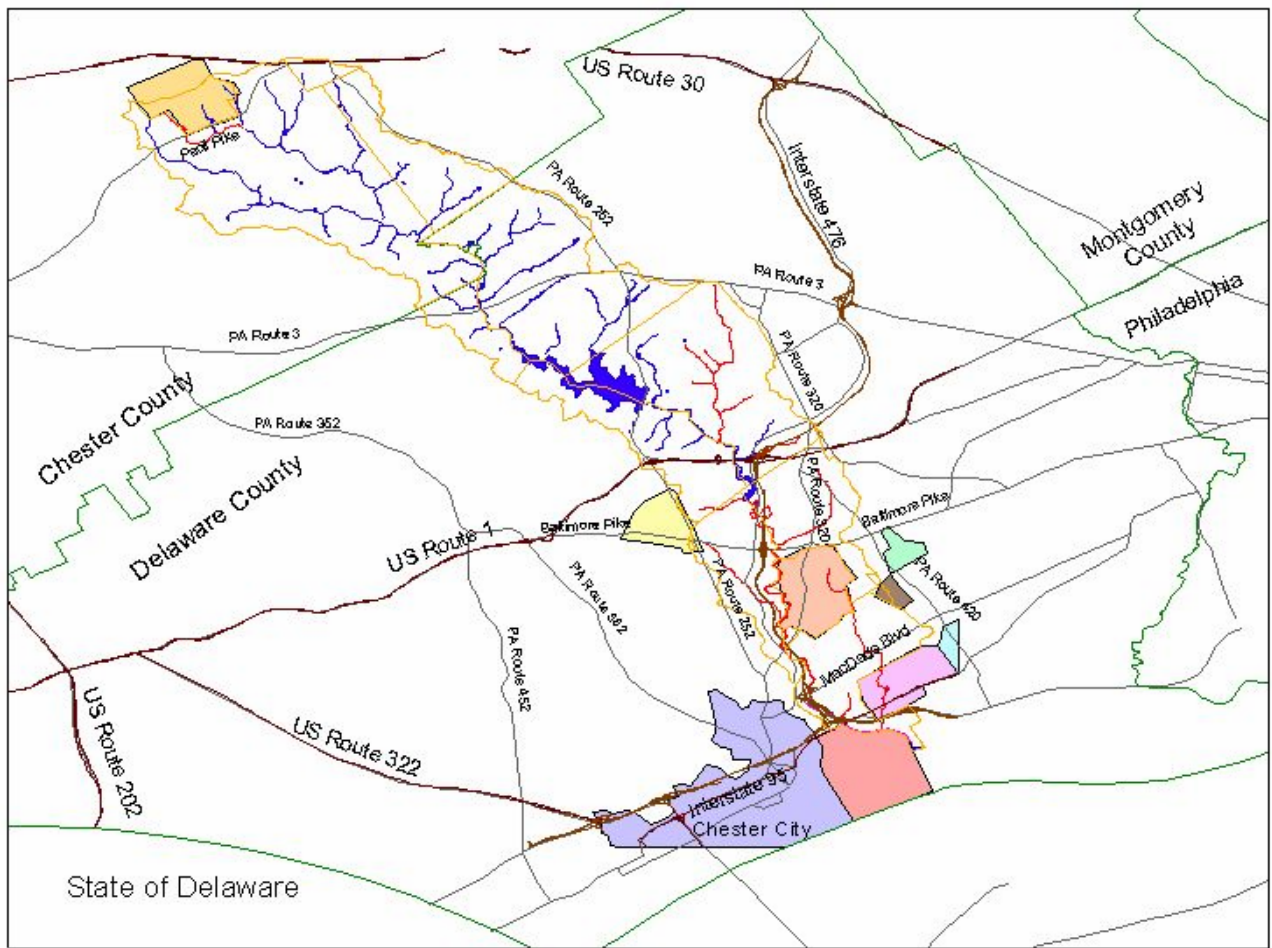
The third project identified for high priority status by the CCWP is a joint project by Nether Providence and Springfield Townships to develop and implement a stormwater inlet labeling and public education program. Stormwater inlets will be inspected by township work crews and necessary repairs will be made. Then, volunteers will be organized and trained in storm sewer stenciling techniques. Finally, crews of volunteers will be performing the labeling and simultaneously distribute leaflets to residents in each neighborhood. Residents will be informed that storm sewers typically lead directly to local streams, and in some cases into drinking water supplies. Proper procedures for disposal of hazardous liquid wastes will also be provided.

### **7. Conclusions and Recommendations**

This report presents the results of a two-year project which has supported the development and growth of a new watershed-wide partnership for protection and restoration of the Crum Creek watershed. Details are provided on partnership formation, establishment of goals, and initiation of implementation projects and on the important role of two watershed conferences in improving public awareness of watershed issues and soliciting input on watershed problems. The significant role that Swarthmore College is playing in watershed education and stewardship of local water resources is explained. Results from targeted monitoring of sites in the lower Crum Creek basin are presented and potential sites for restoration projects are noted. Finally, specific watershed restoration and best management practice implementation projects are described and preliminary designs are presented.

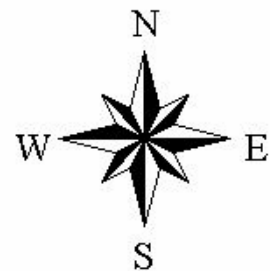
The main recommendations of this project are (1) that efforts be continued in support of the partnership approach to protection and restoration of the watershed, (2) that the proposed restoration projects be funded and implemented, (3) that the performance of the projects be monitored for an extended period after completion, and (4) that the methodology developed for this project be used throughout the Crum Creek watershed to assess potential sites for restoration and protection projects and to work through the Crum Creek Watershed Partnership to prioritize projects and to develop feasible and economical implementation plans.

## **Appendix A - Maps.**



5 0 5 10 Miles

- Townships
- Interstates
- US Roads
- Counties
- Local roads
- Streams water quality status
- Attaining use
- Impaired
- Unassessed
- Lakes in Crum Creek watershed
- Cities
- Boroughs
- Eddystone
- Malvern
- Media
- Morton
- Prospect Park
- Ridley
- Rutledge
- Swarthmore

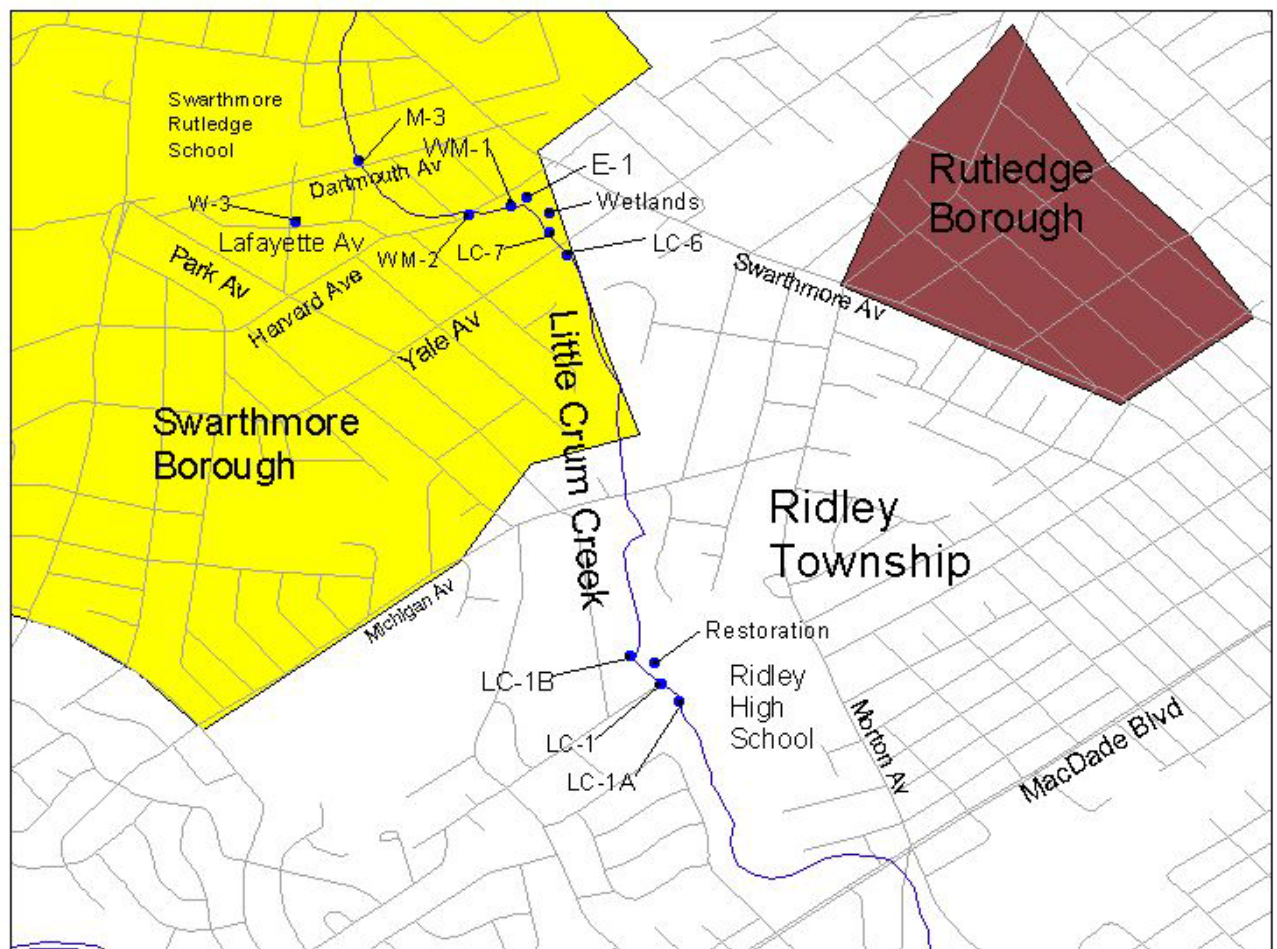


# Crum Creek Watershed

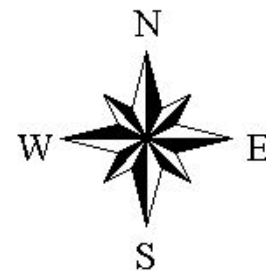
Figure A-1





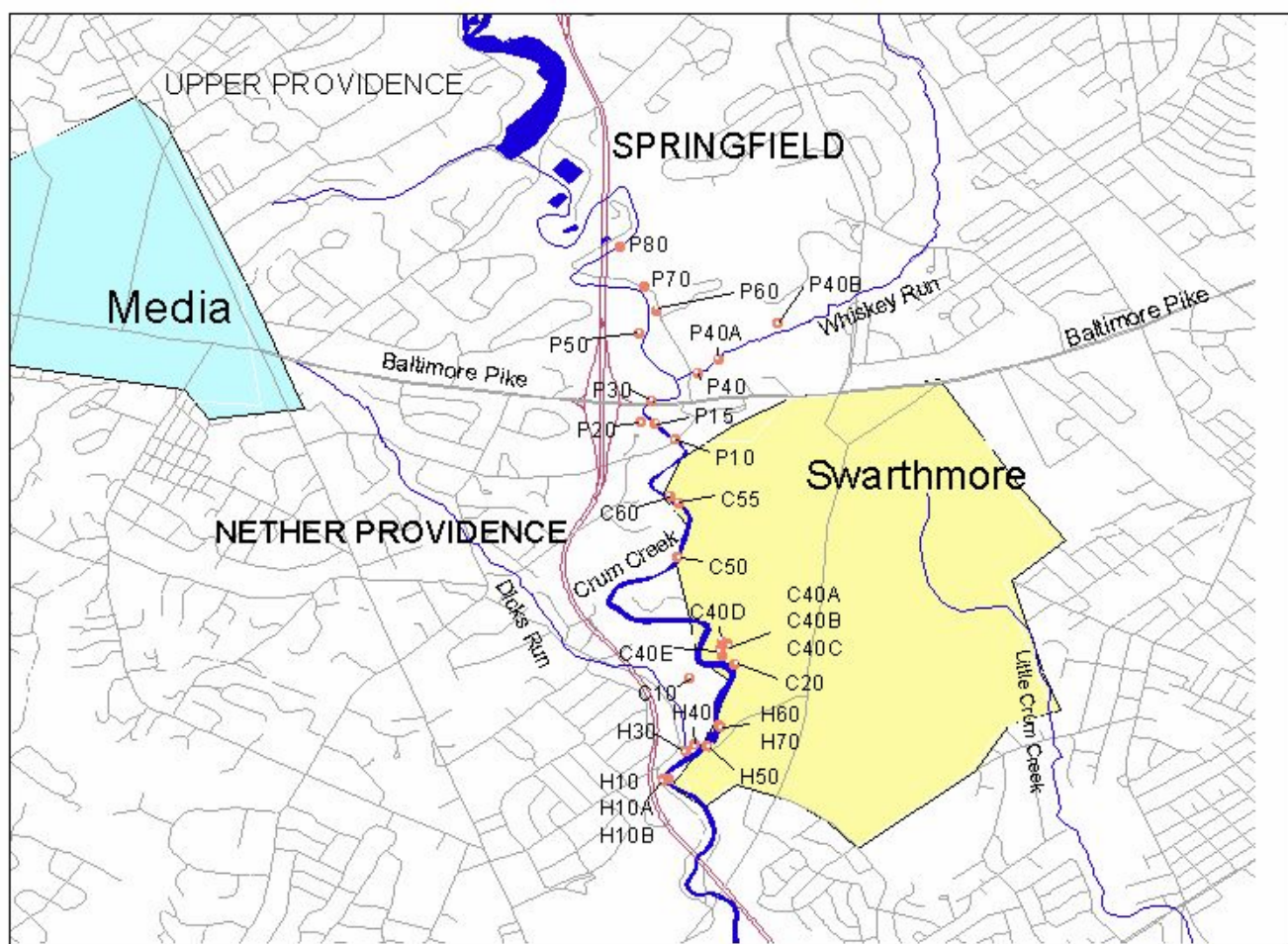


- Little crum creek monitoring sites
- Streams
- State roads
- Township roads
- Local roads
- Boroughs
- Rutledge
- Swarthmore



## Little Crum Creek Monitoring Sites

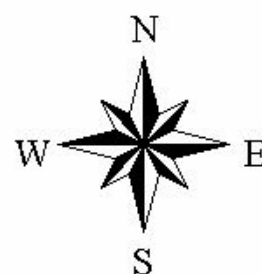
Figure A-2



1 0 1 2 Miles

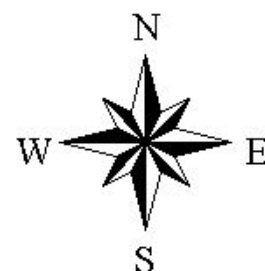
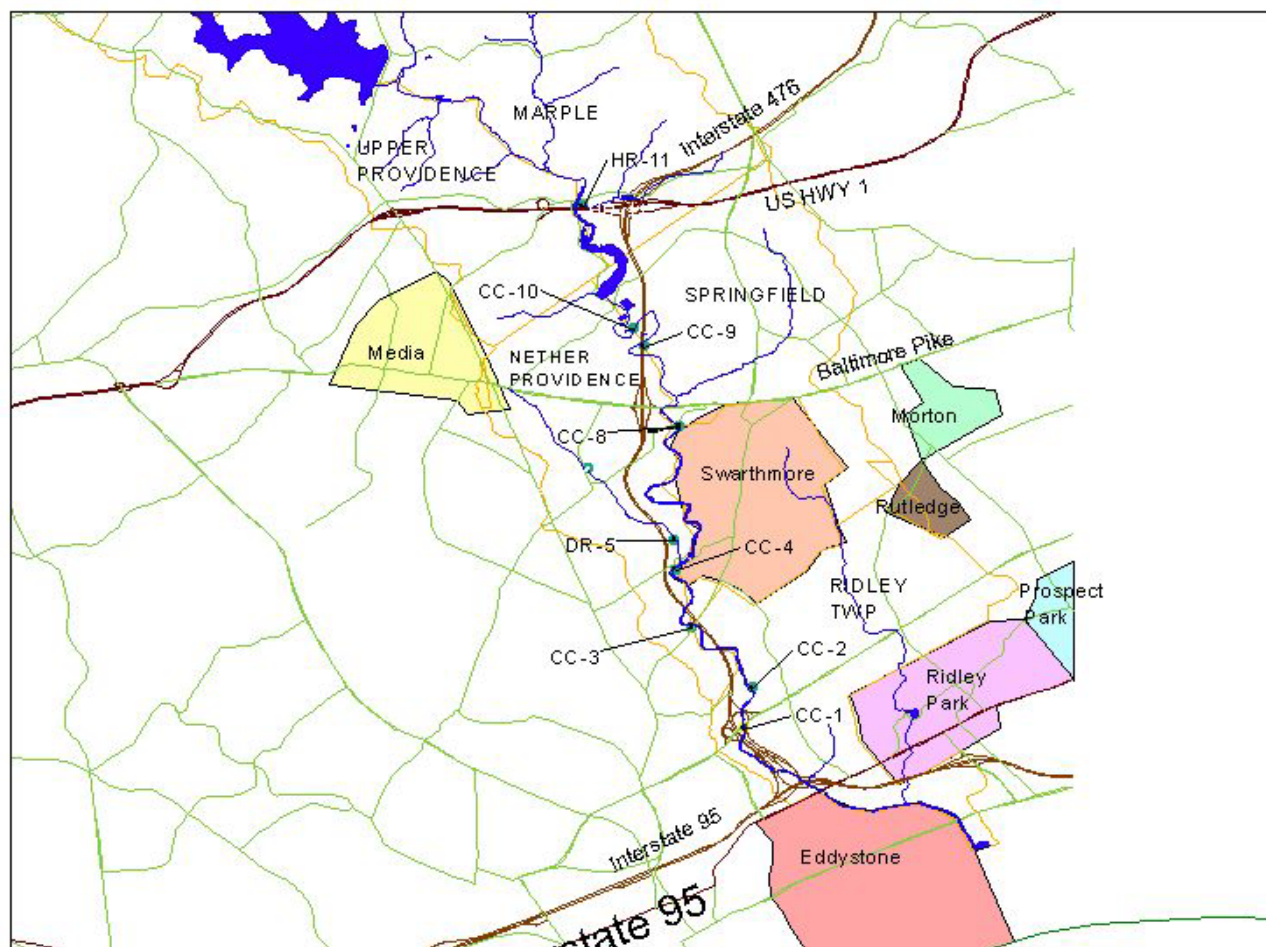
- Monitoring sites
- ▬ Streams
- ▬ Streets and Roads
- ▬ Interstate 476
- Ponds

- Boroughs**
- Media
  - Swarthmore



## Lower Main Stem Monitoring Sites

Figure A-3



# Interstate 476 (Blue Route) Construction Monitoring Sites

Figure A-4



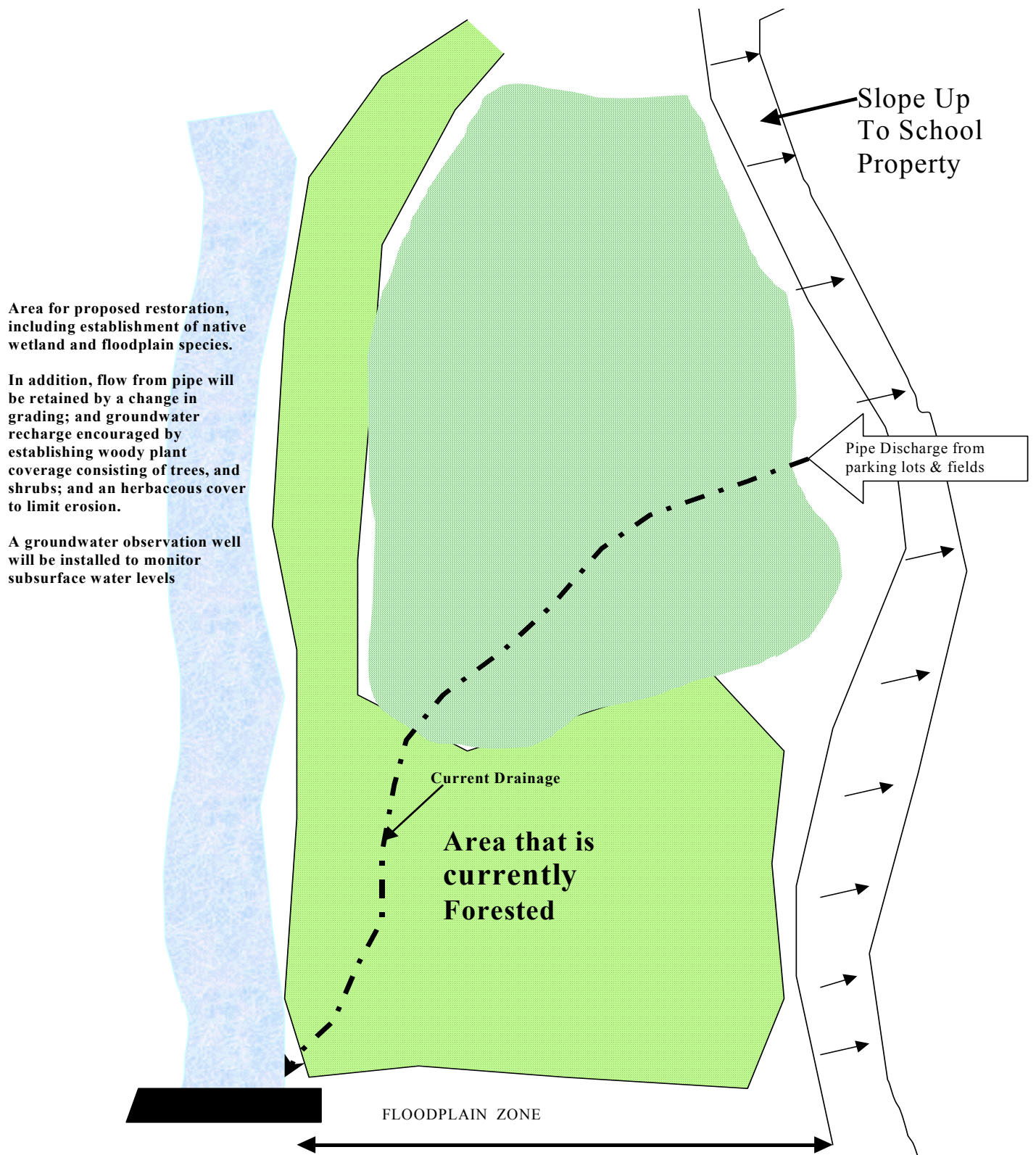


Figure A-5. Riparian Zone Restoration Project Proposed for Little Crum Creek at Ridley High School

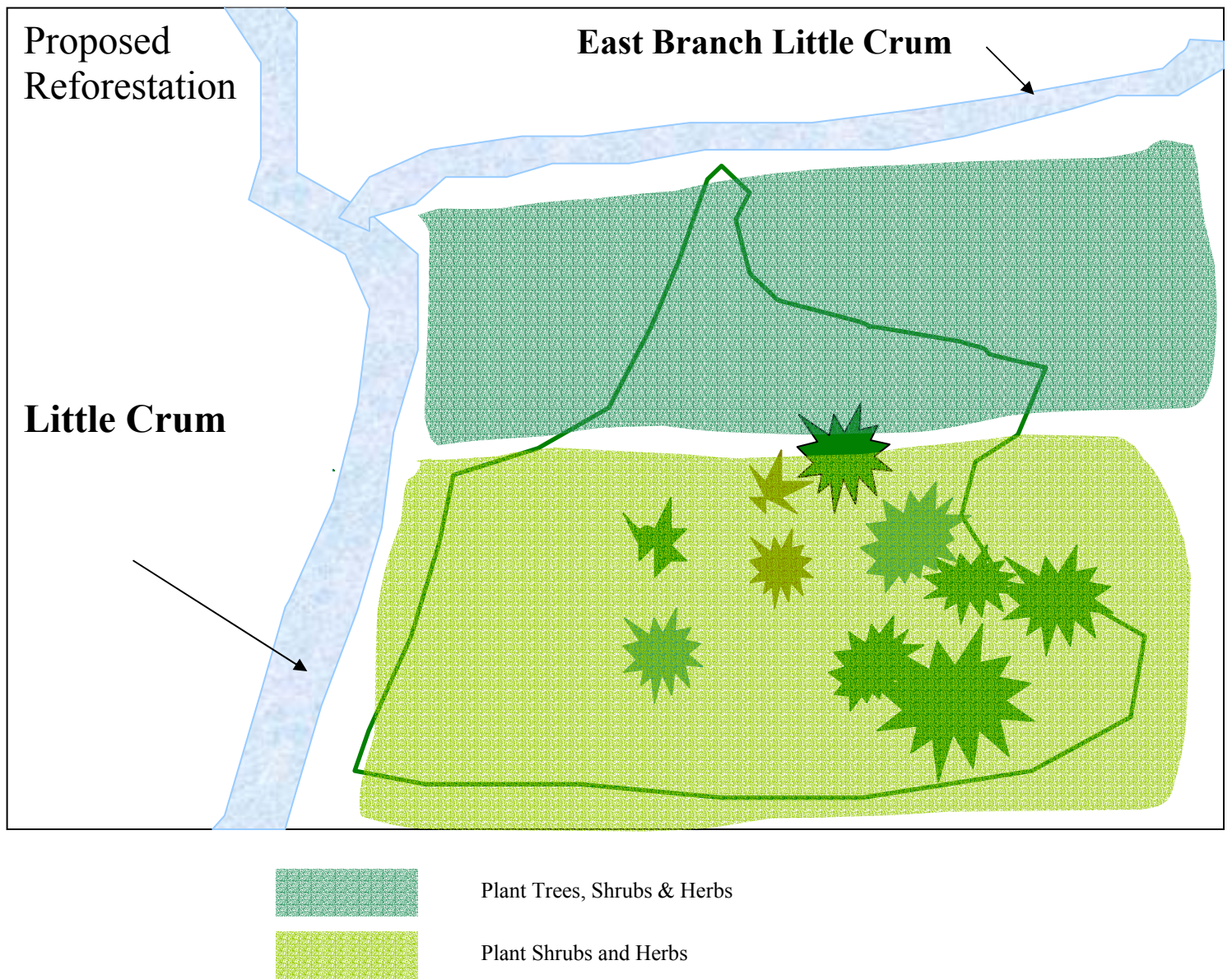


Figure A-6. Restoration Site at Little Crum Creek Park in Swarthmore Borough

## **Appendix B - Photographs**



Site C60



Site H10 Pool



Site H10 Pipe



Constructed Wetland



Site P40



Site C40 Outfall

Figure B-1. Sites monitored on the lower main stem of Crum Creek





Site W-3



Site LC-6



Site E-1



Site WM-3



Restoration site



Little Crum wetland

Figure B-2. Sites on Little Crum Creek



Site DR-7



Site CC-4



Site CC-8



Site CC-9



Site HR-11



Site CC-10

Figure B-3. Sites monitored during the construction of Interstate 476



Early plantings



Intake hose



Completed trenches



Inlet valves



Completed wetland



Initial planning

Figure B-4. Constructed Wetland Senior Design Project in Crum Woods of Swarthmore College

## **Appendix C – Data Tables**

## ***C.1 Locations of Monitoring Sites***

**Table C-1. Lower Main Stem Monitoring Sites**

Site Name	Longitude (Deg)	Latitude (Deg)
H10	-75.3588	39.8934
H10A	-75.3591	39.8935
H10B	-75.3591	39.8935
H20	-75.3586	39.8935
H30	-75.3576	39.8935
H40	-75.3574	39.8944
H50	-75.3571	39.8941
H60	-75.3560	39.8957
H70	-75.3559	39.8956
C10	-75.3575	39.8982
C20	-75.3551	39.8989
C30	-75.3558	39.8994
C40A	-75.3555	39.9000
C40B	-75.3555	39.9000
C40C	-75.3555	39.9000
C40D	-75.3558	39.9001
C40E	-75.3559	39.8997
C50	-75.3582	39.9046
C55	-75.3581	39.9075
C60	-75.3585	39.9078
P10	-75.3583	39.9109
P15	-75.3594	39.9117
P20	-75.3597	39.9117
P30	-75.3600	39.9131
P40	-75.3583	39.9143
P40A	-75.3560	39.9151
P40B	-75.3528	39.9170
P50	-75.3602	39.9165
P60	-75.3595	39.9175
P70	-75.3598	39.9188
P80	-75.3617	39.9215

**Table C-2. Little Crum Creek Monitoring Sites**

Site Name	Longitude (deg)	Latitude (deg)
W-3	-75.3466486	39.9016836
M-3	-75.3451801	39.9030966
WM-2	-75.3421986	39.9018559
E-1	-75.3407524	39.9018383
Wetlands	-75.3398401	39.9017004
LC-6	-75.3402183	39.9009767
LC-1	-75.3377935	39.8902235
Restoration	-75.337838	39.8907232
LC-1B	-75.3384609	39.8909644
LC-1A	-75.3373041	39.8897927
LC-7	-75.3404631	39.9011831
WM-1	-75.3411084	39.901924

**Table C-3. Interstate 476 Construction Monitoring Sites**

Site Name	Longitude (deg)	Latitude (deg)
CC-1	-75.3500	39.8743
CC-2	-75.3490	39.8792
CC-3	-75.3562	39.8862
CC-4	-75.3581	39.8933
DR-5	-75.3583	39.8967
DR-7	-75.3687	39.9053
CC-8	-75.3577	39.9105
CC-9	-75.3620	39.9200
CC-10	-75.3632	39.9222
HR-11	-75.3693	39.9370

## C.2 Data collected by Swarthmore College Environmental Laboratory for inflows to Crum Creek

*Explanation of column headings and units used in chemical data tables:*

*Chlor* = Chloride concentration. Units: mg/L

*Nit* = Nitrate concentration. Units: mg/L

*Phos* = Phosphate concentration. Units: mg/L

*Turb* = Turbidity. Units: NTU

*Sp. Cond* = Specific conductance. Units: microseimens/cm

*COD* = Chemical oxygen demand. Units: mg/L

*Phos load* = Phosphate loading. Units: g/min

*Chlor load* = Chloride loading. Units: g/min

*Nit load* = Nitrate loading. Units: g/min

*E. coli* = Fecal coliform. Units: colonies per 100 mL

*Samp type* = designation of data point as applying to storm or baseline conditions. "S" indicates that the sample was taken under storm conditions. "B" indicates that the sample was taken under baseline conditions.

### I. Data from Swarthmore College reach

*Table 1a: C40A Chemical Data*

Date	pH	Chlor	Nit	Phos	Turb	Sp. cond	COD	Phos load	Chlor load	Nit load	E. coli	Samp type
6/5/00	7.14	79.5	5.0	0.542	3			0.152	22.3	1.41		B
6/6/00	7.05	23.5	0.42	0.225	25			0.176	18.3	0.328		S
6/6/00	6.76	42.1	2.7	0.677	18			0.328	20.4	1.31		S
6/6/00	6.67	64.3	3.1	0.310	8			0.072	15.0	0.722		S
6/15/00	6.59	43.7	1.0	0.254	46			0.169	29.0	0.664		S
6/18/00	6.51	22	1.9	1.502	72			9.21	134.9	11.7		S
6/28/00	5.82	15.7	0.15	0.314	43	63.1	106.3	10.08	504.1	4.82	350	S
7/10/00	5.89	79.9	5.54	0.218	1.02	509	6.31				230	B
7/14/00	5.42	7.42	0.423	0.606	118.7	119.2	81.8	1.69	20.7	1.18		S
7/16/00	5.6	45.8	2.31	0.280	57.8	542		0.180	29.4	1.48		S
7/19/00	6.48	13.5	1.23	0.400	38.58	155.6	67.5	0.636	21.5	1.97	1000	S
7/19/00	6.59	13.5	1.23	0.118	32.1	137.7	31.2	0.044	5.08	0.462		S
7/26/00	6.81	4.81	0.063	0.45	40.8	47.3		2.47	26.4	0.346		S
7/26/00	6.65	35.3	1.505	0.319	19.4	218						S
7/26/00	6.82	28.3	4.28	0.377	8.16	366	15.0				3500	S
7/26/00	6.93	3.93	below MDL	0.352	17.3	52.5	32.2				14500	S
7/30/00	6.91	5.7	1.59	1.633	197.8	179.8	46				10000	S
8/18/00	6.69	7.63	5.94	0.372	0	506	6.53					B

*Table 1b: C40A Metals Concentration Data*

Date	Cadmium	Chromium	Copper	Lead	Nickel	Zinc	Sample
------	---------	----------	--------	------	--------	------	--------



	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	type
6/28/00	below MDL	below MDL	0.043		0.013	0.089	S
7/3/00	below MDL	below MDL	0.018		below MDL	0.169	S
7/10/00		below MDL					B
7/16/00	below MDL	below MDL	0.125	below MDL		0.219	S
7/19/00	below MDL	below MDL	0.149	0.096	below MDL	0.20	S
7/26/00	below MDL	below MDL	0.033	below MDL	below MDL	0.055	S
7/26/00	below MDL	below MDL	0.020	below MDL	below MDL	0.048	S
7/26/00	below MDL		0.029	below MDL		0.056	S
7/30/00	0.0085	below MDL	0.057	below MDL	0.041	0.0526	S

**Table 1c: C40A Metals Loading Data**

Date	Cadmium (g/min)	Chromium (g/min)	Copper (g/min)	Lead (g/min)	Nickel (g/min)	Zinc (g/min)	Sample type
6/28/00			1.38		0.417	2.86	S
7/3/00			0.018			0.170	S
7/16/00			0.080			0.140	S
7/19/00			0.237	0.153		0.318	S
7/26/00			0.181			1.32	S

**Table 2: C40B Data**

Date	pH	Chlor	Nit	Phos	Turb	Sp cond	Phos load	Chlor load	Nit load	Samp type
7/26/00	7.39	4.81	1.59	0.250	13.27	465	0.0035	0.0664	0.0219	S
7/30/00	7.26	below MDL	1.59	0.235	25.5	515				S

**Table 3: C40C Data**

Date	pH	Chlor	Nit	Phos	Turb	Phos load	Chlor load	Nit load	Samp type
6/12/00	6.78	37.1	0.9	0.592	39	1.25	78.6	1.91	S
6/18/00	6.43	25	1.4	0.530	108	288.8	13624	762.9	S



**Table 4: C40D Data**

Date	pH	Chlor	Nit	Phos	Turb	Sp cond	Phos load	Chlor load	Nit load	Samp type
6/6/00	7.30	13.3	below MDL	0.100	3		0.0073	0.967		S
6/15/00	6.45	28.1	below MDL	0.182	18					
6/18/00	7.58	31	0.8	0.395	325		0.0492	3.86	0.0997	S
6/18/00	7.73	18	1.2	0.483	288		0.0115	0.430	0.0287	S
6/28/00	6.00	19.8	0.063	0.404	77	63.4	0.341	16.70	0.0531	S
7/16/00	5.6	3.06	0.782	0.137	10.2	123.6	0.0004	0.0086	0.0022	S
7/19/00	6.66	17.9	1.05	0.173	21.4	107.9				S
7/26/00	7.78	3.06	0.423	0.241	8.16	325	0.0017	0.0212	0.0029	S
7/30/00		below MDL	0.42	0.210	37.8	520				S

**Table 5: C40E Data**

Date	pH	Chlor	Nit	Phos	Turb	Samp type
6/6/00	6.98	47.8	1.6	0.124	130	S

**Table 6: C40H Data**

Date	pH	Chlor	Nit	Phos	Turb	Sp cond	Phos load	Chlor load	Nit load	Samp type
6/18/00	6.77	31	2.5	0.456	38		0.0755	5.14	0.414	S
6/28/00	6.10	19.8	0.063	0.404	44	63.4				S
7/14/00	5.62	6.55	0.153	0.254	121.9	82.5				S
7/16/00	6.1	9.16	0.423	0.0786	77	300	0.0010	0.116	0.0053	S
7/19/00	6.30	11.8	0.422	0.056	51.4	79.2	0.0031	0.651	0.0233	S
7/26/00	7.43	2.19	below MDL	0.172	38.78	121.7	0.0008	0.0098		S
7/30/00	6.91	below MDL	0.60	0.378	19.4	104.7				S

**Table 7: C60 Data (combined from all C60 subsites)**

Date	Subsite name	pH	Nitrate	Phosphate	E. coli	Samp type
6/22/01	C60A		8.76	0.074		B
6/22/01	C60-1		8.76	0.089		B
6/25/01	C60-1	7.1	1.97	0.086		B
6/25/01	C60-2	7.0	2.54	0.091		B
6/25/01	C60-3	6.9	1.86	0.099		B
7/6/01	C60-1		3.09	0.254		B
7/18/01	C60-1		3.62	0.137	110	B

## II. Data from Strath Haven reach

**Table 8: H10 Data**

Date	pH	Chlor	Nit	Phos	Turb	Sp. cond	E. coli	Samp type
7/24/00		33.6	0.872	3.34	17.35	467	98,000	B
7/24/00		35.3	1.3	0.782	14.8	492	69,000	B
7/28/00	6.22	41.0	1.18	2.488	15.3	415		B
6/20/01							130,000	B
6/20/01							90,000	B
6/26/01	6.6		1.54	2.07			78,000	B
7/18/01			0.98	2.52			31,000	B

**Table 9a: H30 Chemical Data (combined from all H30 subsites)**

Date	Sub-site name	pH	Chlor	Nit	Phos	Turb	Sp cond	COD	Phos load	Chlor load	Nit load	E. coli	Samp type
7/12/00	H30	6.41	91.1	1.95	0.206	0	542	17.9					B
7/12/00	H30	6.26	92.9	1.95	0.145	1.02	549					1600	B
7/14/00	H30	7.42	71.9	2.04	0.191	14.3	514						S
7/19/00	H30D	7.07	19.6	0.782	0.178	26.5	197.3		0.013	1.41	0.056		S
7/19/00	H30B	7.36	26.6	1.14	0.205	35.72	194.6	43.6	4.43	574.6	24.6	4000	S

**Table 9b: H30 Metals Concentration Data (combined from all H30 subsites)**

Date	Subsite name	Cadmium (mg/L)	Chromium (mg/L)	Copper (mg/L)	Lead (mg/L)	Nickel (mg/L)	Zinc (mg/L)	Samp type
7/12/00	H30	below MDL		0.0949			0.0117	B
7/19/00	H30B	below MDL	below MDL	0.023	below MDL	below MDL	0.061	S

**Table 9c: H30 Metals Loading Data**

Date	Subsite name	Cadmium (g/min)	Chromium (g/min)	Copper (g/min)	Lead (g/min)	Nickel (g/min)	Zinc (g/min)	Samp type
7/19/00	H30B			0.497			1.32	S

### III. Data from Smedley Park reach

*Table 10a: P20 Chemical Data*

Date	pH	Chlor	Nit	Phos	Turb	Sp. cond	COD	Samp type
8/1/00	6.86	8.07	0.512	0.00513	11.2	479	9.20	B

*Table 10b: P20 Metals Data*

Date	Cadmium (mg/L)	Chromium (mg/L)	Copper (mg/L)	Lead (mg/L)	Nickel (mg/L)	Zinc (mg/L)	Sample type
8/1/00	below MDL	below MDL		below MDL	below MDL	below MDL	B

*Table 11a: P40 Chemical Data*

Date	pH	Chlor	Nit	Phos	Turb	Sp cond	COD	E. coli	Samp type
8/1/00	6.88	13.65	1.23	0.0854	9.18	600	2.47	3100	B
8/14/00	6.87	4.49	0.782	0.019	17.4	200	14.97	5000	S
8/14/00	6.76	3.44	below MDL	below MDL	382.6	188.0	29.4	4250	S
8/14/00	6.75	1.18	0.334	below MDL	11.22	31.3	47.7	2800	S

*Table 11b: P40 Metals Data*

Date	Cadmium (mg/L)	Chromium (mg/L)	Copper (mg/L)	Lead (mg/L)	Nickel (mg/L)	Zinc (mg/L)	Sample type
8/1/00	below MDL	below MDL	below MDL	below MDL	below MDL	below MDL	B

*Table 12a: P70 Chemical Data*

Date	Subsite name	pH	Chlor	Nit	Phos	Turb	Sp cond	E. coli	Samp type
7/28/00	P70B	6.44	24.0	1.84	0.671	10.2	543		B
7/28/00	P70A	7.77	22.2	0.512	0.194	32.7	579	40	B

*Table 12b: P70 Metals Data*

Date	Subsite name	Cadmium (mg/L)	Chromium (mg/L)	Copper (mg/L)	Lead (mg/L)	Nickel (mg/L)	Zinc (mg/L)	Samp type
7/28/00	P70A	below MDL	below MDL	0.011	below MDL	below MDL	0.336	B

### *C.3 Data on Crum Creek Macrobiological Surveys, by site, summers of 1999, 2000 and 2001*

#### ***Explanation of Indices Used to Estimate Stream Health:***

1. Simpson Diversity Index (SDI): This index provides an indication of the level of macrobiological diversity at a site. High values of the SDI are most desirable. The index value increases as the number of different species of macroinvertebrates in a given population increases. The most diverse populations are those with small numbers of organisms from many different species. The higher the diversity of a population, the more stable the population, and vice versa. Populations of low diversity, containing large numbers of organisms from few species, imply instability. The SDI is useful for comparing sites to each other to determine relative levels of diversity at the sites.

2. Pollution Tolerance Index (PTI): This index uses information on the pollution tolerance of each species of organism collected at the monitoring site to determine an estimate of the level of pollution, and therefore the quality of the water, present at the site. Low PTI values indicate high levels of pollution, and vice versa. The scale commonly used to associate water quality with PTI values is given below.

<u>PTI value</u>	<u>Water quality</u>
23 +	Excellent
17-22	Good
11-16	Fair
10-	Poor

3. Shannon Weaver Index (SW): This index, like the PTI, uses information on the pollution tolerance of each species of organism collected at the monitoring site to estimate the overall pollution level present at the site. The scale commonly used to associate SW values with pollution levels in the water is given below.

<u>SW value</u>	<u>Pollution level in water</u>
0 – 1.00	Very polluted
1.00 – 2.00	Polluted
2.00 – 3.00	Mild enrichment
3.00 +	Very clean

***Site H55 (Yale Avenue Dam)***

	1999	2000	2001
Simpson Diversity Index	2.26	--	2.42
Pollution Tolerance Index	11	--	11
Shannon Weaver Index	1.43	--	1.56
Total organisms found	69	--	289

***Site C55 (Swarthmore College campus, behind DuPont science building)***

	1999	2000	2001
Simpson Diversity Index	3.31	--	1.96
Pollution Tolerance Index	22	--	13
Shannon Weaver Index	2.48	--	1.28
Total organisms found	46	--	130

***Site P15 (Plush Mill Road, at Victoria Station)***

	1999	2000	2001
Simpson Diversity Index	4.60	--	1.56
Pollution Tolerance Index	18	--	9
Shannon Weaver Index	2.57	--	0.92
Total organisms found	66	--	107

***Site P50 (unnamed tributary entering from west, in Smedley Park)***

	1999	2000	2001
Simpson Diversity Index	2.72	3.32	1.33
Pollution Tolerance Index	21	17	11
Shannon Weaver Index	2.19	2.08	0.77
Total organisms found	48	53	36

***Site P40-1 (Whiskey Run, below Springfield Mall)***

	1999	2000	2001
Simpson Diversity Index	1.82	3.17	1.11
Pollution Tolerance Index	16	16	4
Shannon Weaver Index	1.50	2.22	0.310
Total organisms found	126	34	18

***Site P40-2 (Whiskey Run, above Springfield Mall)***

	1999	2000	2001
Simpson Diversity Index	1.62	--	1.40
Pollution Tolerance Index	16	--	14
Shannon Weaver Index	1.20	--	0.970
Total organisms found	108	--	56

**Macrobiological data on Ridley Creek, taken Oct. 1997 and July 2001**

***Ridley Creek***

	1997	2001
Simpson Diversity Index	2.30	2.14
Pollution Tolerance Index	17	24
Shannon Weaver Index	1.63	1.72
Total organisms found	49	197

**Comparison of Crum Creek and Little Crum Creek sites with respect to each other**

***Sites P40-1 and P40-2, data from July 1999***

	P40-1	P40-2
Simpson Diversity Index	1.82	1.62
Pollution Tolerance Index	16	16
Shannon Weaver Index	1.50	1.20
Total organisms found	126	108

***Sites P40-1 and P40-2, data from July 2001***

	P40-1	P40-2
Simpson Diversity Index	1.11	1.40
Pollution Tolerance Index	4	14
Shannon Weaver Index	0.310	0.970
Total organisms found	18	56

*Note:* Site P40-1 is downstream of the Springfield Mall; P40-2 is upstream of the mall.

***Sites on Little Crum Creek: LC1-A, LC1-B, LC6***

	LC1-A	LC1-B	LC-6
Simpson Diversity Index	1.39	2.06	1.26
Pollution Tolerance Index	8	7	10
Shannon Weaver Index	0.73	1.38	0.70
Total organisms found	49	38	82

*Note:* Site LC1-A is the site downstream of the new Ridley High School; LC1-B is upstream of the new high school; LC-6 is in Little Crum Creek Park, just downstream of the Yale Avenue bridge.

*C.4 Data collected for sites in Crum Creek during construction of Pennsylvania Route 476. Source: Regularly published public reports from the environmental monitor KCI Technologies (formerly Kidde Consultants, Inc.) issued during the construction of the "Blue Route."*

*Explanation of column headings and units used in chemical data tables:*

**H2O temp** = Water temperature at time of sampling. Units: degrees C

**DO** = Dissolved oxygen concentration. Units: mg/L

**Alk** = Alkalinity. Units: ppm CaCO<sub>3</sub>.

**Chlor** = Chloride concentration. Units: mg/L

**Nit** = Nitrate concentration. Units: mg/L

**Phos** = Phosphate concentration. Units: mg/L

**Turb** = Turbidity. Units: NTU

**BOD** = Biochemical oxygen demand. Units: mg/L

**Sp. Cond** = Specific conductance. Units: microsemens/cm

**E. coli** = Fecal coliform. Units = colonies per 100 mL

**Note regarding the data presented:** It was assumed that all samples for which data are presented here were collected during baseline conditions, as there was no indication that the samples were collected during storm events.

**Table 1a: CC-4 Chemical Data**

Date	H2O temp	DO	pH	Alk	Chlor	Nit	Phos	Turb	BOD	Sp cond	Fecal Coliform
6/1985	20			48	48	0.5	0.3	2.3	3.2	280	240
8/1985	22	5.1	6.99	42	26	0.7	0.19	4.4	2.7	200	2400
10/1985	14.25	8.5	7.17	42	38	0.8	0.09	2.8	1.9	275	11000
2/1986	1	13.2	7.25	38	111	1	<0.05	2.4	4.4	550	93
4/1986	9.5	9.8	7.06	28	51	1.9	0.3	31	12.5	250	2400
6/1986	18	7	7.04	42	37	3	0.11	4.6	2.2	260	1100
8/1986	20.5	5.5	7.16	48	38	0.4	0.08	3.6	1.5	270	2400
10/1986	17	8.96	7.07	40	32	1.2	0.12	3.3	1.1	230	2400
12/1986	2	12	6.78	40	39	1.2	0.34	2.1	2.2	300	750
2/1987	2.5	13.5	6.7	35	78	2.2	0.12	3.2	5	420	93
4/1987	15.5	9.6	6.9	37	28	1.5	0.22	3.8	0.5	230	460
8/1988	26.5	5.4	7.31	50	39	0.6	0.1	1.1	1.5	325	9300
10/1988	9	9.2	7.25	40	26	0.5	0.23	10.8	2.5	200	11000
12/1988	6			42	45	1.2	<0.05	3.2	1.6	345	240
2/1989	5	12	7.54	28	41	1.3	<0.05	11.6	1.7	250	24000
4/1989	12	10.8	7.81	40	34	1.2	0.11	3.6	1.3	250	1100
6/1989	23	7.6	7.59	40	28	0.8	0.07	3.9	1.6	240	2400
8/1989	22	8.8	7.76	44	28	0.6	<0.05	4.7	1	225	24000
10/1989	10	10.6	7.67	48	21	1	0.06	2.7	6.3	260	2400
12/1989	1	13.4	7.59	45	100	1.2	<0.05	1.7	1.4	500	4600
10/15/1990	19	8.8	6.95	54	48	0.6	0.12	2.3	<0.5	325	23
12/12/1990	3	10.8	7.52	49	50	1.2	2.5	2.3	4.5	320	2400
2/1991	3	12.8	7.59	57	55	1.2	0.08	2.6	1.7	325	2400
4/23/1991	11	10.2	7.73	44	31	0.6	0.23	6.8	2.1	225	2400
6/11/1991	19	7.2	7.55	46	57	1.3	1.33	1.9	<0.5	350	11000
8/12/1991	20.5	6.8	7.39	44	43	1.1	0.2	23	<0.5	225	24000



**Table 1b: CC-4 Metals Data**

Date	Cadmium (mg/L)	Chromium (mg/L)	Copper (mg/L)	Lead (mg/L)	Nickel (mg/L)	Zinc (mg/L)
6/1985	<0.005	<0.01	<0.01	<0.02	<0.02	0.04
8/1985	<0.005	<0.01	<0.01	<0.02	<0.02	0.01
10/1985	<0.005	<0.01	0.01	<0.02	<0.02	0.03
2/1986	<0.0005	0.005	0.004	0.005	<0.005	0.038
4/1986	<0.0005	0.005	0.01	0.018	<0.005	0.039
6/1986	0.0005	0.001	0.005	0.002	<0.005	0.011
8/1986	<0.0005	0.001	<0.002	<0.001	<0.005	0.013
10/1986	<0.0004	0.003	0.006	0.0008	<0.005	0.018
12/1986	0.0006	<0.001	<0.002	0.0006	<0.005	0.019
2/1987	<0.0005	<0.001	0.005	0.0055	<0.005	0.067
4/1987	0.0006	<0.001	0.003	0.0031	<0.005	0.01
8/1988	<0.0005	0.001	0.004	0.0011	0.005	0.003
4/1989	0.0008	<0.001	0.004	0.0006	0.008	0.014
8/1989	<0.0005	<0.001	0.003	<0.0006	<0.005	0.003
10/1989	<0.0005	<0.001	0.007	0.0033	<0.005	0.013
12/1989	<0.0005	<0.001	0.005	0.0021	<0.005	0.03
10/15/1990	0.6	<0.001	0.006	0.0035	0.016	0.02
6/11/1991	<0.0005	<0.001	0.004	<0.0006	<0.005	0.005
8/12/1991	<0.0005	<0.001	0.004	0.0018	<0.005	0.007

**Table 2a: DR-5 Chemical Data**

Date	H2O temp	DO	pH	Alk	Chlor	Nit	Phos	Turb	BOD	Sp cond	E. coli
6/1985	19			42	37	1.5	0.37	1.8	3	270	23
8/1985	20	8.1	7.57	45	38	1.9	0.26	3.5	3.5	270	93
10/1985	14.75	9.5	7.42	40	34	1.6	0.07	1.1	2	290	460
2/1986	2	13.8	7.32	36	101	1.5	<0.05	2.5	4.2	510	2100
4/1986	10	9.8	6.3	20	11	0.9	0.22	272	29.2	175	4600
6/1986	16	8.7	7.37	42	37	9	0.16	2.4	2	240	1500
8/1986	18.5	8.1	7.43	42	38	1.4	<0.05	1.5	1	290	240
10/1986	19	8.4	7.36	29	12	2	0.21	3.6	1.5	130	4600
12/1986	4.5	11.8	6.79	38	40	2.4	0.2	0.58	2.9	300	240
2/1987	5.5	12.6	6.86	35	78	3.5	0.11	0.71	2.5	420	210
4/1987	14.5	10.3	6.78	37	39	3.5	0.15	1	1.4	250	460
8/1988	23	7.5	7.43	42	41	2	0.07	0.4	<0.5	350	460
10/1988	9	10.2	7.23	40	34	1.2	0.06	0.6	0.8	260	460
12/1988	8			34	48	2	<0.05	0.5	1.5	320	460
2/1989	5	12	7.56	32	39	1.7	<0.05	3.6	0.9	300	21000
4/1989	9.5	12.7	7.92	35	45	1.8	0.05	3.9	<0.5	300	23
6/1989	18	8.7	7.55	37	44	2.2	0.15	1.1	0.6	320	460
8/1989	19	9.6	7.72	40	43	1.9	0.21	0.5	0.7	300	1100
10/1989	11	10.2	8.09	43	44	1.2	<0.05	12.1	1.2	320	460
12/1989	3	13.4	7.63	34	220	1.7	<0.05	0.5	0.8	900	15
10/15/1990	18	8.5	7.85	47	43	1.3	0.08	1	1	325	210
12/12/1990	5	11.6	7.65	39	44	2.4	<0.05	0.4	3.5	300	150
2/1991	4	14	7.73	40	49	1.4	<0.05	0.6	1.6	310	460
4/23/1991	11	11.2	7.75	40	46	1.3	0.12	0.1	2.5	300	1100
6/11/1991	16	8.6	7.69	39	45	1.7	2.01	0.3	<0.5	300	1100
8/12/1991	19	8.5	7.58	49	61	2.3	0.35	2.6	1.9	300	2400

**Table 2b: DR-5 Metals Data**

Date	Cadmium (mg/L)	Chromium (mg/L)	Copper (mg/L)	Lead (mg/L)	Nickel (mg/L)	Zinc (mg/L)
6/1985	<0.005	<0.01	<0.01	<0.02	<0.02	0.04
8/1985	<0.005	<0.01	0.01	<0.02	<0.02	0.01
10/1985	<0.005	<0.01	<0.01	<0.02	<0.02	0.03
2/1986	0.0011	0.002	0.002	<0.001	<0.005	0.019
4/1986	<0.0005	0.015	0.037	0.14	0.015	0.147
6/1986	0.0006	<0.001	0.004	0.002	<0.005	0.013
8/1986	<0.0005	<0.001	<0.002	<0.001	<0.005	0.011
10/1986	<0.0004	<0.001	0.007	<0.0006	<0.005	0.021
12/1986	<0.0005	<0.001	0.002	0.0012	<0.005	0.013
2/1987	<0.0005	0.002	<0.002	0.0024	<0.005	0.049
4/1987	<0.0005	0.001	0.004	0.0018	<0.005	0.01
8/1988	<0.0005	0.001	0.004	0.0012	<0.005	0.003
4/1989	<0.0005	<0.001	0.008	0.0033	<0.005	0.022
8/1989	<0.0005	<0.001	0.005	<0.0006	<0.005	0.023
4/23/1991	<0.0005	<0.001	0.006	<0.0006	<0.005	0.010
8/12/1991	<0.0005	0.002	0.003	0.0006	<0.005	0.032

**Table 3a: CC-8 Chemical Data**

Date	H2O temp	DO	pH	Alk	Chlor	Nit	Phos	Turb	BOD	Sp cond	E. coli
6/1985	21			42	50	0.4	0.24	2.5	4	290	24000
8/1985	21	7	7.28	40	37	0.5	0.1	3	4.7	240	1100
10/1985	15.25	7.9	7.9	44	53	1.1	<0.05	13.4	6.2	370	240
2/1986	2	13.4	7.17	32	96	1.3	<0.05	1.8	4.1	500	43
4/1986	9	9.6	7	28	28	1.3	<0.05	312	22.7	210	4600
6/1986	19	8.2	7.37	40	40	2.4	0.21	4.2	2.3	280	240
8/1986	20.5	7.4	7.25	52	42	0.2	0.6	2.1	2	300	11000
10/1986	17	8.56	6.6	45	31	1.4	<0.05	10.6	3.6	220	2400
12/1986	3	11.8	6.67	37	43	1.1	0.17	1.7	3.4	320	240
2/1987	3	12.4	6.8	32	99	2.3	0.15	2.2	2	500	110000
4/1987	15	9.5	6.56	38	29	1.8	0.16	3.2	0.7	230	4600
8/1988	28	6.2	7.26	40	50	0.2	0.19	1.1	1	395	2400
10/1988	11	8.8	7.24	38	41	0.6	<0.05	8.4	1.6	270	2400
12/1988	6			40	55	1.1	<0.05	2.3	1.6	350	4
2/1989	4.5	11.2	7.56	34	39	0.8	0.11	9.2	1.4	275	150
4/1989	11.5	10.6	7.73	40	32	1	<0.05	0.5	0.8	250	93
6/1989	24	6.8	7.5	40	28	1	0.14	2.3	1.1	250	460
8/1989	22	8.8	7.65	42	30	0.8	0.06	4.6	1.1	240	460
10/1989	11	9.6	7.53	50	45	1.2	<0.05	2.7	1.4	340	75
12/1989	1	13	7.46	40	142	1	0.05	2.3	1.2	650	4
10/15/1990	18	5.4	7.35	78	41	0.3	0.16	7.5	2.8	350	240
12/12/1990	3.5	11.6	7.65	55	48	0.9	<0.05	3	2.3	340	43
2/1991	4	12.6	7.71	53	53	0.9	0.15	3.5	1.7	310	9
4/23/1991	11	10.4	7.75	46	36	0.6	0.15	4.6	1.9	225	460
6/11/1991	21	8.3	7.6	54	44	0.7	0.12	2	<0.5	275	4600
8/12/1991	21.5	6.8	7.49	54	64	0.9	0.2	11.7	2.1	300	2400

**Table 3b: CC-8 Metals Data**

Date	Cadmium (mg/L)	Chromium (mg/L)	Copper (mg/L)	Lead (mg/L)	Nickel (mg/L)	Zinc (mg/L)
6/1985	<0.005	<0.01	<0.01	<0.02	<0.02	0.04
8/1985	<0.005	<0.01	<0.01	<0.02	<0.02	0.02
10/1985	<0.005	<0.01	0.03	<0.02	<0.02	0.04
2/1986	<0.0005	0.002	0.002	0.002	<0.005	0.046
4/1986	0.0005	0.016	0.025	0.13	<0.005	0.154
6/1986	<0.0005	<0.001	0.004	0.001	<0.005	0.013
8/1986	<0.0005	<0.001	0.004	<0.001	<0.005	0.017
10/1986	0.0004	0.002	0.006	0.0007	<0.005	0.034
12/1986	<0.0005	<0.001	<0.002	0.0007	<0.005	0.03
2/1987	<0.0005	<0.001	0.003	0.0009	<0.005	0.084
4/1987	0.0008	<0.001	0.009	0.0008	<0.005	0.013
8/1988	<0.0005	0.001	0.004	0.0008	0.007	0.004
4/1989	<0.0005	<0.001	0.008	0.0035	<0.005	0.021
8/1989	<0.0005	<0.001	0.004	0.0008	<0.005	0.019
4/23/1991	<0.0005	0.001	0.004	0.0006	<0.005	<0.002
8/12/1991	<0.0005	<0.001	0.002	0.0009	<0.005	0.031

**Table 4a: CC-9 Chemical Data**

Date	H2O temp	DO	pH	Alk	Chlor	Nit	Phos	Turb	BOD	Sp cond	E. coli
6/1985	20			42	36	0.4	0.69	1.7	3.8	210	240
8/1985	21	5.3	7.09	38	20	0.4	0.23	8.8	3	150	93
10/1985	15	5.5	6.83	40	28	0.8	<0.05	7.1	5.1	250	240
2/1986	1	12.4	7.05	30	43	0.9	<0.05	1.8	2.4	300	<3
4/1986	8.5	11.2	7.49	38	25	1	<0.05	15	2.6	200	93
6/1986	19	5.7	6.94	40	29	2.8	0.2	4.3	2	220	240
8/1986	19.5	6.6	7.05	40	31	0.3	2.6	1.5	4.6	240	1100
10/1986	14	5.64	6.34	61	46	<0.1	0.08	126	48	360	120
12/1986	3	11.8	6.36	36	32	1	0.22	1.9	2.4	200	4
2/1987	1.5	11.6	6.43	28	36	1.8	0.11	1.4	1.4	270	7
4/1987	16	9.8	6.83	37	25	1.7	0.17	5.7	1.3	210	93
8/1988	27	6.4	7.25	33	40	0.2	0.08	1.4	1.2	280	43
10/1988	6			40	36	1	0.17	2.5	1.3	350	4
12/1988	9.5	7.4	7.27	45	22	0.5	0.14	4.9	1.8	220	240
2/1989	4	9.4	7.55	35	28	0.7	<0.05	14.9	1.4	230	9
4/1989	12	9.2	7.69	38	28	1.2	<0.05	0.3	0.9	225	23
6/1989	25	7	7.43	40	23	1	0.12	2.1	1.2	200	1100
8/1989	23	7.6	7.62	42	27	0.8	0.06	3.9	1.3	200	1100
10/1989	11	7.6	7.43	44	25	0.7	0.06	2.9	1.7	240	43
12/1989	0.5	11	7.46	45	37	0.9	<0.05	5.8	1.3	280	<3
10/15/1990	18.5	6.8	7.62	67	36	0.2	0.12	4.9	2.7	300	4600
12/12/1990	2.5	10	7.37	52	33	1.2	<0.05	2.4	7.2	250	240
2/1991	3	12	7.62	50	36	0.8	0.2	2.5	1.6	250	15
4/23/1991	11.5	9.6	7.87	48	32	0.6	0.2	3.8	2	225	210
6/11/1991	21	5.2	7.65	46	32	0.7	<0.05	2.4	0.9	225	1000
8/12/1991	21	4.4	7.24	58	43	0.6	0.25	16	2.2	225	2400

**Table 4b: CC-9 Metals Data**

Date	Cadmium (mg/L)	Chromium (mg/L)	Copper (mg/L)	Lead (mg/L)	Nickel (mg/L)	Zinc (mg/L)
6/1985	<0.005	<0.01	0.01	<0.02	<0.02	0.07
8/1985	<0.005	<0.01	0.01	<0.02	<0.02	0.02
10/1985	<0.005	<0.01	0.02	<0.02	<0.02	0.05
2/1986	<0.0005	0.004	0.001	0.002	<0.005	0.107
4/1986	<0.0005	0.002	0.002	0.006	<0.005	0.1
6/1986	<0.0005	<0.001	0.003	0.005	<0.005	0.011
8/1986	<0.0005	<0.001	0.004	<0.001	<0.005	0.124
10/1986	0.0005	0.002	0.005	0.002	<0.005	0.119
12/1986	0.0008	<0.001	0.002	0.0006	<0.005	0.032
2/1987	<0.0005	<0.001	<0.002	<0.0006	<0.005	0.172
4/1987	0.001	<0.001	0.004	<0.0006	<0.005	0.008
8/1988	<0.0005	<0.001	0.003	0.0014	<0.005	<0.002
4/1989	<0.0005	0.003	0.005	0.0014	<0.005	0.033
8/1989	<0.0005	<0.001	0.004	<0.0006	<0.005	0.015
4/23/1991	<0.0005	<0.001	0.003	0.0018	<0.005	<0.002
8/12/1991	<0.0005	<0.001	0.007	<0.0006	<0.005	<0.002

**Table 5a: CC-10 Chemical Data**

Date	H2O temp	DO	pH	Alk	Chlor	Nit	Phos	Turb	BOD	Sp cond	E. coli
6/1985	21.5			38	36	0.5	3.13	20	5.5	240	23
8/1985	22	6.7	7.03	30	20	0.4	0.49	16.5	3.2	150	240
10/1985	15.5	6.3	7.03	60	33	0.15	0.13	17.4	7.3	430	240
2/1986	1.75	12.6	6.96	30	53	0.8	<0.05	1.8	2.8	360	<3
4/1986	8.5	11.4	7.59	38	25	1.8	<0.05	13.8	2.1	200	150
6/1986	18.5	7.7	7.25	37	30	4	0.24	5.5	2	230	93
8/1986	20.5	6.3	7.25	38	32	0.3	2.8	2.7	3.4	240	93
10/1986	13.5	7.12	6.63	70	48	<0.1	0.07	244	57	360	39
12/1986	3.5	12.2	6.56	35	32	0.8	0.15	2.3	2.7	250	<3
2/1987	3	11	6.23	28	42	1.5	0.17	1.4	1.5	300	<3
4/1987	16	9.9	6.78	37	26	1.4	0.16	7.1	1.1	200	460
8/1988	28	6.4	7.25	35	34	0.1	0.22	1.7	1	275	93
10/1988	10	8.6	7.28	41	28	0.4	0.3	8.2	1.5	250	240
12/1988	7.5			40	38	0.6	0.14	2.5	1.5	300	<3
2/1989	5	9.2	7.52	35	27	0.8	0.34	27	1.3	210	2400
4/1989	13.5	10.8	8.03	39	28	1.2	<0.05	2.7	0.6	225	240
6/1989	25	6.8	7.61	40	23	0.5	0.06	3.1	1	200	1500
8/1989	23	8.2	7.71	42	27	0.8	<0.05	3.6	0.9	210	2400
10/1989	11	7.6	7.67	44	25	1	0.06	1.3	1.5	210	240
12/1989	1	10	7.47	45	34	0.8	<0.05	3.3	1.1	260	9
10/15/1990	19.5	8.2	7.19	50	27	0.4	<0.05	4	4	300	11000
12/12/1990	2.5	9.6	7.55	55	31	1.2	<0.05	2.4	3	250	240
2/1991	4	11	7.74	51	36	0.6	<0.05	4	1.8	250	15
4/23/1991	11	8	7.84	46	30	0.5	0.28	4.5	1.8	225	240
6/11/1991	20	5.8	7.62	44	33	0.7	0.05	2	3.5	225	2400
8/12/1991	21	4.6	7.28	30	37	0.6	0.22	35	2.3	175	11000

***Table 5b: CC-10 Metals Data***

Date	Cadmium (mg/L)	Chromium (mg/L)	Copper (mg/L)	Lead (mg/L)	Nickel (mg/L)	Zinc (mg/L)
6/1985	<0.005	<0.01	0.08	<0.02	<0.02	0.22
8/1985	<0.005	<0.01	0.02	<0.02	<0.02	0.04
10/1985	<0.005	<0.01	0.03	<0.02	<0.02	0.09
2/1986	<0.0005	0.003	0.001	0.003	<0.005	0.199
4/1986	<0.0005	0.002	0.003	0.002	<0.005	<0.002
6/1986	<0.0005	<0.001	0.003	0.001	<0.005	0.011
8/1986	<0.0005	0.001	0.002	<0.001	<0.005	0.396
10/1986	0.0005	0.003	0.007	0.0037	<0.005	0.059
12/1986	0.0008	<0.001	<0.002	0.0006	<0.005	0.028
2/1987	<0.0005	<0.001	0.003	<0.0006	<0.005	0.274
4/1987	<0.0005	<0.001	<0.002	<0.0006	<0.005	0.015
8/1988	0.0005	0.002	0.003	0.0021	0.008	0.011
4/1989	<0.0005	0.004	0.005	0.0022	<0.005	0.016
8/1989	<0.0005	<0.001	0.004	0.0009	<0.005	0.002
4/23/1991	<0.0005	<0.001	<0.002	0.0006	<0.005	0.011
8/12/1991	<0.0005	0.002	0.007	0.0053	<0.005	0.004

## **Appendix D - Senior Design Projects**

## **D.1 Design and Construction of a Data Management System for the Lower Crum Creek Watershed Restoration Project – Kristin Chadderton '01**

This project was conducted in order to design and construct a data management system for the Lower Crum Creek watershed restoration project. The data management system was constructed in two parts. The first part is comprised of a storage database and a database designed for summarizing data. These two databases were built using FileMaker Pro 5.0 software. The second part of the management system consists of a database built using ArcView GIS 3.2 software. Statistical tests of the data collected on water quality parameters at two sites along the creek were performed. The results of these tests show that statistical variations exist between data points collected by laboratory staff and data points collected by volunteer monitors. The results also show that statistical variation exists between nitrate levels at the two sites tested; the nitrate concentrations at Swarthmore College's main storm sewer are higher on average than the nitrate concentrations in Dicks Run, a tributary through a downstream residential area. Tests were also run on the data management system itself to determine its effectiveness and the effectiveness of the protocols written for its use. It was determined that the data management system functions properly and will be useful for analysts working on the Lower Crum Creek restoration project in the future. It was also determined that more data on different creek sites and on different chemical parameters will be required for an accurate assessment to be formulated of the quality of the Lower Crum Creek. This assessment will be necessary to the formulation of a restoration plan for the Lower Crum Creek watershed.

## **D.2 A Risk Assessment for Potential Metal Toxicity in Crum Creek Sediment, Determined using Simultaneously Extracted Metals and Sulfide, Organic Carbon, and Interstitial Water – Clara Fuchsman '01**

A risk assessment of sediment metal toxicity in Crum Creek was determined using simultaneously extracted metals (SEM), acid-volatile sulfide (AVS), organic carbon, and interstitial water. High metal concentrations in sediments are harmful to benthic macroinvertebrates. However, sediment toxicity does not correlate with total metal concentrations due to the non-bioavailability of some metals which bind to sulfur or organic carbon. Methods for determining pollution and toxicity, such as simultaneously extracted metals and sulfide, have been created. Sediments with  $SEM/AVS < 1$ , or negative SEM-AVS values, are non-toxic for metals (Hansen, 1996). In streams such as Crum Creek, which have low sulfur concentrations, SEM-AVS values are more useful. When SEM-AVS values are positive, organic carbon must be considered. Di Toro (1999) predicts with 90% confidence non-toxic sediments if  $(SEM-AVS)/g \text{ Organic Carbon} < 130 \text{ micromol/gOC}$ . Metals in interstitial water provide correlating toxicity data, since sediments are nontoxic when  $IWTUs < 0.5$  (Hansen, 1996). Chromium (VI) toxicity can also be monitored using interstitial water where combined chromium concentrations below 1500 micrograms/L indicate non-toxicity (Boothman, 1999).

Samples were taken from three sites: P50, in the main branch of Crum Creek above Swarthmore College; C50, a stormwater outfall which drains college buildings; and H50, which is in the main branch near Yale Avenue Bridge, downstream of the college. Benthic macroinvertebrate surveys of the sites indicated that pollution sensitive species such as stoneflies lived at P50, that C50 had healthy diversity, and that H50 was more polluted but still in “Fair” condition, according to pollution indices. Little sulfide was found at the sites, so SEM-AVS appeared potentially toxic, but when organic carbon data were included, all the values (14.53/6.57 for P50 and 79.92/49.07 for C50) were smaller than 130 micromol/gOC, indicating a lack of toxicity due to metals. However, validity of the use of the number 130 micromol/gOC is questioned due to potential differences in sieving techniques. Interstitial water from H50 had metal concentrations of 16.0 IWTU, C50 of 22.1 IWTU, and P50 of 7.5 IWTU, all much greater than 0.5 IWTU, indicating potential metal toxicity. The large magnitude of each of these IWTUs is due to copper, which has a very low 10-d pollution because organic carbon binds to metals in solution, making them not bioavailable, but these complexes are still detected by atomic absorption. Copper may be at toxic levels in Crum Creek interstitial water, or some copper bound to organic carbon in solution is producing misleadingly high results. High copper and lead concentrations found by total metal extraction of C50 support the potential for copper toxicity. Chromium levels in interstitial water ranged from zero to 360 micrograms/L, all less than 1500 micrograms/L, indicating a lack of toxicity due to Cr (VI).



### **D.3 Experimental Wetlands Design for Swarthmore College Stormwater Discharge**

– Marc Jeuland '01

The short-term goal of this project was to construct an experimental subsurface flow wetland in the Crum Woods to test the efficiency of a bulrush (*scirpus pungens*) and burreed (*sparganium americanum*) system for the cleaning of stormwater. The runoff diverted into this wetland comes from much of the lower and eastern part of the Swarthmore College campus, as well as Chester Road. The site chosen for construction was a natural wetland; this wetland was threatened by a series of invasive Asian species (privet, multiflora rose, and phragmites) which were introduced recently and have no local competitors. The project thus resulted in several benefits: evaluation of the water-treating capability of two local, non-threatening species, restoration of the wetland through removal and treatment of invasive plants, and elimination of unwanted fill disposed of in the wetland during a former construction project. Two plots were created: a control plot containing no plants, and an experimental plot planted with the two species under study. The two plots run parallel to each other, and are each 48 inches long, 16 inches across and 24 inches deep. They are isolated from the ground with rubber and polyethylene plastic. Water was diverted from the nearby stormwater channel with garden hose attached to strainers. The water is fed into the constructed wetland by gravity. The detention time and treatment efficiency of the plots were determined. Preliminary analysis was performed to determine estimates of the removal of nitrate, phosphate and dissolved solids from the stormwater in the experimental and control plots. It was found that percentages of pollutant removal were higher in the experimental plot than in the control plot for all three types of pollutant analyzed, and that the bulrush specimens in general exhibited higher pollutant uptake than the burreed. Further analysis of the constructed wetland and its performance is necessary in order to inform a more appropriate and responsible stormwater management system for Swarthmore College.

#### **D.4 Design of a Non-Point Source Pollution Treatment Optimization Model with Application to the Crum Creek Watershed – Michelle Mizumori '01**

In this project, a linear programming model system was designed to optimize the pollution removal in a watershed cost-effectively. The system consists of two models, one at the watershed-wide level and one at the subwatershed level. The first minimized cost while constrained to a certain annual maximum loading for each subwatershed, while the latter maximized pollution removal constrained to certain budget limitations.

Once this system was designed, it was written in the AMPL computer programming language, and sample runs were made for the lower portion (below the Lower Reservoir) and the middle portion (below Geist Reservoir and above the Lower Reservoir) of the Crum Creek watershed at a watershed-wide level, and for Little Crum Creek at a subwatershed level, for nitrogen, phosphorus and total suspended solids (TSS). The loading removal for Lower Crum Creek ranged 0-70.3% for nitrogen, 0-69.8% for phosphorus, and 0-92.1% for TSS within the seven subwatersheds, while removal for Middle Crum Creek ranged from 38.4%-96.1% for nitrogen, 25.9-82.7% for phosphorus and 0-91.4% for TSS.

The subwatershed model suggested implementing a dry pond to wet pond conversion, seeding of a runoff trench, a residential education plan including posting signs by storm drains, and implementing seeding with erosion control at two sites, with an initial \$50,000 budget. If the budget is raised to \$500,000, another dry pond to wet pond conversion is added, as well as a porous pavement parking lot and a constructed wetland. However, even with the \$500,000 budget, the pollution removal falls well short of the required removal determined by the watershed model.

## **Appendix E - Laboratory QA/QC**

**Swarthmore College Environmental Lab QA/QC Plan is available upon request**

## **Appendix F - Crum Creek Watershed Partnership**

### **F.1 Partnership Steering Committee Members**

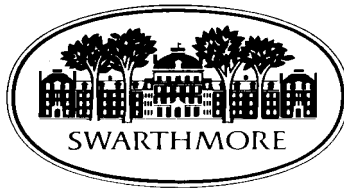
CRC Watersheds Assoc.	Marshall Hamilton	mhamil2741@aol.com
Easttown Twp	Gene Williams	<a href="mailto:easttown@erols.com">easttown@erols.com</a>
Edgmont Twp	Barbara Moore	<a href="mailto:edgmontrealtor@aol.com">edgmontrealtor@aol.com</a>
Edgmont Twp (alternate)	Samantha Reiner	<a href="mailto:manager@edgmont.org">manager@edgmont.org</a>
Malvern Borough	Sarah S. Bones	<a href="mailto:sbonespa@earthlink.net">sbonespa@earthlink.net</a>
Marple Twp	Jim Schmid	<a href="mailto:jaschmid@aol.com">jaschmid@aol.com</a>
Natural Lands Trust	David Harper	<a href="mailto:dharp@natlands.org">dharp@natlands.org</a>
Natural Lands Trust (alt.)	Peter Williamson	<a href="mailto:pwilliamson@natlands.org">pwilliamson@natlands.org</a>
Nether Providence Twp	Jonathan Sutton	610- 565-2852
Nether Providence Twp	Tina Deininger	610-565-5241
Newtown Twp:	Vacant	
Phila. Sub. Water Co	Preston Luitweiler	<a href="mailto:luitweilerp@suburbanwater.com">luitweilerp@suburbanwater.com</a>
Ridley Township	Barbara Ormsby	610-532-5413
Ridley Park Borough	Bob Poole	<a href="mailto:rpoole105@aol.com">rpoole105@aol.com</a>
Springfield Twp	Paul Horna	<a href="mailto:hornaclan@aol.com">hornaclan@aol.com</a>
Swarthmore Borough	Barbara Grove	
Swarthmore College	Art McGarity	<a href="mailto:amcgarity@swarthmore.edu">amcgarity@swarthmore.edu</a>
Tredyffrin Township	Guy Ciarrocchi	<a href="mailto:gciarroc@adphila.org">gciarroc@adphila.org</a>
Tredyffrin Twp (alternate)	Bonnie Marcus	<a href="mailto:bmarcus@pqcorp.com">bmarcus@pqcorp.com</a>
Upper Providence Twp	Catherine Swanson	<a href="mailto:catherine.swanson@phl.boeing.com">catherine.swanson@phl.boeing.com</a>
Willistown Conservation Trust		Mary McLoughlin
	<a href="mailto:mhm@wctrust.org">mhm@wctrust.org</a>	
WCT (alternate)	Alex Van Alen	<a href="mailto:asva@wctrust.org">asva@wctrust.org</a>
Willistown Twp:	Gary Sheehan	<a href="mailto:mesagts@aol.com">mesagts@aol.com</a>
Willistown Twp (alternate)	Ava Zandi	610-889-7584

### **F.2 CRUM CREEK WATERSHED ASSOCIATES**

Chester County Watershed Coordinator: Charlotte Sprenkle	<a href="mailto:csprenkle@chesco.org">csprenkle@chesco.org</a>
CRC Watersheds Association Carl DuPoldt	
	<a href="mailto:cdupoldt@bellatlantic.net">cdupoldt@bellatlantic.net</a>
John Custer: Newtown Square	
	<a href="mailto:jcuster@atxmail.com">jcuster@atxmail.com</a>
Del. County Watershed Coordinator: Bill Gothier	<a href="mailto:delaware.county@dep.state.pa.us">delaware.county@dep.state.pa.us</a>
PaDEP Regional Watershed Manager: Desiree Henning Dudley	<a href="mailto:dhenningdu@state.pa.us">dhenningdu@state.pa.us</a>
Pa. Environmental Council: Jeanne Barrett Ortiz	
	<a href="mailto:jortiz@pecphila.org">jortiz@pecphila.org</a>
Schnabel Engineering: Jane Rowan	<a href="mailto:jrowan@schnabel-eng.com">jrowan@schnabel-eng.com</a>
Eddystone Borough	Pat Rodden
	610-874-1100

### **F.3 Report to Nether Providence Township on Monitoring Results (see letter on next 2 pages)**

Arthur E. McGarity  
Professor of Engineering  
Department of Engineering  
Hicks Hall, 500 College Ave.



Fax: (610) 328-8082  
Voice: (610) 328-8077  
email: amcgarity@swarthmore.edu

**Swarthmore College, Swarthmore, Pennsylvania 19081**

**To: Mr. Jon Sutton, Chair, Nether Providence Environmental Advisory Council**

**From: Art McGarity, Swarthmore College and Crum Creek Watershed Partnership**

**Date: 26 June, 2001**

**Subject: Suspected sewage discharge into Crum Creek from Avondale Rd./I476 in Nether Providence**

**Dear Jon:**

As you know, one objective of the PADEP funded Crum Creek assessment project currently underway at Swarthmore College is identification of "hot spots" where the water quality in the stream is significantly degraded. This monitoring effort is in support of the Crum Creek Watershed Partnership's survey of municipalities in the watershed, to which Nether Providence has made significant contributions through the efforts of the Environmental Advisory Council (EAC). The purpose of this report is to provide you with monitoring results from a specific site in Nether Providence that is most likely a high priority location for repair or remediation to eliminate the continuous discharge of quite potent pollution into the creek that appears to originate from human waste, perhaps from a failed septic system or a leaking sewer.

Data tables on the next page show results of our monitoring the site which we have designated H10. The geographic location, including latitude and longitude, is also indicated. Data from the summer of 2000 and the summer of 2001 show levels of water quality parameters that strongly indicate that the source of the discharge is human waste. Photographs of the site are attached. The samples in Table 1 were taken from the discharge point where there is a plastic pipe that has a continuous flow of water having a strong odor. The pipe emerges from riprap stones at the base of the retaining wall below Avondale Road, which abuts the Blue Route (I476) at this point. The installation appears to be recent, and was probably created during the Blue Route construction in the early 1990's. The water collects in a pool before spilling into a small channel that flows into Crum Creek. The bottom of the pool is coated with black sediments that indicate anaerobic decomposition of sewage, and small pink worms are living in the sediments.

The extremely high fecal coliform (*E. coli*) measurements in the range of 100,000 bacteria colonies per 100 mL are the main indicator that the source is human waste. The very high levels of ammonia nitrogen and phosphate support this conclusion. The Pennsylvania standard for fecal coliform is only 200 colonies per 100 mL. The effect of the discharge on Crum Creek is shown in Table 2. Before the discharge (upstream), the fecal coliform level in the stream is 270 colonies per 100 mL (slightly above the standard), but after the discharge (downstream), the level jumps to 10,000 colonies per 100 mL (greatly exceeding the standard).

Discharge to Crum Creek from Avondale Rd./I476 in Nether Providence –  
Suspected Sewer Leak

Data for the Swarthmore College monitoring site designated H10, located about 150 yards south of the Yale Avenue bridge, adjacent to Avondale Road and approximately 130 yards downstream of confluence of the Crum Creek and Dick's Run. Geographical coordinates of site were determined using GPS as approximately 75.3588 degrees west longitude and 39.8934 degrees north latitude.

**Table 1. Samples Taken at the Discharge Point**

Date of sampling	Nitrate conc. (mg/L)	Ammonia Nitrogen conc. (mg/L)	Phosphate conc. (mg/L)	Specific conductance (μS/cm)	Fecal coliform (colonies per 100 mL)	Notes
<b>Summer 2000:</b>						
7/24/2000	0.872	4.6	3.34	467	98,000	Bucket from Avondale Rd.
7/24/2000	1.3		0.782	492		Bucket from Avondale Rd.
7/28/2000	1.18		2.488	415	69,000	Bucket from Avondale Rd.
<b>Summer 2001:</b>						
6/20/2001					130,000	Direct sample from pool
6/20/2001					90,000	Direct sample from plastic pipe
6/26/2001	1.54		2.07		78,000	Bucket from Avondale Rd.

**Table 2. Samples Taken in Crum Creek Upstream and Downstream of the Discharge Point**

Date of sampling	Fecal coliform (colonies per 100 mL)	Notes
6/20/2001	270	In Crum Creek before the discharge point
6/20/2001	10,000	In Crum Creek after the discharge point

***Note: The Pennsylvania water quality standard for fecal coliform is 200 colonies per 100 mL***



## **Appendix G - Crum Creek Conferences**

# Crum Creek 2000: Watershed Conference and Workshop

## PROGRAM SCHEDULE

Plenary Session Watershed Protection, Partnerships, and Stewardship			
8:00–8:30 a.m. – Registration and Refreshments –			
8:30 a.m.– 8:40 a.m.	Welcome and Introduction–Maurice G. Eldridge, V.P. for College and Community Relations, Swarthmore College; Arthur McGarity, Dept. of Engineering, Swarthmore College		
8:40 a.m.– 9:05 a.m.	PA Watershed Protection Program - Nancy Crickman, Watershed Coordinator, PA Dept. of environmental Protection, Southeast Regional Office, Conshohocken, PA		
9:05 a.m.– 9:20 a.m.	The Lower Crum Creek Watershed Partnership and Watershed Studies at Swarthmore College–Arthur McGarity, Professor of Engineering, Swarthmore College		
9:20 a.m.– 9:50 a.m.	Upper Crum Creek Source Water Protection Jane Rowan, Schnabel Engineering Associates, West Chester, PA, – Preston Luitweiler, Philadelphia Suburban Water Company;		
9:50 a.m.– 10:15 a.m.	Watershed Stewardship–Carol Collier, Executive Director, Delaware River Basin Commission		
10:15–10:30 a.m. – Break –			
Morning Concurrent Sessions			
	Watershed Case Studies	Best Management Practices	Watershed Management Tools
10:30a.m.– 11:00 a.m.	The PA River Conservation Program & the Ridley and Chester Creek Conservation Plans, – David Athey, Natural Lands Trust, Media, PA and Judith Auten, V.P., CRC Watersheds Assoc.	Management of Land- scapes and Backyard Conservation – Ed Magargee, Mgr, Delaware County Conservation District	The “Code & Ordinance Worksheet” of the Center for Watershed Protection, – EuniceAlexander member,CRC Watersheds Association
11:00a.m.– 11:30 a.m.	Chester County Watershed Conservation Plan – Craig Thomas, Water Resources Engineer, Chester County Water Resources Authority	Best Management Practices: A Survey of Options for Retrofit Watershed Restoration in Developed Areas – Carl DuPoldt, Natural Resources Conservation Service of the East Reg. Urban Conservation IRT of USDA, and Pres., CRC Watersheds Assoc.	Geographic Information Systems (GIS) applied to Crum Creek: A Demonstration– William Lucas, Integrated Land Management, Inc. and member of the CRC Watersheds Association
11:30a.m.– 12 Noon	Trout Run and the Marple Township Environmental Advisory Council – James Schmid, Schmid & Co., Inc., Consulting Ecologists	Research on the Effectiveness of Best Management Practices –Robert Traver & Ron Chadderton, Dept. of Civil Engineering, Villanova University	WAMOS: Watershed Monitoring Software Demonstration – Gary Sheehan, Mesa Environmental Sciences and Mitrofan Josan, MJ Environmental, LTD

<b>Watershed Networking, Exhibits &amp; Lunch</b>	
Noon to 1 p.m.	Lunch groupings organized by sub-watersheds: Upper Crum Creek, Trout Run, Hotland Run, Whiskey Run, Little Crum Creek, Dicks Run, etc. Exhibitors available to discuss their displays. Buffet lunch served (vegetarian options available).

<b>Tentative Breakout Groups – Persons Interested in the Following Areas:</b>	
Problems and concerns of residents of neighborhoods that adjoin the banks of Crum Creek and its tributaries	Municipal codes and ordinances affecting stormwater runoff into Crum Creek
Water quality: drinking water protection and preservation of ecology and habitat	Commercial and residential land development and business opportunities in the watershed
Fishing, hiking, and other recreation in Crum Creek and adjacent woodlands and parks	Use of watershed management tools to benefit Crum Creek, including water quality monitoring, databases, and geographic information systems
Other: suggestions are welcome—please write your ideas on the registration form	

<b>Workshop</b>	
1:00–1:15 p.m.	Charge to Breakout Groups – Art McGarity, Swarthmore College
1:15–2:15 p.m.	Breakout Group Meetings
2:15–2:30 p.m.	Break
2:30–3:30 p.m.	Reports by Breakout Groups
3:30–3:45 p.m.	Discussion and Follow-up Planning
3:45–4:00 p.m.	Wrap up–Art McGarity

**Tentative Questions for Breakout Groups to Consider:**

1. How do you use Crum Creek and the Crum Creek Valley, and how do you access it?
2. What are the problems that concern you about Crum Creek and its watershed?
3. What are the solutions to Crum Creek's problems, and what are you willing to do?
4. What are the potential obstacles to the solution of Crum Creek's problems?
5. Why do you care about Crum Creek?
6. Other questions; please write suggestions on the registration form.

# **Crum Creek 2000 Watershed Conference and Workshop**

## **ABSTRACTS**

### **Plenary Session: Watershed Protection, Partnerships, and Stewardship**

1. The Pennsylvania Watershed Protection Program, **Nancy Crickman**, Watershed Coordinator, Pennsylvania Department of Environmental Protection, Southeast Regional Office, Suite 6010, Lee Park, 555 North Lane, Conshohocken, PA 19428-2233. Email: [Crickman.Nancy@dep.state.pa.us](mailto:Crickman.Nancy@dep.state.pa.us), Telephone: 610-832-6100.

Pennsylvania's Department of Environmental Protection has recently adopted a "whole watershed" approach to managing water quality in the Commonwealth. The watershed management process will be discussed including assessment, evaluation, development of plans for projects, and obtaining funds for implementation of projects.

2. The Lower Crum Creek Watershed Partnership and Watershed Studies at Swarthmore College, **Arthur E. McGarity**, Professor of Engineering, Department of Engineering, Hicks Hall, 500 College Avenue, Swarthmore, PA 19081. Email: [amcgarity@swarthmore.edu](mailto:amcgarity@swarthmore.edu), Telephone: 610-328-8077.

During the past six years, Swarthmore College's involvement in watershed studies has been increasing, primarily through the curriculum of the Engineering Department and the Interdisciplinary Program in Environmental Studies. A major focus of these curricular developments has been the study of problems in local watersheds, particularly Crum Creek. Students have been involved in field studies that include water quality monitoring of chemical and biological parameters. These studies occur during the academic year, through courses such as "Water Quality and Pollution Control", through senior honors thesis research, and through senior engineering design projects. Also, summer research projects have been conducted in the College's Environmental Pollution Laboratory.

In October, 1999, a new phase in the College's involvement in local watershed conservation began with the formation of the Lower Crum Creek Watershed Partnership. This initiative will create a working partnership among municipalities, organizations, institutions, and businesses to conserve and restore the Crum Creek watershed in the heavily developed reaches of Delaware County below Springton Reservoir. Decision support models will be applied to the problem of prioritizing the many different best management practices (BMP's) that can be implemented in the lower watershed through analysis of their costs and their effectiveness in reduction of nonpoint pollution. The goal of the current two-year funded project is to develop a plan for stream restoration through nonpoint pollution reduction. This plan will be developed in consultation with the partnership members, preliminary designs will be developed by a team of Swarthmore College's senior engineering students, and proposals will be written to obtain funding for implementation of the selected projects.

3a. Upper Crum Creek Source Water Protection, **Jane Rowan**, Schnabel Engineering Associates, 510 East Gay Street, West Chester, PA 19380. Email: [jrowan@schnabel-eng.com](mailto:jrowan@schnabel-eng.com), Telephone 610-696-6066.

Schnabel Engineering Associates and J.E. Edinger Associates are teamed together to provide a watershed and sourcewater assessment of the Crum Creek Watershed. A combination of detailed analytical modeling as well as more hands on methods will be employed to describe watershed characteristics. The resulting plan will provide a basis for implementation of watershed restoration methods.

First, the watershed water quality will be assessed. Two watershed models and one reservoir model will be used to investigate the Crum Creek watershed and the Springton reservoir. The watershed model will help to evaluate the effects of BMP scenarios on nutrient and sediment loads to the reservoir. The reservoir model will then detail the effects of these loads on water quality in the reservoir. Watershed models being used for this study are GWLF (a simple model), and HSPF (a very complex model). In-lake effects will be analyzed using CE-QUAL-W2 (medium complexity model), a Corps of Engineers reservoir hydrodynamics and water quality model. Modeling results are not yet available, but materials available from other applications of these models will be presented for dissemination of information on how these models work.

In addition to water quality modeling, water quality modeling will be employed on the Crum Creek watershed. It is our opinion that water quality and quantity problems in a watershed are closely if not directly related. We will base our modeling strategy on the best available digital data hydrologic analyses of the Crum Creek Watershed. The baseline data sets include the Crum, Ridley, and Chester Creek Watersheds Spatial Database Development Project Created January 1998 by the Patrick Center for Environmental Research, The Academy of Natural Sciences, Philadelphia, PA for Philadelphia Suburban Water Company and the provisional SSURGO soil survey data for Chester County. The SSURGO data for Delaware County will be added when it becomes available.

The results of the hydrologic analyses will be also used in the water quality modeling and in the watershed characteristic assessment. Using ArcView, we have so far delineated the watershed into 39 subbasins. We have integrated the land cover and soils data to compute the SCS Runoff Curve Number for each subwatershed in Chester County.

We are currently requesting input from municipalities, local government agencies and the watershed associations. We are interested in knowing of areas in the watershed (including the waterbodies in the watershed) where BMP implementations are needed and could be particularly effective. Our plan is to provide these BMP preliminary designs as well as outlining the process needed to analyze a problem, gather the information necessary to decide how to alleviate the problem and implement measures to effect restoration.

3b. Upper Crum Creek Source Water Protection, **Preston Luitweiler**, Philadelphia Suburban Water Company, 762 W. Lancaster Avenue, Bryn Mawr, PA 19010-3489.

Philadelphia Suburban Water Company (PSW) is an investor-owned utility that today supplies water to more than one million people in southeastern Pennsylvania. The company started in 1886 as an enterprise by a group of Swarthmore University professors to pipe spring water to residents of Swarthmore. In 1889 a supply from Whiskey Run was added to the system. In 1892 the company built a pumping station on Crum Creek and one of the first water filtration plants in the country. In the 1930s the Springton Reservoir was built to store 3.4 billion gallons of water. Today the Crum Creek Water Treatment Plant supplies an average 20 million gallons of water per day to customers in Delaware County.

PSW has long been interested in protecting the quality of its source water. Today, the watershed protection program that was begun for Springton Reservoir has evolved to cover many sources, and it has become an important part of a multiple barrier approach to providing quality drinking water. A small staff of Environmental Specialists is supported in this effort by well-equipped Water Quality and Research Laboratories in Bryn Mawr.

Although PSW has treatment in place to remove contaminants to meet drinking water standards, the quality of source water may affect treatment costs and aesthetic qualities of the finished water. PSW's main interests on the Crum Creek watershed are sediment, nutrients (particularly phosphorus) and microbial pathogens. Sediment and nutrients contribute to eutrophication of reservoirs, which in turn may contribute to taste and odor problems from trace levels of natural compounds produced by certain algae. On the Crum Creek watershed, potential sources of microbial pathogens include septic systems, leaking sewer collector lines, and wildlife. Growing numbers of non-native, resident Canada geese are also a significant potential source of pathogens. Disinfection water treatment processes in turn generate trace amounts of by-products (DBPs). To the extent that management of source water quality can reduce pathogens and DBP precursors, the levels these compounds in the finished water may also be reduced. PSW is pleased to be working in partnership with PADEP, USEPA, the Chester Crum Ridley Watersheds Association, the Delaware County Conservation District, Swarthmore College and others to protect water quality on the Crum Creek watershed

## **Concurrent Session: Watershed Case Studies**

1. The Pennsylvania River Conservation Program and the Ridley and Chester Creek Conservation Plans, **David Athey**, Natural Lands Trust, Hildacy Farm, 1031 Palmers Mill Road, Media, PA 19063. Email: [dathey@natlands.org](mailto:dathey@natlands.org), Telephone: (610) 353-5587. **Judith Auten**, Vice President, Chester-Ridley-Crum Watersheds Association, 210 Moylan Avenue, Wallingford, PA 19086. Email: [donjude@aol.com](mailto:donjude@aol.com), Telephone: (610) 566-1627

The Keystone Rivers Conservation Grant Program was created by the Keystone Recreation, Park, and Conservation Fund Act of 1993. It is administered through the Pennsylvania Department of Conservation and Natural Resources (DCNR). Attendees at the Crum Creek conference will learn more about this program including the program purposes, the river conservation process, plan components, project cost allocations, typical issues, and local efforts. This portion of the presentation will be by David Athey, River Conservation Program Manager for the Natural Lands Trust.

The discussion will then shift from general program features to a specific project, the Ridley Creek Conservation Plan, which was completed in 1997. Mr. Athey will be joined by Judith Auten, Vice-President of the Chester - Ridley - Crum Watershed Association (CRCWA), who spearheaded the Ridley project. Mr. Athey and Ms. Auten will discuss specific outcomes of the Ridley Creek Conservation Plan and, perhaps more important, lessons learned from its preparation. Copies of the plan will be available for attendees to review as will other documents including maps, newsletters, and flyers.

2. The Chester County Watershed Conservation Plan, **Craig Thomas**, Water Resources Engineer, Chester County Water Resources Authority, 601 Westtown Rd, Suite 270, P.O. Box 2747, West Chester, PA 19382-0990. Email: [cthomas@chesco.org](mailto:cthomas@chesco.org), Telephone: (610) 344-5400

**Chester County is currently developing a water resources management plan, *Watersheds*, which will set forth a framework for the overall preservation and wise use of the County's water resources. This presentation provides a brief**

**overview of the process that lead to the development of the Plan, the work completed and the next steps, and answers some of the questions you might have about the Plan itself.**

Water resources planning by the Chester County Water Resources Authority (CCWRA) has roots that go back to 1961. However this current management plan is one of the component plans that support *Landscapes*, Chester County's Comprehensive Plan adopted in July 1996. The approach to the *Watersheds* plan seeks a balance between "sound science" and stakeholder consensus building, and is structured to reach a successful conclusion by the fall of 2000. A Water Resources Task Force, appointed in May 1997 by the Chester County Commissioners, has been assisting in developing the plan for the past three years. The Task Force represents a broad array of interest groups, agencies, and stakeholders. The Task Force has participated in identifying problems and issues, and will also be integral in prioritizing planning objectives, and in reviewing the various elements of the Plan as they are produced. The Task Force has developed the mission statement for the plan as:

*"to protect, sustain, and enhance the quality and quantity of all water resources to insure the health, safety, and welfare of the citizens, and preserve the diverse natural resources and aesthetic and recreational assets of Chester County."*

The CCWRA has formed a team with two consulting firms: Camp Dresser & McKee of Lancaster, PA, and Gaadt Perspectives, located in Chadds Ford, PA. Together, the team is working to produce watershed action strategies for each watershed as well as an overall plan for the entire County that will support the vision of the future of Chester County presented in *Landscapes*. The study is based on physical watersheds, not on political boundaries. There are 21 watersheds that have all or a portion of their area within Chester, County, and will be included in the plan. For those watersheds that cross county or state borders, the County has cooperated with Lancaster County, Delaware County, Berks County, New Castle County, DE and Cecil County, MD.

*Watersheds* consists of a series of steps that build upon each other to establish a solid, scientific foundation that will serve the County during the objective and policy development stages. Some of the planning steps include: Data Collection, Organization and Analysis; Public Meetings; Systems Description; Problem Identification and Development of Plan Objective; and Strategies, Policies and Approaches.

As a result of this planning effort, a number of items will be produced. The County will have a comprehensive set of databases with all data pertinent to water resources planning organized and accessible. The Plan will also produce an expanded set of GIS maps designed to improve the future management of the resource. The consultant team will produce a technical report that will describe the entire planning process, contain the pertinent data, and present the results of the various analyses. The technical report will contain sections on the assessment and strategies for managing ground water, surface water, water supply, and wastewater, as well as discussing Integrated Resource Planning concepts at the municipal level. The technical report will serve as the technical backup documentation for the final Chester County *Watersheds*, which will be a more concise and readable document designed for wide public distribution.

3. Trout Run and the Marple Township Environmental Advisory Board, **James Schmid**, Schmid and Company, Inc., Consulting Engineers, 1201 Cedar Grove, Media, PA 19063-1044. Email: [jaschmid@aol.com](mailto:jaschmid@aol.com), Telephone: (610) 356-1416.

Trout Run is a tributary of Crum Creek that drains a large portion of Marple Township in Delaware County, PA, flowing into the Crum from the east, just above. This talk will focus on efforts underway by the Marple Township Environmental Advisory Board to conserve and restore Trout Run. The Marple Township EAB is an active participant in the Lower Crum Creek Watershed Partnership.

## **Concurrent Session: Best Management Practices**

1. Management of Landscapes and Backyard Conservation, **Ed Magargee**, Manager, Delaware County Conservation District, Rose Tree Park, Hunt Club, 1521 Providence Road, Media, PA 19063. Email: [delaware.county@dep.state.pa.us](mailto:delaware.county@dep.state.pa.us), Telephone: (610) 892-9484

The Delaware County Conservation District has assembled much information on how homeowners can manage their property to minimize nonpoint pollution runoff into our streams. This presentation will survey these techniques and provide sources of additional information, including the National Association of Conservation Districts program on "Backyard Conservation."

2. Best Management Practices: A Survey of Options for Retrofit Watershed Restoration in Developed Areas, **Carl DuPoldt**, Natural Resources Conservation Service, US Department of Agriculture and President, Chester-Ridley-Crum Watersheds Association. Email: [cdupoldt@bellatlantic.net](mailto:cdupoldt@bellatlantic.net), Telephone: (609) 561-3223.

**In this presentation, I plan to present an overview of the Pennsylvania Best Management Practices Handbook for Developing Areas and the Home\*A\*Syst – An Environmental Risk-Assessment Guide for the Home. The Pennsylvania Best Management Practices Handbook was completed in March 1998, after an effort that was initiated in June, 1994. The handbook is divided into eight sections, namely,**

**Section 1 - Introduction**

**Section 2 – How to Use the Handbook**

**Section 3 – Planning Concepts**

**Section 4 – Using BMP's Effectively**

**Section 5 – BMP Design**

**Section 6 – BMP Retrofitting – Remediating Existing Developments**

**Section 7 – BMP Maintenance**

**Section 8 – Descriptions of Selected Best Management Practices**

The handbook also includes nine appendices, namely,

Appendix A – State Regulations

Appendix B – References

Appendix C – Program Resources

Appendix D – Sample Ordinances

Appendix E – Approach for Developing Material Specifications

Appendix F – Runoff Capture Design

Appendix G – Glossary

Appendix H – Plant Lists for Wetland Management

Appendix I – Common Design Elements

The presentation will involve a discussion on management to the pre-development hydrograph. Examples of stormwater management BMP's will be presented that can fit within the developed landscape. Systems of BMP's will be discussed for optimum effectiveness. A display of the functions of the BMP's presented in the handbook will be made. Next, a discussion of homeowner's assessment techniques will be presented.

The Home\*A\*Syst program describes measures that homeowners can undertake to manage the environment around their home. The program consists of eleven (11) chapters, namely,

Chapter 1 – Site Assessment: Protecting Water Quality around Your Home

Chapter 2 – Stormwater Management

Chapter 3 – Drinking Water Well Management

Chapter 4 – Household Wastewater: Septic Systems and Other Treatment Methods

Chapter 5 – Managing Hazardous Household Products

Chapter 6 – Lead in and around the Home: Identifying and Managing Its Sources

Chapter 7 – Yard and Garden Care

Chapter 8 – Liquid Fuels: Safe Management of Gasoline, Heating Oil, Diesel, and Other Fuels

Chapter 9 – Indoor Air Quality: Reducing Health Risks and Improving the Air You Breathe

Chapter 10- Heating and Cooling Systems: Saving Energy and Keeping Safe

Chapter 11- Managing Household Waste: Preventing, Reusing, Recycling and and composting



The presentation will focus mainly on stormwater management in and around the home.

3. **Research on the Effectiveness of Best Management Practices**, **Robert G. Traver**, Ph.D., PE, Department of Civil and Environmental Engineering, Villanova University, Tolentine Hall - Room 147, Villanova, PA 19085. Email: [rtraver@email.vill.edu](mailto:rtraver@email.vill.edu), Telephone: (610) 519-7899. **Ronald A. Chadderton**, Ph.D., PE, Department of Civil and Environmental Engineering, Tolentine Hall - Room 142, Villanova University, Villanova, PA 19085. Email: [Ronald.Chadderton@villanova.edu](mailto:Ronald.Chadderton@villanova.edu), Telephone: (610) 519-7397

Stormwater, with its rapidly changing and widely fluctuating flows, has the potential to deliver large pollutant loads to receiving waters during short time intervals. Best Management Practices (BMP), including wet and dry basins, infiltration beds, sand filters, and stormwater wetlands have been implemented to control stormwater runoff, but detailed information on their performance remains a significant research topic. To meet the Phase II National Pollutant Discharge Elimination System (EPA 1999) goals, and the targeted reduction in non-point source pollutant loads to the Chesapeake Bay, comprehensive quantitative assessment of stormwater BMPs is needed. The performance of urban stormwater BMPs, including wet ponds and wetlands, especially as related to retention of nitrogen, phosphorus and metals, has attracted research efforts (Schueler et al. 1992, Schueler 1995). For example, Wu (1989) presented an evaluation of the performance of two wet pond BMPs for removal of total N, total P, Zn and Fe based on 11 storm events. Stanley (1994) reported moderate to high removals of particulate pollutants (N, P, Cd, Cr, Cu, Pb, Ni, Zn), but considerably lower removals of soluble pollutants, in a dry (actually moist) extended detention pond BMP. Studies to date have indicated considerable between-storm and within-storm variability in nutrient and metal removal, yet the role of various factors contributing to this variability has not been adequately assessed. The ASCE Urban Water Resources Research Council has recognized this need and shown leadership by developing a national database soliciting performance data on BMP's from its members (ASCE 1999).

Villanova is in the process of studying two stormwater wetland site focusing on the effectiveness, design parameters, maintenance etc. of these structures. The most recent structure consists of the conversion of a 1 acre detention basin into a stormwater wetland, while the second is an intense examination of the removals of metals and pollutants on a small stormwater wetpond created as part of the Blue Route expansion.

The larger on campus site is current in its final stage, and has been funded by PaDEP as part of the EPA 319 program. The objectives of this study are:

- 1) to provide nonpoint pollutant treatment to a degraded urban watershed and stream segment through conversion of a stormwater detention basin to an extended detention wetland best management practice (BMP).
- 2) to create a permanent wetland BMP demonstration site that has substantial research, education, and technology transfer value for the future.

The presentation will focus on the design and construction process.

The second site, is a much smaller wetpond built to mitigate flooding on Route 30. Literally "across the street" from Villanova University, the basin quickly took on the form of a stormwater wetland, due to its hydrology and migration of plants from the adjacent wetlands. The site was instrumented to collect water quantity data, and a routine schedule of weekly and storm-event water sampling was implemented. The Nutrient Subcommittee of the Chesapeake Research Consortium provided funding for the equipment, data collection, and analyses. Other contributors to the project have been the Bureau of Environmental Quality of the Pennsylvania Department of Transportation, EPA Region III, and the Philadelphia Suburban Water Company.

While the presentation focuses on the results from the first series of storms, it is expected that the total body of collected data will allow assessment on a variety of time scales. The comprehensive, interdisciplinary nature of the approach, coupled with the unusually intensive data gathering efforts is expected to provide considerable insight into the performance of this type of BMP on various time-scales.

## **Concurrent Session: Watershed Management Tools**

1. **The "Code and Ordinance Worksheet" of the Center for Watershed Protection**, **Eunice Alexander**, Volunteer Monitoring Coordinator, Chester-Ridley-Crum Watersheds Association, 1101 Fern Hill Rd., West Chester, PA 19013-5792. Email: [ela6@bellatlantic.net](mailto:ela6@bellatlantic.net).

This session will offer attendees a tour through the COW—the Code and Ordinance Worksheet. Developed by the Center for Watershed Protection, the COW is a unique tool—a straight-forward worksheet that offers municipal officials and citizens a practical way to assess the environmental friendliness of municipal regulations. After completing the COW, it becomes clear which requirements need revision in order to make a healthy environment possible. Those attending will have the opportunity to view the responses of one municipality in the Commonwealth and will receive their own copy of the Code and Ordinance Worksheet. Subsequent sharing of the COW with one's own municipality is very welcome!

2. **Geographic Information Systems (GIS) Applied to Crum Creek: A Demonstration**, **William Lucas**, Integrated Land Management, Inc., 820 Forest Lane, Malvern, PA 19355. Email: [wlucas@earthlink.net](mailto:wlucas@earthlink.net), Telephone: (610) 644-0606.

The GIS Working Group of the Chester-Ridley-Crum Watersheds Association has been working on a project to use the GIS program Arcview for analysis of the three watersheds. This presentation will summarize progress on the project, and demonstrate fundamental concepts of GIS.

3. **WAMOS: Watershed Monitoring System Demonstration**, **Gary Sheehan**, Mesa Environmental Sciences, 7 Frazer Avenue, Malvern, PA 19355. Email: [mesagts@aol.com](mailto:mesagts@aol.com)

The Watershed Monitoring System (WAMOS) software package is a Visual Basic/Excel-based application developed by MJ Environmental Associates, Ltd./Mikon Systems, Inc. The program, which analyzes and presents data for watershed monitoring and planning, will be demonstrated at the Crum Creek 2000 Watershed Conference. WAMOS is now being employed on the Cooks Creek Watershed program in upper Bucks County. Use of WAMOS has been proposed as part of the Upper Crum Creek Watershed program grant application by the partnership of Willistown Township Environmental Advisory Council, the Willistown Conservation Trust, Mesa Environmental Sciences, Inc. and MJ Environmental.

Currently, the off-line operating phase of the Cooks Creek project has been completed, to be followed shortly by the on-line (continuous data acquisition and analysis) operational phase. New WAMOS applications are being developed based on user needs, including auto-regressive prediction (flood or drought prediction and alarm notification).

The following statistical analysis options are currently available:

- ✓ **Simple statistical analysis** - min, max, average, base-flow and run-off separation, discharge ratio, on various time basis (interval, yearly, monthly etc).
- ✓ **Advanced statistical analysis** - trends, periodicity, auto-regressive prediction.

These options can be used in either one of the two operating modes:

- ✓ **Off-line** - the acquired data are downloaded from a data logger, collected by hand, or input manually from existing databases, and imported into the analysis application.

- ✓ **On-line** - continuous data acquired directly from the stream gauge (via satellite or cable), allowing on-site monitoring and real-time analysis and remote data transmission into a regional monitoring system (SCADA).

Clients have the option of requesting specific WAMOS software applications in accordance with their needs. In addition, any number of sub watersheds can be linked together to monitor the regional watershed, making WAMOS an ideal tool for managing river basins or County water resources.

**Crum Creek 2001 Watershed Conference and Workshop**  
**March 24, 2001**  
**Kohlberg Hall, Swarthmore College**

Final Program Schedule		
Plenary Session (Scheuer Room)		
8:00–8:30 a.m. – Registration and Refreshments –		
8:30 a.m.– 8:45 a.m.	Welcome and Introduction – Arthur E. McGarity, Dept. of Engineering, Swarthmore College and Mary McLoughlin, Willistown Conservation Trust	
Crum Creek Assessment Studies:		
8:45 a.m.– 9:15 a.m.	Chester County Watershed Conservation Plan: Components for Crum Creek - Craig Thomas, Chester County Water Resources Authority	
9:15 a.m.– 9:45 a.m.	Upper Crum Creek Source Water Protection– Jane Rowan, Schnabel Engineering Associates, West Chester, PA; Preston Luitweiler, Philadelphia Suburban Water Company	
9:45 a.m.– 10:15 a.m.	The Lower Crum Creek Watershed Assessment Project at Swarthmore College–Arthur E. McGarity, Professor of Engineering, Swarthmore College	
10:15–10:30 a.m. – Break and Refreshments–		
Morning Concurrent Sessions:		
	Stormwater Management and Nonpoint Pollution Control (ROOM 115)	Watershed Assessment and Planning: Government Programs and Watershed Organizations (ROOM 116)
10:30 a.m.– 11:15 a.m.	Comprehensive Stormwater Management, Wesley Horner, Cahill Associates, West Chester, PA	10:30 – 11:00: Pennsylvania’s County Watershed Coordinator Program, Bill Gothier, Delaware County Conservation District and Charlotte “Chotty” Sprenkle, Chester County Conservation District 11:00 – 11:15: Darby Creek Valley Association: Organization and Project Update, Andy Saul, Darby Creek Valley Association
11:15 a.m.– NOON	Conversion of an Urban Stormwater Detention Basin to a Wetland Best Management Practice, Ronald Chadderton and Robert Traver, Dept. of Civil Engineering, Villanova University, Villanova, PA	Southeastern Pennsylvania Riparian Buffer Assessment Project, Russ Johnson, Director, Delaware River Watershed Initiative, Heritage Conservancy, Doylestown, PA

## Crum Creek 2001 Watershed Conference and Workshop

### Final Program Schedule (Continued)

12:00 p.m. - 12:30 p.m. – Networking Lunch		
12:30 p.m. – 1:15 p.m. – Exhibits and Student Paper Poster Session		
Afternoon Concurrent Sessions:		
	Watershed Assessment Tools and Methods (ROOM 115)	Developments on Neighboring Watersheds (ROOM 116)
1:15 p.m. – 1:50 p.m.	Reservoir and Watershed Modeling in the Crum Creek Watershed, Rajeev Jain and Edward M. Buchak, J.E. Edinger Associates, Inc., Wayne, PA	Ridley Creek – A Volunteer Assessment, Ann Smith, Director, Watersheds Program, Southeast Pennsylvania Regional Office, Pennsylvania Environmental Council, Philadelphia, PA
1:50 p.m. – 2:30 p.m.	DURMM: Delaware Urban Runoff Management Model, William C. Lucas, Principal, Integrated Land Management, Inc., Malvern, PA	Ecosystem Restoration and Nonpoint Source Pollution in Fairmont Parks, Joseph Berg, Senior Environmental Scientist, Biohabitats, Inc. Timonium, MD
Stormwater Management Site Visits:		
2:30PM – 3:15PM	Site Visits: Swarthmore College’s Biostream and Experimental Constructed Wetland	
3:15 – 3:30 - Break		
3:30 – 4:00 – Panel Discussion – What’s Next for Crum Creek? A panel discussion with audience participation on future implementation projects in the watershed – led by members of the Crum Creek Watershed Partnership Steering Committee		

# **Crum Creek 2001 Watershed Conference and Workshop**

## **FINAL PROGRAM SCHEDULE AND ABSTRACTS**

**8:30 AM – 10:15 AM (Scheuer Room)**

### **Plenary Session: Reports on Crum Creek Assessment Studies**

8:30 AM – 8:45 AM: Welcome and Introduction – **Arthur E. McGarity**, Chair, Crum Creek Watershed Partnership and Professor of Engineering, Swarthmore College; and **Mary McLoughlin**, Vice Chair, Crum Creek Watershed Partnership and Willistown Conservation Trust

8:45 AM – 9:15 AM: Chester County Watershed Conservation Plan: Components for Crum Creek, **Craig Thomas**, Water Resources Engineer, Chester County Water Resources Authority, 601 Westtown Rd, Suite 270, P.O. Box 2747, West Chester, PA 19382-0990. Email: [cthomas@chesco.org](mailto:cthomas@chesco.org), Phone: (610) 344-5400

**As part of Chester County's *Watersheds* planning effort, the Chester County Water Resources Authority is preparing a River Conservation Plan for Crum Creek watershed. This presentation will provide a brief overview of the *Watersheds* planning effort and discuss the draft Crum Creek River Conservation Plan. The presentation will include discussions of draft planning goals and objectives; watershed characteristics; conclusions from analyses conducted as part of the *Watersheds* planning effort; identified problems/issues through public outreach; and ongoing initiatives within the Crum Creek watershed.**

9:15 AM – 9:45 AM: The Crum Creek Source Water Assessment, **Jane Rowan**, Schnabel Engineering Associates, 510 East Gay Street, West Chester, PA 19380. Email: [jrowan@schnabel-eng.com](mailto:jrowan@schnabel-eng.com); Telephone 610-696-6066; and **Preston Luitweiler**, Philadelphia Suburban Water Company, 762 W. Lancaster Avenue, Bryn Mawr, PA 19010-3489.

**Through the U.S. Environmental Protection Agency, the Pennsylvania Department of Environmental Protection has made available funds to do a Source Water Assessment on the Crum Creek Watershed. Much of Delaware County and some surrounding areas are provided drinking water from this watershed through the Philadelphia Suburban Water Company. The assessment provides a way to help “narrow down” and prioritize the potential sources of contamination to public drinking water sources. Concerned citizens can then use this information to support voluntary, local programs to protect their drinking water source. Schnabel Engineering has been contracted by the Delaware County Conservation District to provide assistance with the Source Water Assessment in Crum Creek. Preliminary results of the Susceptibility Analysis will be presented.**

9:45 AM – 10:15 AM: The Lower Crum Creek Watershed Assessment Project at Swarthmore College, **Arthur E. McGarity**, Professor of Engineering, Department of Engineering, Hicks Hall, 500

College Avenue, Swarthmore, PA 19081. Email: [amcgarity@swarthmore.edu](mailto:amcgarity@swarthmore.edu), Telephone: 610-328-8077.

During the past seven years, Swarthmore College has increased its involvement in the study of nonpoint pollution in urban streams, primarily through the curriculum of the Engineering Department and the Interdisciplinary Program in Environmental Studies. Most of these efforts have been directed towards water quality problems in the impaired reaches of Crum Creek near the campus. Students are involved in field studies that include water quality monitoring of chemical and biological parameters. These studies occur during the academic year, through courses such as "Water Quality and Pollution Control", through senior honors thesis research, and through senior engineering design projects. Also, summer research projects are regularly conducted in the College's Environmental Pollution Laboratory.

Recently, the College's involvement in local watershed conservation expanded with the formation of the Crum Creek Watershed Partnership. A steering committee was formed to create a watershed-wide partnership among municipalities, organizations, institutions, and businesses to protect and restore the Crum Creek watershed. Municipal representatives are drawn primarily from the Environmental Advisory Councils in the different communities. Major projects to date include (1) a survey of municipal managers and engineers to solicit information on specific problems related to the Crum Creek in their jurisdictions, (2) submission of a Growing Greener grant application to PADEP for three implementation projects in the lower Crum watershed, and (3) organization of the Crum Creek 2001 conference. The partnership's web site is: [http://watershed.swarthmore.edu/crum\\_partnership](http://watershed.swarthmore.edu/crum_partnership)

During the summer of 2001, the College's Environmental Pollution Laboratory was upgraded to adhere to USEPA's rigorous standards for nonpoint pollution monitoring. Regular monitoring was accomplished during storm runoff events, and pollution loadings were calculated for nutrients and metals. Presently, several senior engineering students are completing design projects that relate directly to the Crum Creek assessment study. Poster presentations on these projects are on display at the conference.

## **MORNING CONCURRENT SESSIONS**

### **10:30 AM - Noon**

#### **Room 115 - Morning Concurrent Session A: Stormwater Management and Nonpoint Pollution Control**

10:30 AM – 11:15: AM Comprehensive Stormwater Management, **Wesley Horner**, Principal Planner, Cahill Associates, 104 South High Street, West Chester, PA 19382, <http://www.thcahill.com>

Mr. Horner received his bachelors degree from Haverford College and Master in City and Regional Planning from Harvard University's Graduate School of Design in 1975. He has 25 years of experience in both the public and private sectors, including the Delaware and Chester County Planning Commissions, the Brandywine Conservancy (Associate Director), and a variety of private consulting organizations and currently directs environmental planning and watershed projects at Cahill Associates. His primary focus has been water resources, working to develop programs linking land management and water resources management. He has performed numerous environmental impact studies throughout the country on actions ranging from expansion of water and sewer systems to highway and rail construction to development of large residential and commercial complexes. At the Brandywine Conservancy he directed development of Delaware's



*Conservation Design for Stormwater Management* manual. He has presented frequently at national and regional conferences and published numerous articles involving innovative environmental planning tools and technique.

11:15 AM – Noon: Conversion of an Urban Stormwater Detention Basin to a Wetland Best Management Practice, **Ronald A. Chadderton**, Ph.D., PE, Department of Civil and Environmental Engineering, Tolentine Hall - Room 142, Villanova University, Villanova, PA 19085. Email: [Ronald.Chadderton@villanova.edu](mailto:Ronald.Chadderton@villanova.edu), Telephone: (610) 519-7397; and **Robert G. Traver**, Ph.D., PE, Department of Civil and Environmental Engineering, Villanova University, Tolentine Hall - Room 147, Villanova, PA 19085. Email: [rtraver@email.vill.edu](mailto:rtraver@email.vill.edu), Telephone: (610) 519-7899.

*The objectives of this project have been: 1) to provide nonpoint pollutant treatment to a degraded urban watershed and stream segment through conversion of a stormwater detention basin to an extended detention wetland best management practice (BMP). 2) to create a permanent wetland BMP demonstration site that has substantial research, education, and technology transfer value for the future.*

Urban stormwater has the potential to deliver large pollutant loads to receiving waters during short intervals. Best management practices are currently recommended to control storm-water runoff. Detailed information on their performance is still emerging as recognized by Pennsylvania's Chesapeake Bay Nutrient Reduction Strategy (PADEP 1996a) and the Pennsylvania Handbook of Best Management Practices for Developing Areas (PACD 1998).

**An existing stormwater detention basin on Villanova University property has been converted into an extended detention wetland BMP (Center for Watershed Protection 1996) using the design concepts presented in the Pennsylvania Handbook of Best Management Practices for Developing Areas (PACD 1998). Detailed design data is included with this report as appendices. The stormwater wetland treats runoff from a 41 acre site that includes at least 16 acres of impervious surface, that forms the headwaters of a watershed listed as medium priority on the degraded watershed list, and treats flows that impacts a high priority stream segment on the 303(d)list.**

The site has been instrumented to collect flow data, and already numerous presentations and tours have been conducted. Educational signage has been installed to enhance the learning experience. In November 2001 a state wide symposium will be held at Villanova, which will further showcase the project. Future research focusing on the pollutant removal and hydraulic performance of stormwater wetlands is planned for the future.

As of this report, all contracted deliverables have been supplied to PADEP, to include this report and electronic copies. This main body is considered an overview; further details are included as appendices. The proposed site project supports the Commonwealth's Nonpoint Source Program, the Pennsylvania Chesapeake Bay Nutrient Reduction Strategy (PADEP 1996a), and Coastal Zone Program. The stormwater wetland provides relief to a degraded watershed and stream and demonstrates the use and effectiveness of BMP's. A permanent technology transfer, education, and research site has resulted from the project. Though not required, Villanova has greatly exceeded the amount of matching funds promised.

## **Room 116 - Morning Concurrent Session B: Watershed Assessment and Planning: Government Programs and Watershed Organizations**

10:30 AM – 11:00 AM: Pennsylvania's County Watershed Coordinator Program, **Bill Gothier**, Watershed Specialist, Delaware County Conservation District, 1521 N. Providence Road, Media, PA 19063,

Telephone: (610) 892-9484; and **Charlotte “Chotty” Sprenkle**, Chester County Conservation District, West Chester, PA

Pennsylvania has recently funded the creation of new county watershed coordinator positions in county conservation district offices around the Commonwealth. The recently appointed coordinators for Delaware and Chester Counties will report on this new program.

11:00 AM – 11:15 AM: Darby Creek Valley Association: Organization and Project Update, **Andy Saul**, Chester Ridley Crum Watersheds Association

The Darby Creek watershed, which borders the Crum Creek watershed to the east, has a very active watershed organization that is working to restore water quality. A brief report on the organization and its current activities will be presented.

11:15 AM – Noon: Southeastern Pennsylvania Riparian Buffer Assessment Project, Russ Johnson, Director, Delaware River Watershed Initiative, Heritage Conservancy, 85 Old Dublin Pike, Doylestown PA 18901, Tel: (215) 345-7020, E-mail: [rjohnson@heritageconservancy.org](mailto:rjohnson@heritageconservancy.org), Website: [www.heritageconservancy.org](http://www.heritageconservancy.org)

Riparian forest buffers provide benefits such as shading and cooling the water, trapping nutrients and sediment run-off, stabilizing riverbanks, and providing food and cover for aquatic and terrestrial wildlife. During 2000, Heritage Conservancy conducted an assessment via aerial photography of the riparian forest buffers along several creeks in Southeastern Pennsylvania. Areas lacking tree cover were coded onto a Geographic Information System (GIS) to produce a computerized map of riparian buffer “hot spots.” Local conservation groups and municipalities can use the map to target areas for riparian buffer plantings to improve water quality.

**The four watersheds assessed were the Chester (Delaware County), Valley (Chester County), Perkiomen (Montgomery County), and Neshaminy (Bucks County) creeks. The assessment included the main stem, tributaries and small headwaters streams. A total of 1,200 miles of stream in southeastern Pennsylvania were assessed. The project was funded by the Pennsylvania Department of Environmental Protection (PADEP) as part of the Coastal Zone Management (CZM) Program. The project was accomplished with a series of helicopter flights over the main stem and selected tributaries of the four creeks to videotape stream corridor conditions. A “sky cam,” the gyroscopically stabilized camera used in television news coverage, recorded the streams and the latitude and longitude of the location from the onboard global positioning system (GPS). The conservancy then established a set of benchmarks by matching photos from the helicopter with photos taken at ground level and the 1" = 400' black-and-white high altitude aerial photographs for known locations. Conservancy staff used these benchmarks as a guide to interpret the full set of aerial photos and classify all the named tributaries in each watershed.**

## **AFTERNOON CONCURRENT SESSIONS**

### **1:15 PM - 2:30 PM**

## **Room 115 - Afternoon Concurrent Session A: Watershed Assessment Tools and Methods**

1:15 PM – 1:50 PM: Reservoir and Watershed Modeling in the Crum Creek Watershed, **Rajeev Jain and Edward M. Buchak**, J.E. Edinger Associates, Inc., Suite 609, 983 Old Eagle School Road, Wayne, PA

Combined watershed and reservoir modeling has been in progress since last year for the Crum Creek watershed. The emphasis in the modeling aspects of the study is on nutrient and sediment issues in the two reservoirs and their associated watershed. The models being used will be introduced, the data being used will be described, and current status of the project will be summarized.

1:50 PM – 2:30 PM: DURMM: Delaware Urban Runoff Management Model, William C. Lucas, Principal, Integrated Land Management, Inc., 820 Forest Lane, Malvern, PA 19355, Phone: 610-644-0606, Fax: 610-644-6583, e-mail: [wlucas@integratedland.com](mailto:wlucas@integratedland.com)

In 2000, the Delaware Department of Natural Resources and Environmental Control retained Integrated Land Management, Inc to develop DURMM, a spreadsheet program to design certain nonstructural BMPs referred to in the 1997 *Conservation Design Manual*. The goal is to quantitatively evaluate the benefits of conservation design practices that restore the natural hydrology of a site as much as possible, without relying on structural practices. DURMM is based upon a detailed literature review of the current state of the art in BMP Design and analysis, as set forth in its companion Technical Manual. The first draft of DURMM was released in March 2001.

**1. HYDROLOGY.** DURMM explicitly incorporates elements of conservation design not addressed by normal engineering practices. The hydrological processes incorporated into the DURMM Model recognize the infiltration/interception contributions of soils as affected by soil type and land cover. The hydraulic design component routes runoff through storage structures, and partitions overland discharge from infiltration components. DURMM disaggregates different combinations of land cover and soil type, based on the Curve Number method set forth in TR-20. For modeling hydrology of small urban watersheds under smaller storm events, TR-20 is modified in DURMM to use an infiltration approach similar to that incorporated in the SLAMM model.

**2. POLLUTANT REDUCTIONS.** BMPs function to remove pollutants from urban runoff through five major pathways: infiltration, filtration, adsorption, settlement and transformation. Depending on the BMP, some, or even all, of these processes can occur simultaneously. Note that DURMM examines the reduction in pollutant EMCs by BMPs, not removal rates in terms of pollutant loads. This is due to the fact that runoff volume losses are explicitly accounted for in the disconnection routines, so it is the EMCs of pollutants in the remaining surface runoff that become the parameters of interest.

**3. BMP ROUTING.** Surface storage routing uses the storage-indication method typically used for hydraulic design of detention facilities. DURMM also incorporates routines for computing the detention storage provided by infiltration trenches. DURMM routes surface and exfiltration flows simultaneously. DURMM also provides for computing detention storage as routed through either bioswales or terraces. For both of these routing BMPs, storage is provided by check dams with spillways at regular intervals along the swale or terrace. These check dams create a series of cascading pools to distribute storage along the entire length of the terrace or swale. While DURMM permits manual entry of stage-elevation for irregular

**geometries, it also provides a routine to automatically enter the appropriate values as a function of swale or terrace geometry. When the swale or terrace with check dam option is used, the DURMM calculates the precise stage-area relationships for the swale/terrace check dam system, based upon slope, dam interval, and swale/terrace geometry. This method makes it possible to determine the increase in volume provided by closer spacing and/or differing geometry.**

Room 116 – Afternoon Concurrent Session B: Developments on Neighboring Watersheds

1:15 PM – 1:50 PM: Ridley Creek – A Volunteer Assessment, **Ann Smith**, Director, Watersheds Program, Southeast Pennsylvania Regional Office, Pennsylvania Environmental Council, Philadelphia, PA.

A lot can be learned about the health of a stream just by looking at it. The Ridley Creek Volunteer Visual Assessment project was undertaken to evaluate the health of the Ridley. This presentation will describe the visual assessment process and provide preliminary information on the results. The Ridley Creek contains over 80 miles of stream and over 60 volunteers participated in the process, so a major challenge was to subdivide the watershed into manageable pieces. The volunteers were trained in a visual assessment protocol. In the field, they evaluated their section based on this protocol as well as took photographs. All of this information is currently being compiled into a GIS format and will be distributed once complete. Most of the data was collected last fall and more will be collected this spring.

1:50 PM – 2:30 PM: Ecosystem Restoration and Nonpoint Source Pollution in Fairmont Parks, **Joseph Berg**, Senior Environmental Scientist, Biohabitats, Inc. Timonium, MD.

The Natural Lands Restoration and Environmental Education Program (NLREEP) staff of the Fairmount Park Commission have been working on a comprehensive Park-wide restoration program. The existing resource condition was assessed, restoration needs were identified, restoration projects were prioritized, and the most highly prioritized restoration projects are in the process of being constructed. The Philadelphia Academy of Science was the lead organization for the assessment, identification of restoration needs, and prioritization. Biohabitats, Inc. is responsible for the design and providing construction implementation assistance. NLREEP staff have been involved in every aspect of this effort, from obtaining the initial grant from the William Penn Foundation through construction inspection. Approximately 40 restoration projects, from forest enhancement plantings to stream restoration and wetland creation projects, are being implemented in Cobbs Creek Park. Many of these planting projects are being implemented through a highly developed network of volunteer groups and NLREEP volunteer coordinators. These volunteer projects started in Spring of 2000. Other projects require excavation contractors due to large volumes of excavation or a requirement for specialized equipment. These construction projects started Winter of 2001 and will continue through Spring 2002, possibly longer if the grant through the William Penn Foundation is extended.

In this presentation, the NLREEP and Biohabitats approach for developing selected restoration designs will be discussed. The discussion will include a wetland enhancement/stormwater treatment system in the vicinity of Indian Creek and Cobbs Creek, a stream restoration project on an unnamed tributary to Cobbs Creek in Yeadon, a project which includes stormwater infiltration and gully repair in an upland area adjacent to the floodplain, and a wetland creation project at the confluence of Naylor Run and Cobbs Creek. Site considerations that influenced the designs will be described and a summary of water quality benefits will be presented.