PHASE I & II REPORT
CHRISTINA RIVER BASIN
WATER QUALITY MANAGEMENT STRATEGY

May 1998

Prepared by:

Water Resources Agency for New Castle County
Newark, Delaware

Chester County Conservation District
West Chester, Pennsylvania

Chester County Water Resources Authority
West Chester, Pennsylvania

On behalf of the Christina Basin Water Quality Management Committee

MEMORANDUM

TO: Christina Basin Water Quality Management Committee

FROM: Jerry Kauffman
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DATE: April 2, 1998

SUBJECT: Draft Phase I and II Report

Enclosed for your review is the final draft Phase I and II Report for the Christina Basin Water Quality Management Strategy. Please mail, fax, phone, or e-mail your comments to me by Friday April 24, 1998. After receiving the comments, we will revise and distribute the final report to you one week prior to our May 21, 1998 Committee Meeting which will be held at the WRA offices at the University of Delaware. We hope to approve the final report at our May Committee Meeting. Please note the final report will include the following:

1. Cross-reference table of contents, figures, tables, maps, etc. Editing grammar, spelling, and format for consistency.

2. Color report cover, maps, and figures.

3. Complete maps and data base tables for Maps 1 (Geology), 2 (Soils), 3 (Outfalls/Intakes), 5 (Land Use), 6 (Zoning), 9 (Hazardous Waste), and 10 (BMP's). The final maps will be retitled "Christina Basin Water Quality Management Strategy" to reflect emphasis in point and nonpoint sources. Complete the population density table.

Thank you for your support involving clean water in the Christina Basin.

FINAL PHASE I & II REPORT

CHRISTINA RIVER BASIN
WATER QUALITY MANAGEMENT STRATEGY
"A Christina Clean Water Strategy"

May 21, 1998

Prepared by:

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Newark, Delaware

On behalf of the Christina Basin Water Quality Management Committee:

- Brandywine Valley Association (BVA)/ Red Clay Valley Association (RCVA)
- Chester County Conservation District (CCCD)
- Chester County Health Department (CCHD)
- Chester County Planning Commission (CCPC)
- Chester County Water Resources Authority (CCWRA)
- Delaware Department of Natural Resources and Environmental Control (DNREC)
- Delaware Nature Society (DNS)
- Delaware River Basin Commission (DRBC)
- New Castle Conservation District (NCCD)
- Pennsylvania Department of Environmental Protection (PADEP)
- U. S. Environmental Protection Agency, Region III (USEPA)
- U. S. Geological Survey (USGS)
- U. S. Natural Resources Conservation Service (USDA-NRCS)
- Water Resources Agency for New Castle County (WRANCC)

PHASE I & II REPORT
CHRISTINA RIVER BASIN WATER QUALITY MANAGEMENT STRATEGY
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ACKNOWLEDGEMENTS

The authors wish to thank all of the members of the Christina Basin Water Quality Management Committee for their assistance in assembling this report. Staff from the Delaware River Basin Commission including David Pollison and Paul Scally provided a mediator role in bringing the States of Delaware and Pennsylvania together to resolve common water quality problems. Veronica Kasi and Russell Wagner of the Pennsylvania Department of Environmental Protection and Nancy Goggin and Jenny McDermott of the Delaware Department of Natural Resources and Environmental Control deserve credit for their diligence in obtaining funding for the first phases of the Christina Basin Strategy. Mr. Bernard Dworsky provided resources, budget, and administrative commitments for Water Resources Agency for New Castle County staff on the project. Key members of the Technical Group responsible for the watershed inventory, water quality assessment and stormwater monitoring tasks include Lisa Senior and Kent Crawford of the U.S. Geological Survey; Wayne Clapp and Robert Ihlein of the Chester County Planning Commission; Brad Smith, Hassan Mirsajadi, and Rick Greene from the Delaware DNREC; Kevin Magerr, Sarah Blackman, and Tom Henry from the U.S. Environmental Protection Agency; Charles Rehm, Rob Ryan, Nancy Crickman, Bill Goman, and Gary Price from the Pennsylvania DEP; Jim Stingel and Debi Weiker from the New Castle Conservation District; and Christy Green, Rose Marie Alicea, Suzanna Donohue, Annemarie Cinaglia, Katie Miller, Tammy Nguyen, Erin Guire, Deborah Mills, Nicole Minni, Vern Svatos and Martin Wollaston of the Water Resources Agency for New Castle County. Janet Bowers of the Chester County Water Resources Authority provided vigilant editing of the document. Bob Struble and Erin Doyle of the Brandywine Valley Association led the public education and outreach programs. And lastly, the authors would like to thank the decision-makers responsible for identifying the Christina River Basin as a priority and for providing the time and resources for staff to complete Phase I and II in a timely manner. The Policy Committee for this effort includes Irene Brooks (DRBC and PADEP), Gerard Esposito (DNREC), Dr. Hugh Archer (Pennsylvania DEP), Gerald Hansler (DRBC), and Dr. Al Morris (USEPA). Through the efforts of the members of the Christina Basin Water Quality Management Committee, we learned that watershed management efforts require cooperative contributions from many people and jurisdictions.

CHAPTER 1. PHASE I & II STRATEGY

1.1 INTRODUCTION

This report summarizes Phase I and II of a 5-year Water Quality Management Strategy for the Christina River Basin. The first two phases of work were conducted during 1995, 1996 and 1997 and include a watershed inventory, preliminary water quality assessment, and public education/outreach effort crafted to identify and understand the sources of pollutant loads entering drinking water streams. This strategy is designed as a watershed-based, multi-agency, interstate approach toward improving the water quality of Christina Basin streams which provide drinking water for over a half-million people in Pennsylvania, Maryland and Delaware. The 5-year water quality strategy is expected to culminate in the year 2000 with the adoption of Total Maximum Daily Loads (TMDL) for the major streams of the Christina River Basin and completion of a watershed management plan.

The Christina Basin Water Quality Management Strategy is especially important given the recent national "Clean Water Action Plan" announced by the President of the United States. The President's "Clean Water Action Plan - Restoring and Protecting America's Waters" dated February 1998, reports that 40% of U.S. waters assessed do not meet water quality goals. Half of the nation's 2000 major watersheds have serious or moderate water quality problems. Fortunately, watershed management, such as the strategy underway in the Christina River Basin, is available to address water quality problems.

1.2 DESIGNATED STREAM USES

Clean water in the streams of the Christina River Basin is required to sustain the diverse human, ecological, aesthetic, and recreational resources of the watershed. The quality of life, health, and vitality of citizens and businesses of New Castle County, Delaware; Chester County, Pennsylvania; and small portions of Cecil County, Maryland are also dependant upon these waters. The four major streams in the 565-square mile Christina Basin include the Brandywine Creek, White Clay Creek, Red Clay Creek and the Christina River. The headwaters of these streams form in Pennsylvania and Maryland and flow through the Piedmont hills of northern New Castle County in Delaware to the Delaware River at Wilmington (Figure 1-1).

Preservation of the quality of ground and surface waters is important, as they provide 75 percent of the public water supply for residents in New Castle County, Delaware and much of the water supply withdrawals in Chester County, Pennsylvania (CCPC, 1996 and WRANCC, 1997). Waters of the Christina Basin provide close to 100 million gallons per day in public water supplies to more than a half-million people in the three States. The following public water suppliers withdraw surface and/or ground water from the Christina River Basin for domestic, commercial and industrial use.

Delaware

- Artesian Water Company (ground water)

- City of Newark (surface and ground water)
- United Water Delaware (surface water)
- City of Wilmington (surface water).

Pennsylvania

- West Grove Borough (ground water)
- Avondale Borough (ground water)
- Kennett Square Borough (ground water)
- Downingtown Municipal Water Authority (surface water)
- City of Coatesville Authority (surface water)
- Philadelphia Suburban Water Company (surface and ground water)
- Lukens Steel (surface water)
- Embreeville Hospital (surface water).

In addition to water supply, the streams of the Christina Basin provide many recreational and ecological opportunities as well as important habitats for wildlife, aquatic life, and plant life. The stream corridors provide valuable recreation such as fishing, canoeing, and hiking for residents of the watershed. The cool waters support an abundant fishery for species such as rainbow/brown trout, smallmouth bass, and white perch. Nature lovers can enjoy the natural beauty which includes an abundance of wildlife from wood ducks to bog turtles to the graceful Great Blue Heron. In Delaware, 30,000 legal-sized trout are stocked annually in Christina Basin waters. Over 2700 trout stamps are sold to Delaware anglers to fish these waters. Canoe liveries report many canoeists ply their craft over Brandywine rapids. In Delaware, approximately 8,400 registered boats are owned by Christina Basin mariners. And the Parks and Recreation Department of both States report many visitors enjoy the open space in the Christina Basin for recreation pursuits (DNREC, 1997).

According to the "State of Delaware Surface Water Quality Standards (as amended February 26, 1993)", the streams in the Christina Basin provide the following designated uses:

- Public, Agricultural and Industrial Water Supply
- Primary and Secondary Contact Recreation
- Fish, Aquatic Life and Wildlife
- Cold Water Fish (Put and Take)
- Waters of Exceptional Recreational or Ecological Significance (ERES).

According to Chapter 93 of the "Pennsylvania Water Quality Standards," the designated uses for streams in the Christina Basin include:

- Potable, Industrial, and Livestock Water Supply
- Irrigation
- Water Contact Sports and Aesthetics
- Boating and Fishing
- Wildlife Water Supply
- Trout Stocking and Warmwater Fishes
- Cold Water and Migratory Fishes
- High Quality (HQ) and Exceptional Value (EV) Waters.


Christina Basin Water Quality Management Strategy
Base Map
HONEYBROOK
PENNSYLVANIA
PENNSYLVANIA
BRANDYWINE CREEK
SUB-BASIN
LANCASTER COUNTY
CHESTER COUNTY
DOWNINGTOWN
COATESVILLE
SOUTH
COATESVILLE
PARKESBURG
WEST
CHESTER
RED CLAY CREEK
SUB-BASIN
KENNETT
SQUARE
DELAWARE COUNTY PENN
WEST
GROVE
AVONDALE
PENNSYLVANIA
DELAWARE
WHITE CLAY CREEK
SUB-BASIN
CHESTER
COUNTY
NEW CASTLE COUNTY
WILMINGTON
ELSMERE
NEWPORT
NEWARK
NEW CASTLE
DELAWARE RIVER
CHRISTINA RIVER
SUB-BASIN
Legend
Christina Basin
Watersheds
Hydrology
Municipal Boundaries

1.3 WATER QUALITY PROBLEMS

Water quality and the biological health of the Christina Basin streams are becoming stressed due to rapid growth and increased utilization of the streams for water supply and wastewater discharges. Currently, some streams in the Christina Basin exhibit impaired water quality and habitat primarily due to impacts from human-related activities (DNREC, 1994). The major water quality problems in the lower reaches of the Brandywine Creek are due to elevated levels of suspended sediment, bacteria, nitrogen and phosphorus. Surface water in the main stem of the Red Clay Creek is impaired due to high levels of bacteria, nutrients, metals, and organics. Impaired water quality in the lower reaches of the White Clay Creek primarily in Delaware is due to elevated nutrients, bacteria, temperature and suspended solids. According to the "Habitat Quality of Delaware Nontidal Streams" published in 1994, 39 percent of the nontidal streams in the Piedmont of Delaware have "poor" habitat (DNREC, 1994). Both states have posted fish consumption advisories along the Brandywine Creek, Red Clay Creek, and tidal Christina River due to unacceptable levels of PCB's, chlordane, and dioxin found in fish tissue and sediment (DNREC and PADEP, 1997).

Impaired surface water quality and habitat is attributed to point and nonpoint sources of pollutants which enter the streams of the Christina Basin. Point (end-of-pipe) sources of pollutants include combined sewer overflows (CSO's) and municipal/industrial wastewater discharges. Non-point sources of pollutants include stormwater runoff from land development, active construction, unmitigated contaminated sites, commercial/industrial sites, roads/highways, turf, recreation, golf course facilities, agriculture activities, and eroding stream banks. In addition, non-point sources include diffuse contributions of pollutant loads carried to the streams by ground water, such as septic disposal systems, subsurface contamination from hazardous waste sites, old landfills, and agricultural chemicals. The identification and inventory of the point and non-point sources of water pollution is one of the objectives of this Christina Basin Water Quality Management Strategy.

1.4 PRIORITY WATERSHED STATUS

The Federal Clean Water Act's Section 319 Nonpoint Source Pollution Management Programs of Delaware and Pennsylvania have identified priority watersheds for water quality assessment in the Christina Basin. The Delaware DNREC Division of Soil and Water Conservation has identified the White Clay Creek and Christina River as priority watersheds for funding and implementation in New Castle County (DNREC, 1995). The Pennsylvania Department of Environmental Protection, Bureau of Watershed Conservation has identified the White Clay Creek and Red Clay Creek as high priority watersheds based on a list of 104 watersheds in the Commonwealth (PADEP, 1994). The Delaware Estuary Program has identified the Christina Basin as a priority watershed for non-point source pollutant reduction (DELEP, 1997).

1.5 INTER-STATE WATER QUALITY STRATEGY

In recent history, Delaware and Pennsylvania had disagreements regarding disparate water quality standards in the Christina Basin. In 1993, the U.S. Environmental Protection Agency mediated and recommended that the Delaware River Basin Commission bring the two States together and create the Christina Basin Water Quality Management Committee to resolve water quality problems involving the Christina Basin streams in Delaware and Pennsylvania. The fundamental purpose of this watershed-based effort is to coordinate the surface water quality

management policies of Pennsylvania, Delaware and the Federal government within the Basin. The Christina Basin Water Quality Management Committee developed a unified 5-year strategy toward improving the quality of these streams which supply drinking water to residents on both sides of the Pennsylvania and Delaware state line. Agencies and stakeholders represented on this multi-State Committee include the:

- Brandywine Valley Association (BVA)/Red Clay Valley Association (RCVA)
- Chester County Conservation District (CCCD)
- Chester County Health Department (CCHD)
- Chester County Planning Commission (CCPC)
- Chester County Water Resources Authority (CCWRA)
- Delaware Dept. of Natural Resources and Environmental Control (DNREC)
- Delaware Nature Society (DNS)
- Delaware River Basin Commission (DRBC)
- New Castle Conservation District (NCCD)
- Pennsylvania Department of Environmental Protection (PADEP)
- U. S. Environmental Protection Agency (Region III) (USEPA)
- U. S. Geological Survey (USGS)
- U. S. Natural Resources Conservation Service (USDA-NRCS)
- Water Resources Agency for New Castle County (WRANCC)

In 1994, the Pennsylvania DEP, Delaware DNREC, and USEPA identified the Chester County Conservation District, Chester County Water Resources Authority and Water Resources Agency for New Castle County as local coordinators for the Christina River Basin. In March 1995, the CCCD and WRANCC prepared a work plan and proposal for Phase I of the Christina Basin Water Quality Management Strategy for consideration by the Committee. On May 15, 1995 the Committee approved the first phase of the program to include a watershed inventory, design of a stormwater monitoring program, and a public education/outreach program. Watershed data collected during the initial phases of work will be used as input for the Christina Basin TMDL model. In September 1995, the Delaware DNREC with funding assistance from USEPA and Pennsylvania DEP authorized $166,000 in Section 319 funds to the Committee to commence Phase I of the 5-year program. In September 1996, the Pennsylvania DEP awarded $82,000 in Section 319 funds for Phase II of the strategy.

1.6 TMDL APPROACH

The Christina Basin Water Quality Management Committee plans to address point and non-point source water quality problems through two approaches: (1) voluntary watershed/water quality planning and management and (2) a Total Maximum Daily Load (TMDL) approach. Section 303(d) of the 1972 Federal Clean Water Act (CWA), as amended, requires the development of TMDL's for all stream segments not meeting water quality standards after the implementation of technology based effluent controls. In 1996, The Widener School of Law, on behalf of the American Littoral Society and the Sierra Club, filed a federal complaint with EPA asking the Court to order Pennsylvania and Delaware to establish TMDL's for water quality limited segments. In 1996, the DNREC and PADEP published a Section 303(d) list which set a deadline for completion of a TMDL in main stem segments of the Christina Basin by the year 2000. In 1997, the DNREC and USEPA signed an interagency Memorandum of Understanding which established deadlines for completion

of the TMDL's. The Christina Basin TMDL will be the second completed in the State of Delaware. The first TMDL in Delaware was completed in the Appoquinimink River watershed in 1997.

The Total Maximum Daily Loads (TMDL) for the Christina Basin will include three components - a waste load allocation (WLA), a load allocation (LA), and a margin of safety (MOS). The waste load allocation is the portion of the TMDL that is allocated to point sources such as end-of-pipe wastewater discharges. The WLA is being developed by collecting stream water quality data at 33 in-stream monitoring stations in the Christina Basin. The stream water quality data will be combined with NPDES wastewater discharge data using a Low-Flow, Point Source WASP receiving water model. The Load Allocation is the portion of the TMDL that is allocated to non-point sources and natural background conditions. Load allocations will be developed by collecting land use, soils, and stormwater monitoring data and inputting them into an HSPF nonpoint source model. The third component of the TMDL is the margin of safety which is set aside to account for uncertainty in the allocation process. The complex TMDL will consist of the following components in the Christina River Basin.

TMDL = WLA + LA + MOS

Where:

TMDL = The Total Maximum Daily Load which is the maximum amount of a pollutant that can be put into the water body without violating water quality standards.

WLA = Waste Load Allocation which is allocated to point sources through a low flow, WASP receiving water model.

LA = Load Allocation allocated to nonpoint sources through a high flow, HSPF hydrodynamic and water quality model.

MOS =The Margin of Safety set aside to account for uncertainty in the allocation process.

By the year 2000, the completed TMDL may recommend reductions in point and nonpoint source loads to meet water quality standards in the Christina River Basin. Point-source reduction programs may include modified effluent limits and/or improvements to NPDES wastewater treatment plants. Non-point source reductions may be achieved through structural, nonstructural, and institutional best management practices (BMP's) such as detention ponds, reforestation, agricultural conservation and riparian stream buffers to control stormwater runoff and reduce water quality impacts to the receiving streams in the Christina Basin. A major emphasis will be placed on public involvement to facilitate BMP implementation.

1.7 COMPATIBILITY

The Water Quality Management Strategy is designed for compatibility and to avoid redundancy with existing water-quality programs in the Christina River Basin. The Strategy is especially designed to coordinate the initiatives of the Delaware DNREC Piedmont Whole Basin Program and the Chester County Water Resources Management Plan. The Strategy is also designed to support watershed management efforts of volunteer and non-profit organizations that are consistent

with the goals and objectives of this strategy. The Christina Basin Strategy will be integrated with the following initiatives:

- Delaware DNREC Piedmont Whole Basin Program
- USGS/Chester County Cooperative Monitoring Programs and Studies
- Water Resources Management Plan for Chester County, Pennsylvania
- Delaware Estuary Program Comprehensive Management Program
- Pennsylvania Act 167 Stormwater Management Requirements
- Section 319 Non-Point Source Program for the States of Delaware and Pennsylvania
- U. S. EPA NPDES Part 2 Stormwater Permit Application for New Castle County, Delaware and Delaware DOT
- Red Clay/White Clay Creeks, PL 83-566 Project
- White Clay Creek Wild and Scenic River Study, Watershed Management Plan
- Combined Sewer Overflow Study for Wilmington, Delaware
- Governor's Task Force on the Future of the Brandywine and Christina Rivers, A Vision for the Rivers, Delaware
- WATER 2000/2020 Plan for New Castle County, Delaware
- Volunteer stream watch and monitoring programs such as the Brandywine Valley Association, White Clay Watershed Association, Red Clay Valley Association, Christina Conservancy, Delaware Nature Society, Brandywine Conservancy, and Stroud Water Research Laboratory
- Local municipal watershed/water quality initiatives.

1.8 MISSION STATEMENT/OBJECTIVES

The mission of the Christina Basin Water Quality Management Strategy is to complete a five-year program to: (1) identify point and nonpoint source pollutants in the watershed, (2) establish achievable water quality goals for the watershed, and (3) develop and implement a water quality management plan to achieve and maintain water quality utilizing public outreach and consensus building among the public and all stakeholders.

The purpose of the Christina Basin Strategy has evolved into 4 distinct objectives:

1. Develop Water Quality Goals for the Watershed (i.e. Complex TMDL's)
   a. Point source modeling and water quality goals
   b. Nonpoint source stormwater modeling and water quality goals
   c. Integrate the point and nonpoint source TMDL's to create the complex TMDL's for the watershed

2. Provide Effective Demonstration Best Management Practices (BMP's)
   a. Riparian buffers
   b. Reforestation
   c. Agriculture conservation
   d. Stream reforestation
   e. Stormwater/wetland management
   f. Institutional tools for municipal ordinances, zoning and planning

3. Stakeholder Involvement (Public/Local Government Water Suppliers/Discharges/Land Owners)
   a. Introduce stakeholders to the Christina Basin Initiative
   b. Educate stakeholders regarding their individual responsibility to water quality management
   c. Involve stakeholders in process of finalizing water quality goals and development of a watershed management plan

4. Develop and Implement a Christina Basin Watershed Management Plan
   a. Utilize the regulatory TMDL Plan
   b. Stress a voluntary, consensus driven approach
   c. Emphasize responsibilities of all stakeholders

1.9 5-YEAR WATER QUALITY MANAGEMENT STRATEGY

The Christina Basin Water Quality Management Committee plans to accomplish the Strategy during several phases over a 5-year period. The duration of each phase will be approximately one year. The 5-year program began in September 1995 and is expected to extend through 2000:

Phase I - Water Resource Inventory/Public Education/Demonstration BMP's (1996)

- Inventory and map watershed resources such as land use, soils and other data.
- Collect stream water quality data at over 33 monitoring stations for the point source effort.
- Assess existing surface water quality on a stream by stream basis.
- Evaluate adequacy of existing local stormwater management ordinances to control runoff quality.
- Estimate stormwater pollutant loads and percent impervious cover and existing land uses for the subwatersheds utilizing the Schueler "Simple Method."
- Select subwatersheds for implementation of demonstration BMP's in the Delaware and Pennsylvania portions of the Basin.
- Design a stormwater monitoring program to characterize representative stormwater quality in priority subwatersheds.
- Develop public outreach and education initiatives.
- Prepare a Phase I Watershed Report.

Phase II - Stormwater Monitoring/TMDL Watershed Model/Public Education (1997)

- Input the watershed inventory into a GIS format and disseminate the mapping and data to agencies and the public.
- Implement the stormwater monitoring program to characterize representative stormwater pollutant loads from various land uses.
- Initiate development and calibration of the TMDL Models to include a point source, low flow WASP receiving water model and a nonpoint source high flow HSPF model.
- Develop guidance and sample language for use in stormwater, soil erosion, sediment control, and subdivision/zoning codes and ordinances.

- Expand and continue the public outreach/education program through the Christina Basin Task Force.
- Implement demonstration BMP's in the watershed.
- Prepare a Phase II Watershed Report.

Phase III - TMDL Model/Demonstration BMP's/Public Education (1998)

- Update the GIS Watershed inventory to include future land uses and biological stream health data.
- Finalize the Point Source WASP receiving water model. Complete calibration of the nonpoint source HSPF model.
- Continue to implement Demonstration BMP's and monitor the status and effectiveness of previous demonstration projects.
- Continue stormwater quality monitoring to characterize pollutants in nonpoint source runoff.
- Expand the public outreach/education program including newsletters and a series of evening outreach meetings.
- Prepare Phase III Watershed Report.
- Develop the scope of a watershed management plan.

Phase IV - TMDL Negotiation (1999)

- Complete the low flow WASP and high flow HSPF models.
- Develop a draft TMDL for the Christina Basin.
- Develop a draft watershed management plan.

Phase V - Comprehensive Watershed Management Plan (2000)

- Hold public information hearings and meetings on the TMDL.
- Finalize adoption of the TMDL incorporating public input.
- Finalize a watershed management plan to manage water quality throughout the Christina Basin based on the adopted TMDL approach and associated point and non-point source load reductions.
- Continue stormwater monitoring to measure effectiveness and implementation of the watershed.
- Continue public involvement program.
- Coordinate the watershed management plan with other State/Federal programs and all private/public stakeholders.
- Prepare final report summarizing Phases I through V.

Implementation

- Continue implementation and update of the watershed management plan and coordinate stakeholder programs and activities.

1.10 PHASE I and II SCOPE OF WORK

Phases I and II of the Christina Basin Water Quality Management Strategy were conducted during 1995, 1996 and 1997 according to the following scope of work:

Task 1 - Project Management

Task 1.1 - The Water Quality Management Committee met bi-monthly to review the progress of work. The Committee was chaired by the Chester County Conservation District (CCCD) and the Water Resources Agency for New Castle County (WRANCC) with overall mediation by the Delaware River Basin Commission (DRBC) and the U.S. Environmental Protection Agency (USEPA).

Task 1.2 - Develop a detailed work plan for Phase I outlining project tasks, budget, milestones, and roles of contracting and subcontracting agencies. The work plan was prepared by the CCCD and the WRANCC incorporating proposals from the various cooperating agencies. Memoranda of Understanding (MOU) by the participating agencies were prepared following approval of the final scope of work.

Task 1.3 - Form a Watershed Inventory Technical Work Group responsible for the collection and organization of data using a Geographic Information System (GIS) in an ARC/INFO format. The work group defined the roles of lead agencies and sources of data as required under Task 2 (Watershed Inventory). The work group included staff from agencies with GIS capability such as the WRANCC, CCWRA, CCPC, NCCD, USGS and others.

Task 2 - Watershed Resource Inventory

Task 2.1 - Prepare a digital base map of the Christina River Basin delineating watershed/subwatershed boundaries, streams/hydrology, reservoirs, roads and state/county/municipal boundaries. The base map and data base were prepared using an ARC/INFO data management system. Thirty eight (38) subwatersheds, each approximately 5 to 30 square miles in area, were delineated on the base mapping for the 565-square mile Christina Basin. The data were organized in a format consistent with the input requirements of the WASP and HSPF watershed models which will be assembled during later phases of the strategy.

Task 2.2 - Inventory watershed resource data on a series of GIS map overlays for the Christina River Basin. Watershed data will be used to identify nonpoint pollutant sources, estimate pollutant loads, and construct a nonpoint source load model during future phases of work. The following series of maps were prepared in a digital format:

- Base Map
- Map 1 - Geology
- Map 2 - Soil Associations
- Map 3 - Outfalls/Intakes
- Map 4 - Topography

- Map 5 - Land Use
- Map 6 - Zoning
- Map 7 - Water Resource Areas
- Map 8 - Parks/Open Space/Protected Lands
- Map 9 - Potential Contaminant Sources
- Map 10 - Best Management Practices
- Map 11 - Stream Water Quality
- Map 12 - Fish Consumption Advisories
- Map 13 - Total Suspended Sediment (TSS) Loads
- Map 14 - % Impervious Cover
- Map 15 - % Agricultural Area
- Map 16 - % Wooded Area
- Map 17 - Watershed Pollution Potential

Task 2.3 - Review the data collected during the Watershed Inventory for consistency with WASP and HSPF format requirements. This included checks of each of the digital coverages and correction of minor errors. The subwatershed delineations conducted during task 2.1 were reviewed and revised to reflect current drainage patterns.

Task 2.4 - Using the ARC/INFO data management system, derive estimates of population density using census data (persons/square mile) and percent imperviousness for each of the 38 subwatersheds in the Christina Basin. Estimates of percent imperviousness were compiled in a format consistent for input to an HSPF model.

Task 3 - Water Quality Assessment

Task 3.1 - Review and assess existing reports and monitoring data to identify water quality problems on a reach-by-reach basis. The assessment catalogued existing water quality data in a digital format and summarized was data "gaps" which will require further surface water and stormwater monitoring. Existing data will be collected from DNREC, DRBC, PADEP, USGS, CCWRA, USEPA - STORET, Private/Public Water Utilities, and stream watch programs conducted by the nature society and watershed associations.

Task 3.2 - Summarize existing water quality information graphically on a digital map of the Christina Basin. The map delineates stream reaches with poor, fair, and good water quality.

Task 4 - Inventory Stormwater Management Programs

Task 4.1 - Review and evaluate existing State, County, and Municipal stormwater management programs for effectiveness in controlling non-point source runoff within the Christina Basin. This work will be conducted by the Delaware DNREC and the PADEP. The following programs were reviewed within New Castle County, Delaware; Chester County, Pennsylvania; and Cecil County, Maryland:

- Stormwater/Floodplain Ordinances
- Soil Erosion/Sediment Control Regulations
- Zoning/Subdivision Codes.

Task 4.2 - Recommend necessary modifications to existing stormwater management programs to reduce the quantity and improve the quality of runoff.

Task 5 - Estimate Stormwater Pollutant Loads

Task 5.1 - Select representative mean concentrations (mg/l) of total suspended sediment using USEPA, National Urban Runoff Program (NURP), Chesapeake Bay Program, and other literature values.

Task 5.2 - Utilize the GIS to estimate annual pollutant loads from non-point sources from each subwatershed in the Christina Basin using a modification of the following "Simple Method" model by Schueler, 1987:

$$L = (A)(P)(R)(C)(0.226)$$

Where:

L = Annual Pollutant Load (lb.)
A = Subwatershed Area (acres)
P = Annual Precipitation (in.)
R = % Impervious for existing land uses including:
- Protected Lands
- Wooded Areas
- Commercial, Industrial, Office, Manufacturing
- Low, Medium, High Density Residential

C = Mean Pollutant Concentration (mg/l)
0.226 = Conversion Factor

Task 6 - Prioritize and Rank Subwatersheds by Pollutant Potential

Task 6.1 - Using the "screening" model, summarize stormwater pollutant load estimates (lb./acre/yr.) in tabular and graphical form by:

- Subwatershed
- Pollutant
- Land Use.

Task 6.2 - Based on the estimates of total suspended sediment loads and other environmental indicators, estimate the pollutant potential of the subwatersheds to assist in prioritizing demonstration BMP's in future phases of the Christina Basin Water Quality Strategy. Rank the subwatersheds from highest to lowest based on the annual pollutant load estimates.

Task 6.3 - Modify the ranking of subwatersheds based on total loads from the screening model by utilizing:

- Stream Water Quality Monitoring Data

- % Impervious Cover, % Wooded, % Agriculture, and relative TSS loadings
- Watershed Prioritization Report prepared by the CCCD in the Brandywine Creek Watershed
- Best Professional Judgement of Committee Members

Task 7 - Design a Stormwater Monitoring Program

Task 7.1 - Design a stormwater monitoring program to characterize nonpoint source loads from representative land uses in the Pennsylvania and Delaware portions of the Christina Basin. Actual stormwater monitoring was initiated during the Fall of 1997.

The goal of the stormwater monitoring program is to collect representative pollutant load data from sub-watersheds that are mostly homogeneous with respect to land use. The pollutant load data will be used as input data for the HSPF model which will be used for the nonpoint source component of the TMDL model. The design of the stormwater monitoring program includes the following components:

- Monitoring station location in priority subwatersheds
- Monitoring for base flow and storm events
- Siting of monitoring stations based on existing water quality and flow data
- Number of sampling stations
- Station installation/calibration
- Sampling frequency
- Representative storm criteria (mean storm depth/duration)
- Precipitation gage location and design
- Selected pollutants for sampling and lab analysis
- Design of sediment sampling stations
- Method of sampling
    - grab or composite flow weighted
    - manual or automatic sampling
- Laboratory analytical and QA/QC procedures
- Sampling crew responsibilities and roles

Task 7.2 - Compile historical meteorological data for the Christina Basin in an HSPF-compatible format to include precipitation, temperature and evaporation.

Task 7.3 - Compile historical and current flow and discharge data in an HSPF-compatible format for the Christina Basin.

Task 7.4 - Compile existing stream channel, slope roughness, and cross-sectional area data for the Christina Basin.

Task 7.5 - Develop a Stormwater Monitoring Procedures Manual summarizing the sampling and analysis program to be conducted during future phases. Excerpts from existing publications will used to develop the manual for the Christina Basin.

Task 8 - Public Outreach/Education Program

Task 8.1 - Conduct a public outreach and education program to inform landowners concerning the need to implement BMP'S. The education program was conducted by the Chester County Conservation District with assistance by the USEPA Regional Administrator's staff and DRBC and include the following components:

- Document progress and success of the Christina Strategy
- Inform citizens about BMP's such as fertilizers/pesticide management, septic systems operation, and riparian buffer protection
- Sustainable Development Planning
- Instill in citizenry a sense of stewardship in the Christina Strategy.

Task 8.2 - Retain a part-time coordinator for the Public Education Component. The Brandywine Valley Association was engaged to conduct the work.

Task 8.3 - Develop and distribute a quarterly Christina Basin Strategy newsletter.

Task 8.4 - Conduct an annual workshop on water quality issues in the Christina Basin.

Task 8.5 - Conduct public meetings to review progress.

Task 8.6 - With assistance by USEPA and DRBC, prepare quarterly press releases describing project progress.

Task 8.7 - Prepare Christina Basin brochures and factsheets.

Task 8.8 - Provide funding for at least one demonstration project utilizing BMP's in each State's portion of the Christina Basin. The CCCD implemented the BMP demonstration projects in the Pennsylvania portion of the Christina Basin. The City of Newark, with assistance by the NCCD and WRANCC, implemented the BMP demonstration project in the Delaware portion of the Basin. The demonstration projects consist of the following:

- Pennsylvania - Riparian Buffer, Reforestation, Agriculture Conservation.

- Delaware - Install and measure the effectiveness of a Natural Stream Restoration Projectutilizing bioengineering, native vegetation, and reforestation techniques along the Upper Christina River in the City of Newark.

<u>Task 9 - Prepare Phase I and II Report</u>

Task 9.1 - Prepare a draft Phase I and II report summarizing:

- Watershed Resource Inventory
- Water Quality Assessment
- Review of Stormwater Management Ordinances
- TSS Load Estimates
- Subwatershed Prioritization

- Stormwater Monitoring Program Design
- Public Outreach/Education Program

Task 9.2 - Circulate the draft report for review and comment by the Christina Basin Water Quality Management Committee and the public.

Task 9.3 - Prepare a final Phase I and II report and submit to USEPA-Region III, Delaware DNREC, and Pennsylvania DEP in accordance with Section 319 program grant procedures.

1.11 FUNDING

The USEPA distributed funds from Section 319 of the Clean Water Act to the States of Delaware and Pennsylvania under a unique arrangement for the first two phases of the Christina Basin Strategy. The Delaware DNREC, Division of Soil and Water Conservation administered the Section 319 funds during Phase I of the project in 1995 and 1996. A local match was required for funds distributed under the DNREC Section 319 program. During Phase II in 1997, the Pennsylvania DEP, Division of Watershed Conservation administered the Section 319 funds. A local match is not required for funds administered by the PADEP. The USEPA provided additional funding support including contract support for watershed training, $30,000 for HSPF training, and $5,000 for consultation to the Christina Basin Committee. Table 1-1 provides a funding summary of the first two phases of the Christina Basin Water Quality Management Strategy.

In addition, Chester County (CCHD, CCWRA, County Commissioners) and the USGS cooperatively funded several stream gage instrumentation sites and monitoring programs that contributed directly to this project (Table 1-2). These data are provided to municipalities, water suppliers, and stakeholders for related water resources management in the Brandywine, Red Clay, and White Clay Creeks watersheds. These programs have been cooperatively funded for over 20 years. In addition, Chester County and the USGS have cooperatively funded numerous other studies and interpretative reports in the Christina Basin, including an updated low flows statistical analysis of stream base flow, radon in ground water, biological data report, and biological trends analyses that will be published in 1998 and 1999.

2. WATERSHED INVENTORY

2.1 GIS APPROACH

The Water Quality Management Committee compiled a watershed inventory consisting of existing data for the Christina Basin. The inventory includes a summary of watershed data on a series of map overlays in a digital format. The purpose of the watershed inventory is to:

- Consolidate data from the 3 States in the Christina Basin in a cohesive format
- Identify point and non-point sources of pollutants
- Define environmental indicators of watershed and stream health
- Estimate pollutant loads
- Prioritize subwatersheds for monitoring and implementation
- Compile data for use in a TMDL watershed model in latter phases

The Water Resources Agency for New Castle County (WRANCC) compiled the watershed inventory including a base map and 10-map series using the ARC-INFO Geographic Information System (GIS). A Technical Committee was established to provide data in a paper-map and digital format to the WRANCC. The data was organized in a format consistent with the input requirements of the WASP point source and HSPF nonpoint source models which will be used for the TMDL approach. Various Federal, State, and Local agencies provided data. Table 2-1 summarizes the map layers, responsible agencies, and data sources for the watershed inventory effort.

The following 11-map series was compiled in a digital format with attributed data layers:

- Base Map
- Map 1 - Geology
- Map 2 - Soils
- Map 3 - Outfalls/Intakes/Discharges/Monitoring Sites
- Map 4 - Topography
- Map 5 - Land Use
- Map 6 - Zoning
- Map 7 - Floodplains/Wetlands/Groundwater Protection
- Map 8 - Parks and Open Space Areas
- Map 9 - Hazardous Waste, Superfund, Landfill Sites
- Map 10 - Existing Best Management Practices

TABLE 2 - 1
GIS WATERSHED INVENTORY DATA SOURCES
Christina Basin Water Quality Management Strategy

MAP	COVERAGE	DELAWARE			PENNSYLVANIA			MARYLAND		
		GIS MAPPING AGENCY	SOURCE OF DATA	STATUS	GIS MAPPING AGENCY	SOURCE OF DATA	STATUS	GIS MAPPING AGENCY	SOURCE OF DATA	STATUS
BASE MAP	* Watersheds	WRANCC	WRANCC	Complete	WRANCC	WRANCC	Complete	WRANCC	USGS	Complete
	* Minor watersheds		WRANCC	Complete		USGS	Complete		USGS	Complete
	* Hydrology		DELDOT	Complete		PENNDOT	Complete		MDDOT	Complete
	* Roads		DELDOT	Complete		PENNDOT	Complete		MDDOT	Complete
	* State/Co./Municipal Boundaries		DELDOT	Complete		PENNDOT	Complete		MDDOT	Complete
1. GEOLOGY	* Geology	WRANCC	DGS	Complete	CCWRA, CCPC	USGS	Complete	WRANCC	MDGS	Complete
	* Sinkholes		DGS	Complete		USGS	Complete			Complete
2. SOIL ASSOCIATIONS		NCCD	USDA, NRCS	Complete	CCWRA, CCPC	USDA, NRCS	Complete	WRANCC	USDA, NRCS	Complete
3. OVERALLS/ INTAKES	* Stream Gages	WRANCC	USGS	Complete	CCWRA, CCPC	USGS	Complete	WRANCC		
	* Observation Wells		DGS	Complete		USGS, CCWRA	Complete			
	* Precipitation Gages		USNWS	Complete		USGS, CCWRA	Complete			
	* Public Surface Water Withdrawals		DNREC	Complete		PADEP	Complete		MDWRA	Need to Update
	* Public Wells		DNREC	Complete		PADEP	Complete		MDWRA	Need to Update
	* NPDES Discharges		DNREC	Complete		PADEP	Complete		MDWRA	Complete
	* Water Quality Stations		DNREC	Complete		PADEP, USGS	Complete			
	* Ind./Rec./Irr. Intakes		DNREC	Complete		PADEP	Complete			
	* Health Dept. Sampling Stations					CCHD	Complete			
	* Spray Irrigation Sites					PADEP	50% Complete			
	* Stormwater Monitoring Stations		USGS	Complete		USGS	90% Complete			
	* Combined Sewer Overflows		Wilmington	Complete						
4. TOPOGRAPHY	* Hypsography at 10 - 20 feet Contour Interval	WRANCC	DGS	Complete	WRANCC	USGS	DEM received from USGS	WRANCC	DGS	Complete
5. LAND USE		WRANCC	WRANCC NCC, DOP	Complete	CCWRA, CCPC	DVRPC	Complete	WRANCC	Cecil Co. - OPZ	Complete
6. ZONING		WRANCC	NCC	Complete	CCWRA, CCPC	CCPC, Townships	Complete	WRANCC	Cecil Co. - OPZ	Complete
7. WATER RESOURCE AREAS	* Floodplains	WRANCC	FEMA	Complete	CCWRA, CCPC	FEMA	Complete	WRANCC	FEMA	Complete
	* Wetlands		USFWS	Complete		USFWS, NWI	Complete Except 2 Quads		USFWS, NWI	Complete
	* Groundwater Protection Areas		WRANCC	Complete		CCPC, Townships	Complete			
8. PARKS and OPEN SPACE	* Ag. Districts/Easements	WRANCC	DNREC, NCC	Digitizing	CCWRA, CCPC	CCPC, Townships	Need to Update	WRANCC	Cecil Co.	Need to Update
	* Public Open Space		DNREC, NCC	Complete		DVRPC	Need to Update		Cecil Co.	Need to Update
	* Private Open Space		DNREC, NCC	Complete		DVRPC	Need to Update		Cecil Co.	Need to Update
9. HAZARDOUS WASTE, SUPERFUND, LANDFILLS	* Hazardous Waste	WRANCC	DNREC	Complete	CCWRA, CCPC	PADEP	Complete	WRANCC	Cecil Co.	Need to Update
	* Superfund Sites		DNREC	Complete		PADEP	Complete			Need to Update
	* Landfills		DNREC	Complete		PADEP	Complete			Need to Update
	* Leaking UST		DNREC	Complete		PADEP	Need to Update			Need to Update
10. EXISTING BMP'S	* Agricultural	WRANCC	DNREC	Digitizing	WRANCC	CCCD	Digitizing	WRANCC	Cecil Co.	Digitizing
	* Stormwater		NCC - DPW	Available 6/98		CCCD				

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To date, the Water Resources Agency for New Castle County has distributed the GIS watershed maps in a digital and paper format to the following agencies and members of the public:

1. Berkshire Area Planning Commission
2. Brandywine Conservancy
3. Brandywine Valley Association
4. Cahill, Mr. Tom
5. City of Newark
6. City of Wilmington
7. Chester County Conservation District
8. Chester County Planning Commission
9. Chester County Water Resources Authority
10. Delaware DNREC
11. Delaware Estuary Program
12. Delaware River Basin Commission
13. DuPont Company Experimental Station
14. East Nantmeal Planning Commission
15. Gordon, Ms. Angie
16. Hall, Mr. Bill
17. Louis Berger, Associates
18. McCarter, Ms. June
19. McLaughlin, Ms. Suzan
20. New Castle County Conservation District
21. New Castle County Land Use Department
22. Pennsylvania DEP
23. Pennsylvania State University
24. Philadelphia Water Department
25. Reese, Mr. Ed
26. Shapiro, Ms. Connie
27. U. S. Geological Survey (Massachusetts)
28. U. S. Environmental Protection Agency (Source Water Protection Program)
29. United Water Delaware
30. University of Delaware
31. Wallace Township
32. West Chester University
33. West Virginia University
34. Wilmington River-City Steering Committee

2.2 BASE MAP

The base map includes the fundamental framework of watersheds, streams, roads, and State/County municipal boundaries for the 565-square mile Christina Basin (Figure 2-1). The base map was prepared in a GIS format by starting with the roadway and stream network obtained from the DELDOT, Maryland DOT, and PENNDOT. Next, the man-made boundaries such as State, County, Township, and City/Boroughs were added to the map. Finally, the boundaries for 38 subwatersheds were digitized to provide basic hydrogeologic planning units.

Unless noted otherwise, the data listed below was obtained in a digital format.

Data Sources

Roadway and Stream Network

Delaware DOT - 1995
Pennsylvania DOT - 1995
Maryland DOT - 1995

State/County/Municipal Boundaries

DELDOT - 1995
PENNDOT - 1995
Maryland DOT - 1995

Watershed Boundaries

Delaware - Water Resources Agency for New Castle County, 1995
Pennsylvania - Digitized from Chester County Planning Commission Watershed map by the WRANCC, 1995
Maryland - Digitized from USGS Newark West Quadrangle by the WRANCC, 1995

Review of the Christina Basin Base Map provides several observations concerning the subwatersheds and local governments in the watershed. Four major watersheds were delineated - the Brandywine, Red Clay, White Clay Creeks and the Christina River. Within the 4 watershed, Thirty eight subwatersheds were delineated ranging from 4 to 33 square miles in area (Table 2-2). The 38 subwatersheds serve as the basic hydrologic planning units for identifying watershed health, assessing stream water quality, and conducting stormwater monitoring and TMDL modeling on the base map.

The local governments in the Christina Basin were identified by superimposing the state/county and local boundaries. On the base map, the Christina Basin includes three States - Delaware, Maryland, and Pennsylvania; five Counties - Lancaster County; Chester County; Delaware County, Pennsylvania; Cecil County, Maryland; and New Castle County, Delaware. The Basin includes five local governments in Delaware and 45 townships, boroughs, and cities in Pennsylvania (Table 2-3). The differing governments in Pennsylvania and Delaware pose additional challenges in watershed management. In the Delaware portion of the Christina Basin, government is provided largely by three jurisdictions - New Castle County, Wilmington, and Newark. Whereas in Pennsylvania, government is provided by dozens of local municipalities. Each of these governments have separate water quality standards and stormwater ordinances thus providing complexities which must be recognized and coordinated to achieve a unified Christina Basin Strategy.

The Christina Basin extends over 30 linear stream miles from the headwaters in the Appalachian foot hills north of the Pennsylvania Turnpike to the tidewater at Wilmington. The subwatersheds on the base map provide the building blocks for a unified water quality management strategy for the Christina Basin.

Christina Basin Water Quality Management Strategy
Base Map

TABLE 2 - 2
SUBWATERSHEDS
Christina Basin Water Quality Management Strategy

		Subwatershed Area (sq. mi.)
Brandywine Creek Watershed		
B1. Upper West Branch at Honey Brook		18.49
B2. Upper West Branch at Hibernia		26.04
B3. Lower West Branch at Coatesville		17.64
B4. Lower West Branch at Embreeville		17.09
B5. Buck Run		27.53
B6. Doe Run		22.57
B7. Broad Creek		6.44
B8. Upper East Branch at Struble Lake		33.04
B9. Upper East Branch at Shamona Creek		10.00
B10. Lower East Branch		20.93
B11. Marsh Creek		19.98
B12. Beaver Creek		18.09
B13. Valley Creek		20.65
B14. Main Stem above Chadds Ford		24.56
B15. Pocopson Creek		9.14
B16. Main Stem below Chadds Ford		26.46
B17. Main Stem through Wilmington		6.06
	Subtotal	**324.71**
Red Clay Creek Watershed		
R1. West Branch		17.47
R2. East Branch		9.96
R3. Burroughs Run		7.11
R4. Main Stem above Wooddale		12.45
R5. Main Stem below Wooddale		7.11
	Subtotal	**54.10**
White Clay Creek Watershed		
W1. West Branch		10.18
W2. Middle Branch		15.87
W3. East Branch above Avondale		18.74
W4. East Branch below Avondale		14.33
W5. Mill Creek		12.92
W6. Pike Creek		6.64
W7. Middle Run		3.89
W8. Main Stem above Newark		10.12
W9. Main Stem above Delaware Park		9.05
W10. Main Stem at Churchmans Marsh		5.51
	Subtotal	**107.25**
Christina River Watershed		
C1. East / West Branch above Cooches Bridge		21.06
C2. Muddy Run		8.66
C3. Belltown Run		6.43
C4. Little Mill Creek		9.23
C5. Main Stem above Smalley's Pond		10.67
C6. Main Stem Lower Tidal		21.95
	Subtotal	**78.00**
Total Christina River Basin		**564.06 sq. mi.**

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TABLE 2 -3
STATE, COUNTY, AND LOCAL GOVERNMENTS
Christina Basin Water Quality Management Strategy

PENNSYLVANIA

Chester County:

Boroughs/Cities:

Avondale
Coatesville
Downingtown
Honey Brook
Kennett Square
Modena
Parkesburg
South Coatesville
West Chester
West Grove

Townships:

Birmingham
Caln
East Bradford
East Brandywine
East Caln
East Fallowfield
East Marlborough
East Nantmeal
East Whiteland
Franklin
Highland
Honey Brook
Kennett
London Britian
Londonderry
London Grove
New Garden
Newlin
New London
Penn
Pennsbury
Pocopson
Sadsbury
Thornbury
Upper Uwchlan
Uwchlan
Valley
Wallace
West Bradford
West Brandywine
West Caln
West Fallowfield
West Goshen
West Marlborough
West Nantmeal
West Sadsbury
Westtown
West Vincent
West Whiteland

PENNSYLVANIA

Delaware County:

Bethel Township
Birmingham Township
Concord Township

Lancaster County:

Salisbury Township

DELAWARE

New Castle County:

Elsmere
Newark
Newport
Wilmington

MARYLAND

Cecil County

TABLE 2 - 4

LAND USE BY COUNTY

Christina Basin Water Quality Management Strategy

County	Area (sq. mi.)	Percentage
Cecil County, MD	8.4	1.5%
Chester County, PA	388.3	68.7%
Delaware County, PA	9.1	1.6%
Lancaster County, PA	2.8	0.5%
New Castle County, DE	156.3	27.7%
Total	**564.9**	**100.0%**

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2.3 GEOLOGY

The geology map summarizes the subsurface bedrock characteristics which affect surface and groundwater quality. Geologic data can provide estimates of depth to bedrock and permeability which are needed for watershed modeling. Certain geologic formations such as the Cockeysville Marble, are productive aquifers for public water supplies but are highly vulnerable to contamination. Thus, delineation of the geologic features can assist in identifying vulnerable recharge areas that could be protected from contamination such as the existing Water Resource Protection Area program. The geology data base includes the:

- Geologic Formation
- Depth to Bedrock
- Depth to Groundwater Table
- Sinkholes, Latitude/Longitude, and Status
- Quarries
- Faults

Data Sources

Delaware - Delaware Geological Survey Quadrangles, 1970, 1972, 1975
Pennsylvania - Chester County U. S. Geological Survey, 1995
Lancaster and Delaware Counties, U. S. Geological Survey, 1981
Maryland - Maryland Geological Survey Quadrangle, 1986
Sinkholes - Delaware Geological Survey Field Notes, undated and Open File Report No. 14, 1981
- Pennsylvania Geological Survey, Open File Report 93-01, 1993

Map 1 provides the description and location of geologic features in the Christina Basin. Note by the colors of each formation that each of the States provided interpretations of geology which do not necessarily match at the State boundaries. The disparity in geologic mapping demonstrates the need for a watershed approach. The geologic features in the Christina Basin should be consolidated to develop a consistent standard nomenclative in a future phase of this program.

The geologic formations in the Pennsylvania portion of the Christina Basin are typical of the Piedmont Province. The geologic formations include the diabase, gneiss and marble in the headwaters above Downingtown and Coatsville, the Limestone and Marbles of the Great Valley and the Schists/Gneisses lower in the basin. The formations of the Piedmont of Delaware and Maryland include the Wissahickon Schist, Gneiss, and Cockeysville Marble. The Cockeysville and other limestone marble formations are the most productive water supplies for ground and surface water. The lower portion of the basin below the fall line in Delaware includes the Columbia Potomac sediments of the Coastal Plain. Table 2-5 summarizes the geologic formations in the Christina River Basins.

Christina Basin Water Quality Management Strategy
Map 1: Geology

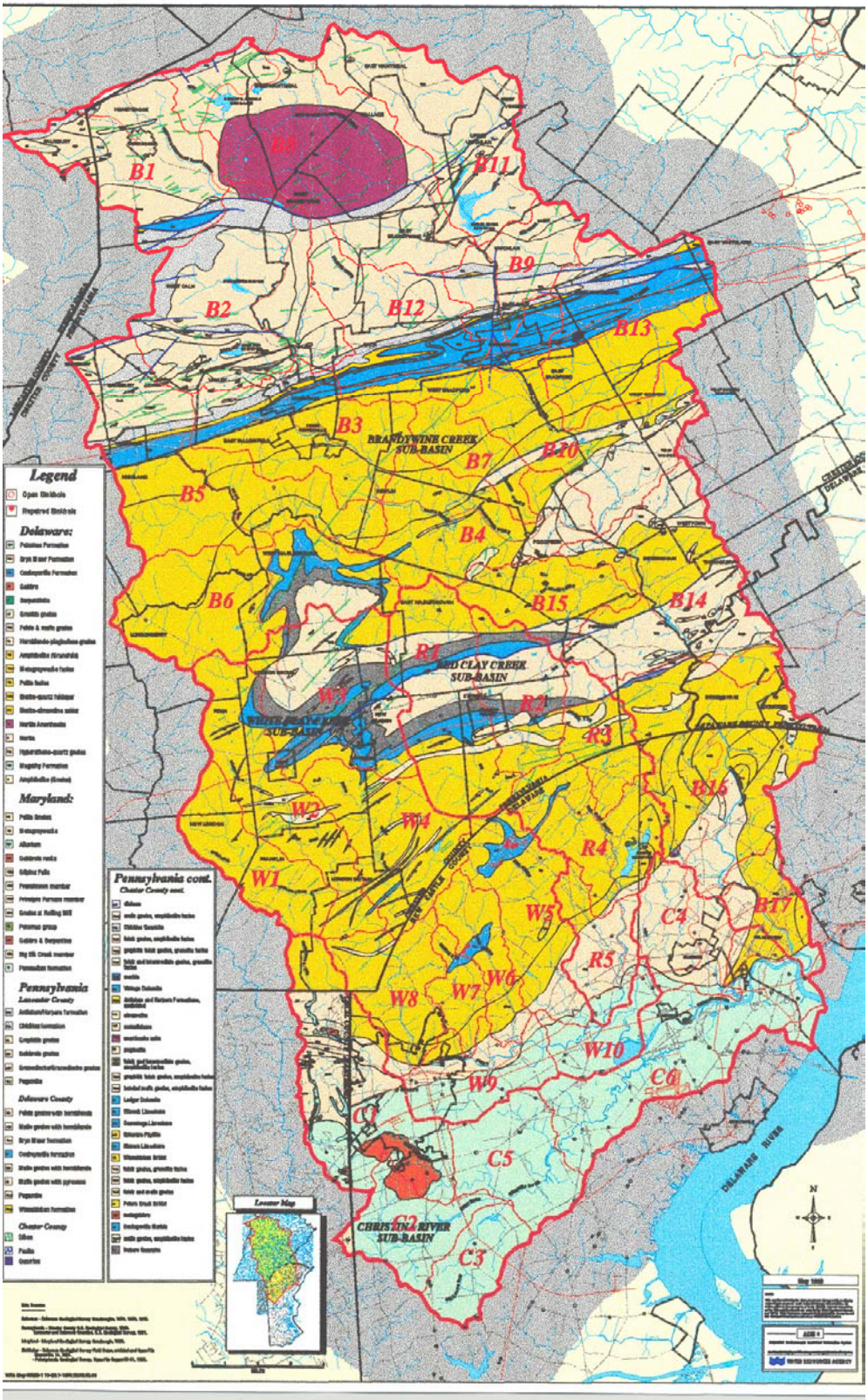

TABLE 2 - 5
GEOLOGIC FORMATIONS
Christina Basin Water Quality Management Strategy

Geologic Formation	Geologic Period	Age (yrs)	Potential Well Yield (gpm)
Columbia	Pleistocene	1.8 million	10 to 100
Potomac	Cretaceous	140 million	400 to 500
Diabase, shales, sandstone	Triassic	200 million	80
Wilmington gneiss	Early Paleozoic	340 million	400
Conestoga limestone	Ordovician	450 million	500
Elbrook and Kinzer Limestone	Cambrian	500 million	500
Serpentine, Wissahickon schists	Lower Paleozoic	570 million	400
Cockeysville marble	Lower Paleozoic	570 million	500
Quartzite	Precambrian	900 million	100
Baltimore gneiss	Precambrian	2.5 billion	400

Source: USGS

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The following rock types are present in the Piedmont province of the Christina Basin:

Original Rock Type	Present Form
Shales (sedimentary)	Schists
Sandstones (sedimentary)	Quartrites
Limestones (sedimentary)	Marble
Granite (igneous)	Gneisses

2.4 SOILS

Soils provide indications of permeability and drainage which are necessary to estimate groundwater recharge, erodability, and stormwater runoff. The permeability of soils are dependent on the type (sand, silt or clay) and hydrologic soil group A,B,C,D. Soils are used to delineate floodplains, identify fragile erosion prone slopes and define septic system limitations. Generally silts and clays are less permeable, generate greater stormwater runoff, and sustain greater sediment loads. In contrast, sands and gravels provide greater groundwater recharge and less runoff and sediment loads. The soils data base includes:

- Soil Association
- Brief Description
- Depth to Groundwater Table
- SCS Hydrologic Soil Group (A, B, C, D)
- Permeability (in/hour)
- Soil Type (sand, loam, clay)

Data Sources

Delaware - USDA, Soil Conservation Service, New Castle County Soil Survey, 1970

Pennsylvania - USDA, SCS, Chester and Delaware County Soil Survey, 1963.

Maryland - USDA, SCS, Cecil County Soil Survey, 1972.

There are 19 soil associations in the Christina River Basin (Map 2). Note the soil associations were mapped according to different standards along the Maryland/Delaware/ Pennsylvania stateline thus providing an example of the need to map soils on a watershed basis. The predominant soil which occupies 3/4 of the basin is the Glenelg - Manor - Chester Loam which exhibits moderate to well-drained characteristics. Most of the soils are silts which overlay bedrock. The distribution of soils are silts which overlay bedrock. The distribution of soils in the Christina Basin reflect the bedrock geology and physiography of the watershed.

The more specific soil classifications were developed in a digital GIS format in the Chester County portion of the basin. The Chester County soil classifications were digitized from the 1963 soil survey by the U. S. Army Corps of Engineers. A GIS map of the Chester County Soil is published separately. A digital soil survey of New Castle County soil classification is not available for compilation in the watershed inventory.

The following paragraphs provide a brief description of the soil associations in the Christina Basin.

1. Glenelg-Manor-Chester association: Nearly level to steep, well-drained, medium - textured soils formed over micaceous crystalline rocks; on uplands.

2. Edgemont association: Moderately deep, channery soils on grayish quartzite and phyllite.

3. Glenelg-Manor-Chester association: Shallow to deep silty and channery soils on grayish-brown schist and gneiss.

4. Neshaminy-Glenelg association: Moderately deep and deep, well-drained, silty, channery, and gravelly soils on gabbro and granodiorite.

5. Neshaminy-Chrome-Conowingo association: Moderately deep and deep, silty soils on serpentine.

6. Neshaminy-Aldino-Watchung association: Level to steep, well drained, moderately well drained, and poorly drained, medium-textured soils formed over dark-colored gabbroic rocks; on uplands.

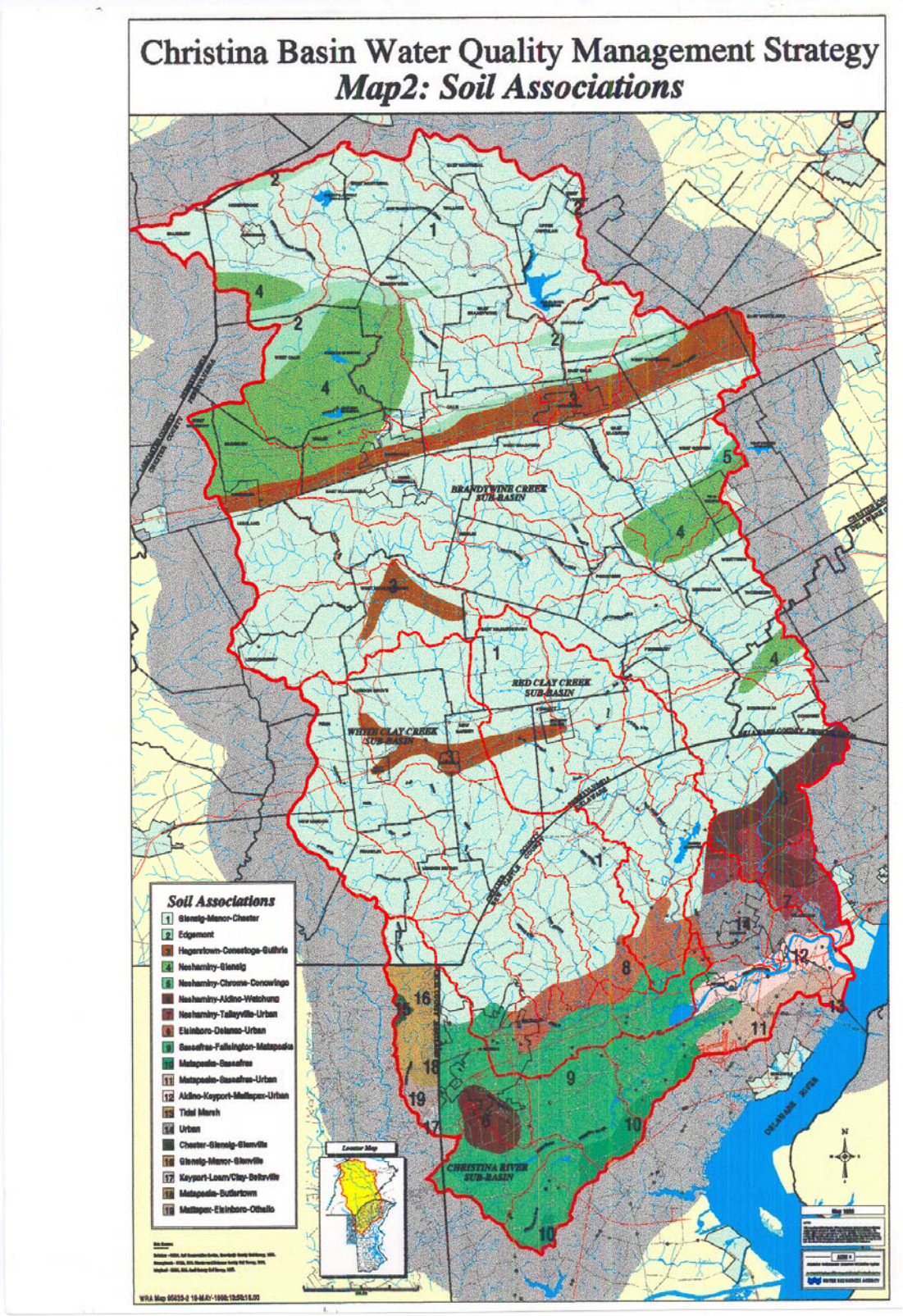
7. Neshaminy-Talleyville-Urban land association: Level to moderately sloping, well-drained, medium-textured soils, relatively undisturbed to severely disturbed; formed over dark-colored gabbroic rocks; on uplands.

8. Elsinboro-Delanco-Urban land association: Level to gently sloping, well-drained and moderately well drained, medium-textured soils, relatively undisturbed to severely disturbed; formed in old alluvium on stream terraces.

9. Sassafras-Fallsington-Matapeake association: Level to gently rolling, well-drained and poorly drained, moderately coarse textured and medium-textured soils on uplands.

10. Matapeake-Sassafras association: Nearly level to steep, well-drained, medium-textured and moderately coarse textured soils on uplands.

11. Matapeake-Sassafras-Urban land association: Level to gently sloping, well-drained, medium-textured and moderately coarse textured soils, relatively undisturbed to severely disturbed; on uplands.


Christina Basin Water Quality Management Strategy
Map2: Soil Associations
BRANDYWINE CREEK SUB-BASIN
RED CLAY CREEK SUB-BASIN
WHITE CLAY CREEK SUB-BASIN
CHRISTINA RIVER SUB-BASIN
Soil Associations
1 Glenelg-Manor-Chester
2 Edgemont
3 Hagerstown-Conestoga-Guthrie
4 Neshaminy-Glenelg
5 Neshaminy-Chrome-Conowingo
6 Neshaminy-Aldino-Watchung
7 Neshaminy-Talleyville-Urban
8 Elsinboro-Delanco-Urban
9 Sassafras-Fallsington-Matapeake
10 Matapeake-Sassafras
11 Matapeake-Sassafras-Urban
12 Aldino-Keyport-Mattapex-Urban
13 Tidal Marsh
14 Urban
15 Chester-Glenelg-Glenville
16 Glenelg-Manor-Glenville
17 Keyport-Loam/Clay-Beltsville
18 Matapeake-Sutlertown
19 Mattapex-Elsinboro-Othello
Locator Map
DELAWARE RIVER

12. Aldino-Keyport-Mattapex-Urban land association: Level to gently sloping, moderately well drained, medium-textured soils, relatively undisturbed to severely disturbed; on uplands.

13. Tidal marsh association: Marshy areas bordering the Delaware River and short tidal streams.

14. Urban land association: Areas used for streets, sidewalks, and buildings and other areas where cutting and filling have been extensive.

15. Chester -Glenelg-Glenville association: Deep, well drained and moderately well drained, nearly level to sloping loamy soils derived from micaceous rock material.

16. Glenelg-Manor-Glenville association: Deep, somewhat excessively drained to moderately well drained, gently sloping to steep, loamy soils derived from micaceous rock material.

17. Keyport-Loamy and clayey land-Beltsville association: Deep, well drained to moderately well drained, nearly level to steep soils that developed in old coastal plain deposits ranging from gravelly loamy sand to clay.

18. Matapeake-Butlertown association: Deep, nearly level to gently sloping, well drained and moderately well drained, loamy soils on the coastal plain.

19. Mattapex-Elsinboro-Othello association: Deep, well-drained to poorly drained, nearly level to sloping, loamy soils on the coastal plain and over coarse water-transported material on stream terraces.

2.5 OUTFALLS/INTAKES

This map summarizes the physical water supply and water quality management infrastructure in the Christina Basin (Map 3). This information is needed to identify the surface and groundwater source water supplies, water quality monitoring stations, and wastewater discharges. The map and associated coverages provides the input data necessary for water budgets and the TMDL models for the Christina Basin. This map series includes:

- Stream Gages
- Observation Wells
- Precipitation Gages
- Public Surface Water Withdrawals
- Community Public Water Supply Wells
- NPDES Discharges
- Stream Water Quality Monitoring Stations
- Industrial, Recreational and Irrigation Intakes
- Health Department Sampling Stations
- Spray Irrigation Facilities

- Nonpoint Source Stormwater Quality Sampling Stations
- Combined Sewer Overflows (CSO's)
- Water Supply Pipelines
- Public Wastewater Service Areas
- Public Water Supply Service Areas

Data Sources

Stream Gages
Delaware Geological Survey, 1975
U.S. Geological Survey, 1998

Observation Wells
Delaware Geological Survey, 1995
U. S. Geological Survey, 1998

Precipitation Gages
U. S. National Weather Service, 1995
Delaware Geological Survey, 1995
Chester County Water Resources Authority, 1998
U. S. Geological Survey, 1998

Public Surface Water Withdrawals
Delaware DNREC, 1995
Pennsylvania, DEP, 1998

Community Public Water Supply Wells
WRANCC, DNREC, 1998
PADEP, CCWRA, 1998

NPDES Discharges
Delaware DNREC, 1998
Pennsylvania DEP, 1998
U. S. EPA, 1998

Stream Water Quality Monitoring Stations
Delaware DNREC, 1998
Pennsylvania DEP, 1998
USGS, 1998

Industrial/Recreational/Irrigation Intakes
Delaware DNREC, 1996
Pennsylvania DEP, 1998

Health Department Sampling Stations
Chester County Health Department, 1996

Spray Irrigation Facilities
Pennsylvania DEP, 1998

Nonpoint Source Stormwater Quality Monitoring Stations
U. S. Geological Survey, 1998

Combined Sewer Overflows
City of Wilmington, 1998

Water Supply Service Pipelines
WRANCC, 1995
CCWRA, 1995

Public Sewer Areas
NCC Department of Public Works, 1995
CCWRA, 1995

Public Water Supply Service Areas
WRANCC, 1995
CCWRA, 1995

The outfall/intake map provides information regarding the potential for wastewater and water supply impacts on water quality. This map provides data to assemble a water budget for the subwatersheds. The map delineates areas served by public sanitary sewers. Septic systems are commonly used for wastewater management outside of the public sewer areas. Thus, the map also indicates those areas where septic systems are in use and may represent sources of non-point source pollution. Table 2-6 provides a summary of these features in the Christina Basin.

Christina Basin Water Quality Management Strategy

Map 3: Outfalls and Intakes

TABLE 2 - 6
OUTFALLS, INTAKES, AND MONITORING STATIONS
Christina Basin Water Quality Management Strategy

Parameter	PA	DE	MD	Total
Stream Gages	13	10		23
Observation Wells	14	4		18
Precipitation Gages	10	4		14
Public Surface Water Withdrawals	5	5		10
Public Wells	279	38		317
NPDES Discharges	62	10	2	74
Stream WQ Monitoring Stations	13	31		44
Indust. / Recreat. / Irrigat. Intakes	21	20		41
Health Dept. Sampling Stations	34	1		35
Spray Irrigation Sites	8			8
Stormwater Monitoring Stations	6	5		11
Combined Sewer Overflows		39		39

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2.6 TOPOGRAPHY

The topographic map provides the land contours for the Christina Basin (Map 5). Topographic data is used to identify fragile steep slopes, estimate stormwater runoff, and estimate sediment loads. The topography in the Christina Basin varies from sea level in the Coastal Plain near Newark and Wilmington, to elevations of 100 feet through the fall line and peaking at elevations near 1200 feet in the Appalachian foothills. The Piedmont topography includes steeply sloped incised stream valleys with more mild slopes along the ridge lines and floodplains. The topography is mapped at a 10 to 20-foot contour intervals utilizing USGS Standard DLG Format 1:24000 hypsography..

Data Sources

Delaware - Delaware Geological Survey, 1992 and 1993.

Pennsylvania - Pennsylvania Geological Survey, Digital Elevation Model (DEM) Files, 1995

Maryland - Delaware Geological Survey, USGS Newark West Quadrangle, 1992

2.7 LAND USE

Along with soils data, land use is a fundamental indicator of stormwater loads and impacts on the quality of receiving waters. Land use data is used to estimate pollutant loads and provide indicators of watershed management needs in the watersheds. The nature and intensity of land use influences water quality in watersheds. Generally, watersheds with low intensity land uses such as wooded areas, and protected lands experience relatively healthy water quality. In watersheds with large areas of urban or agricultural land uses may experience water quality impairment due to high sediment, bacteria, nutrient, and toxic loads. Map 6 portrays the land use map which includes the following categories:

1. Single Family Residential - Single family and duplex units at a maximum density of 4 dwellings per acre.

2. Multi-Family Residential - Urban townhouse, duplex, and apartment units at a density greater than 4 units per acre.

3. Office - Consumer, commercial, professional, administration, and management services.

4. Industrial - Associated warehouses, storage yards, research laboratories, parking, and manufacturing.

5. Transportation/Utility - Roads, highways, railroads, airports, and Shipping transportation; telephone, telegraph, television, and radio communications; and electric, gas, solid waste, sewage, and water utilities.

6. Commercial - Lodging, retail sales, indoor recreation, and automotive sales.

7. Institutional - Health, education, religion, corrections government, associations, charities, and cultural facilities.

8. Protected Lands - State/County/Local open space and parks and public and privately-owned conservation easements, golf courses, and athletic fields.

9. Wooded - Forest land occupying more than 50% of a given parcel including deciduous, coniferous, and mixed woody vegetation.

10. Agriculture - Cropland, pasture, row crops, fallow land, orchards, vineyards, mushroom operations, nurseries, gardens, livestock, poultry, and brushland with less than 10% woody cover.

11. Mining - Borrow pits, quarries, and extractive use operations.

12. Water - Streams, canal, ponds, lakes, reservoirs, bays, estuaries, and wetlands.

13. Vacant - Beaches, rock exposures, and transitional graded or cleared land.

Data Sources

Delaware Landuse - Digitized by the WRANCC in 1995 from 1 inch = 200 feet scale aerial photographs, from the New Castle County Department of Planning, dated April 1993. Field checked and updated to March 1995 by the WRANCC.

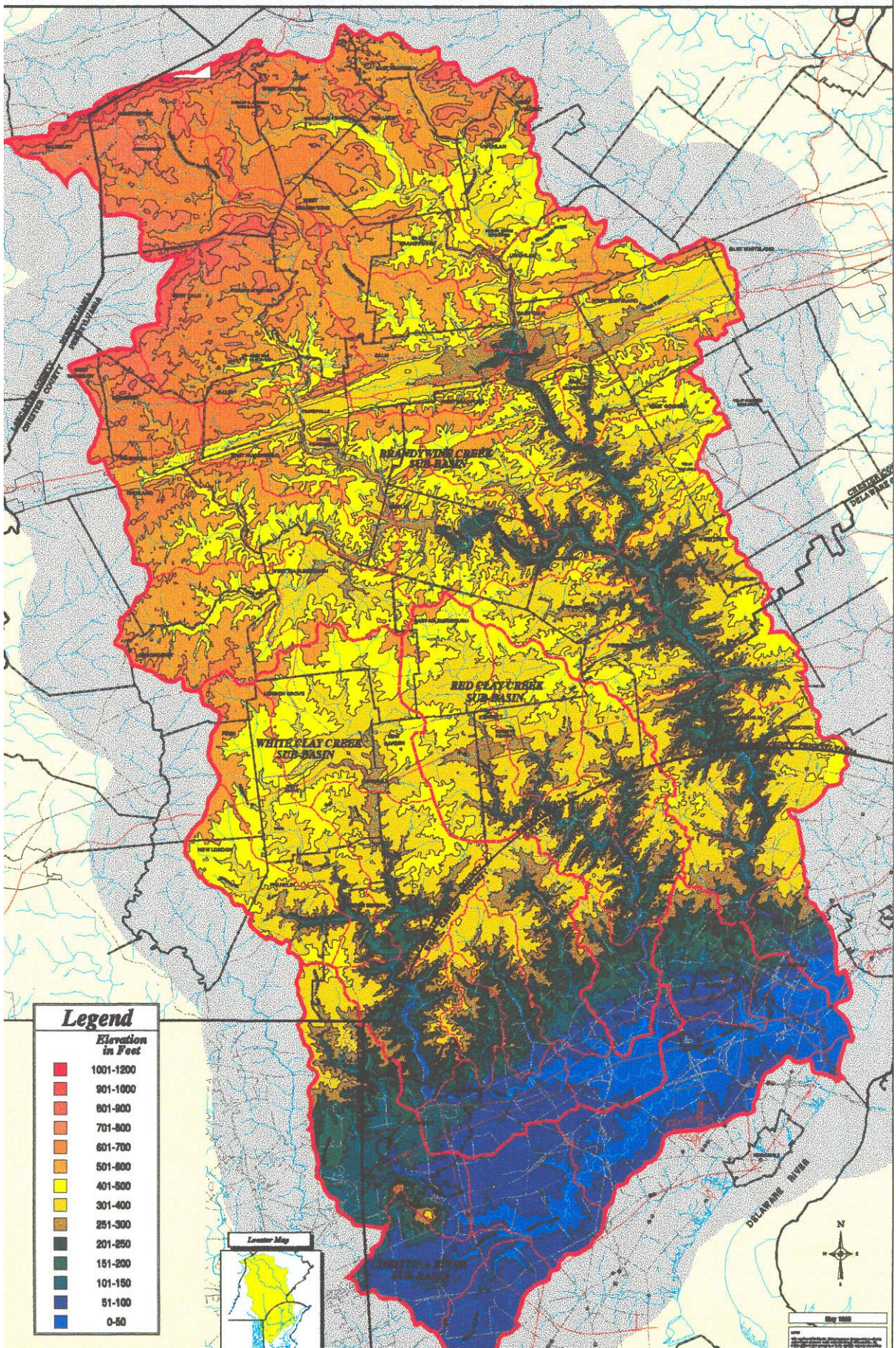
Pennsylvania Landuse - Delaware Valley Regional Planning Commission, 1995.

Maryland Landuse - Cecil County Office of Planning and Zoning, 1993.

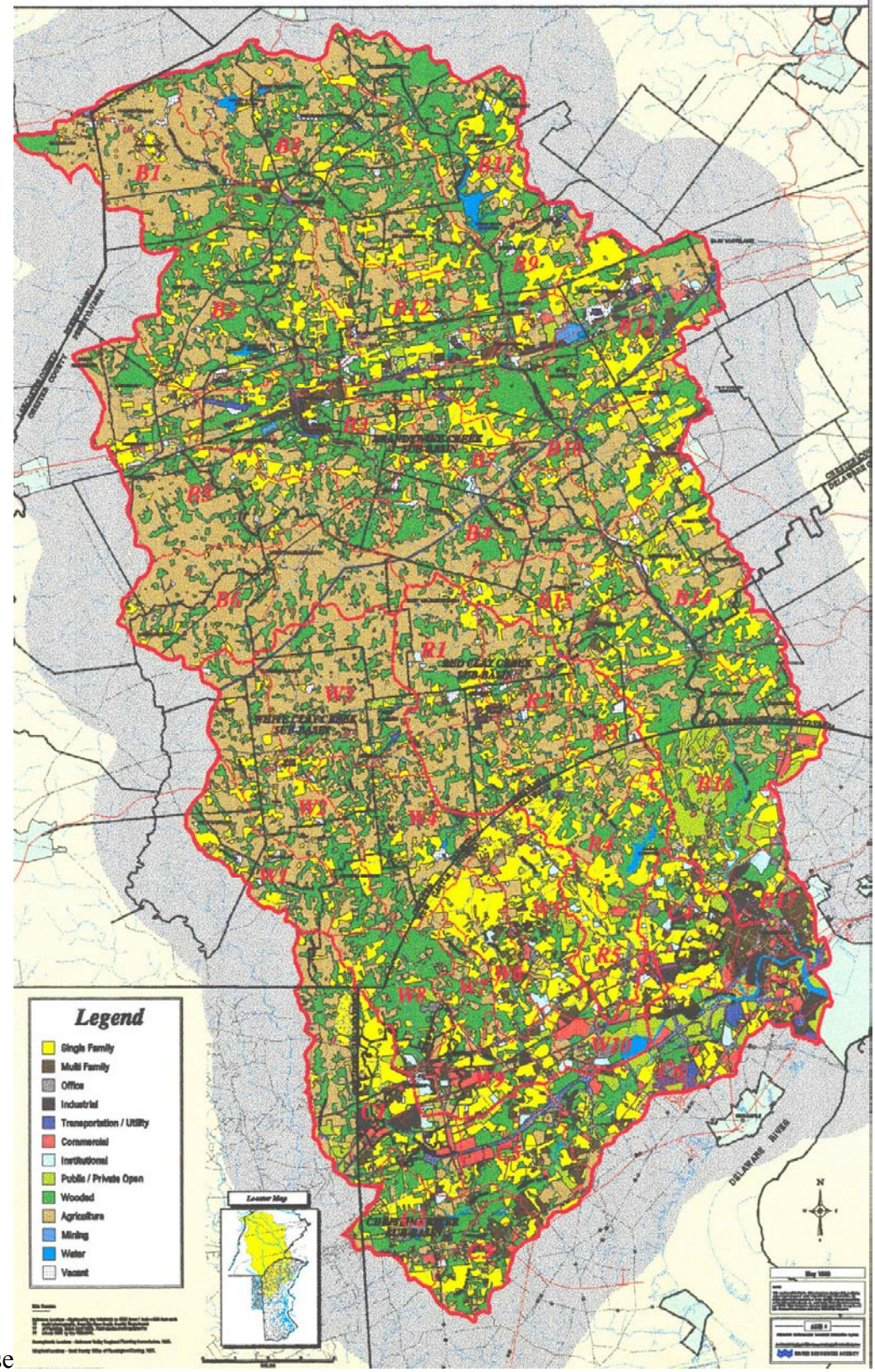
Tables 2-7, 2-8, 2-9 provide a summary of land use in the Christina Basin. Urban\suburban, wooded, and agriculture areas are the predominant land uses in the Christina Basin, each occupying about 1/3 of the basin. The watershed is mostly urban in the lower reaches and becomes more rural to the north and upstream. Delaware has a higher percentage of developed lands. Urban land uses exist in a corridor that stretches from Newark to Wilmington. In Pennsylvania, the watershed is more rural exemplified by higher percentages of agriculture and wooded area. Urban areas in Pennsylvania are concentrated in the Route 202 and Route 30 corridors which connect West Chester, Coatesville and Downingtown. The land use data will be used to derive indicators of watershed health such as percent impervious cover, wooded area, agriculture area, open space, and total suspended sediment loads. Significant amounts of protected lands and open space exist in Chester County but have not yet been compiled for mapping. Thus, values represented for Chester County protected lands are under estimated.

Christina Basin Water Quality Management Strategy

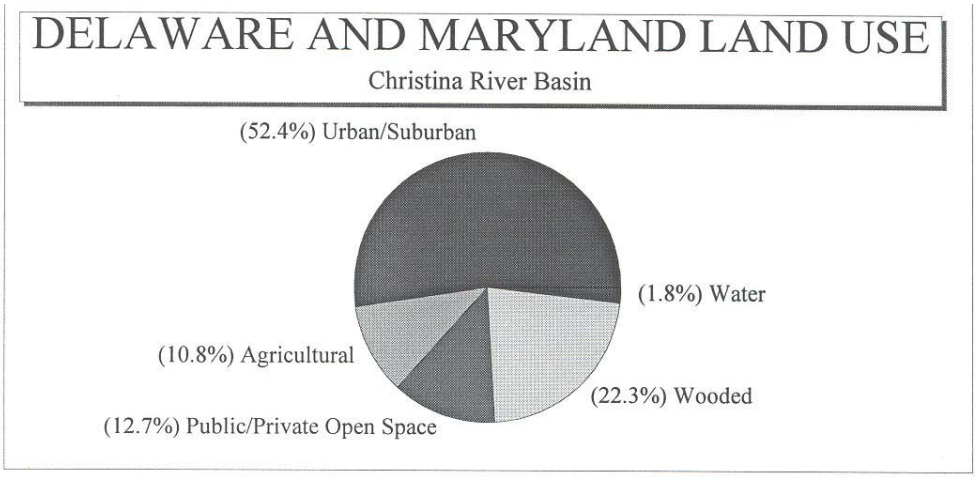
Map 4: Topography

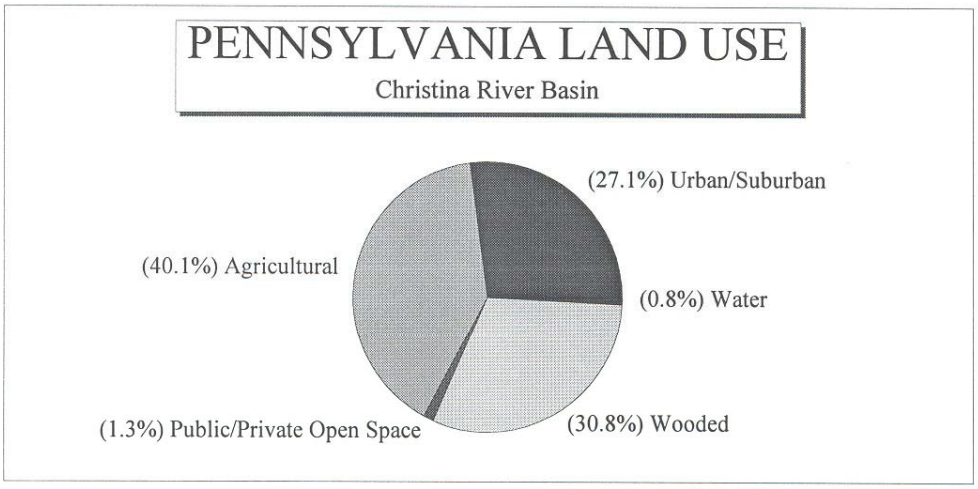


Christina Basin Water Quality Management Strategy
Map 5: Land Use



Use





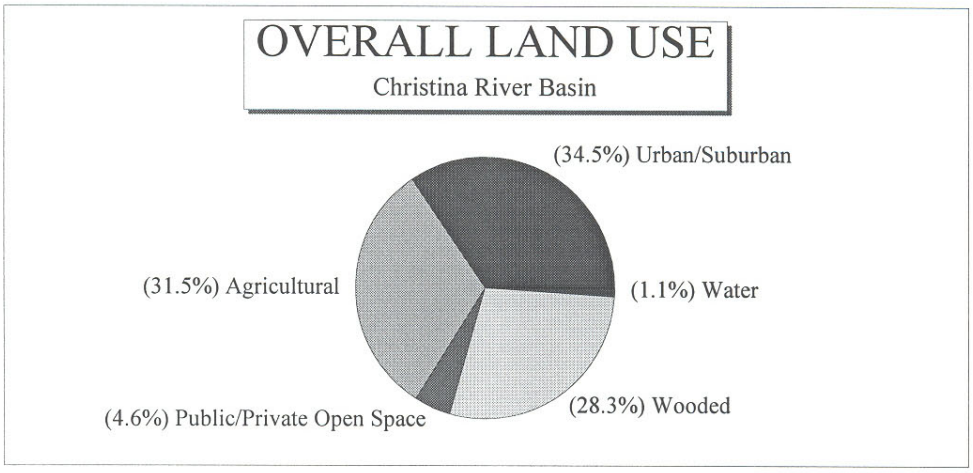


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Figure 2 - 1 Land Use Summarized for Each State in the Christina Basin

TABLE 2 - 7
LAND USE SUMMARY
Christina Basin Water Quality Management Strategy

Land Use	Delaware/ Maryland (sq. mi.)	Pennsylvania (sq. mi.)	Subtotal (sq. mi.)	Subtotal (%)
Urban/Suburban	87	108	195	34
Agricultural	18	160	178	31
Open Space/Protected Lands	21	5	26	5
Wooded	37	123	160	28
Water/Other	3	3	6	2
Total	**166**	**399**	**565**	**100**

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TABLE 2 - 8
LAND USE AREA BY SUBWATERSHED
Christina Basin Water Quality Management Strategy

No.	ID	Subwatershed	Drainage Area		LAND USE (ACRES)												
			(Acres)	(Sq. Mi.)	Single Family Residential	Multi - Family Residential	Office	Industrial	Transport/ Utility	Commercial	Institutional	Public/Private Open Space	Wooded	Agricultural	Mining	Water	acant/Barren
		Brandywine Creek Watershed															
1	B1	Upper West Branch at Honeybrook	11,833.60	18.49	802.21	29.95			62.26	89.62	53.99	4.81	2,403.26	8,017.16	38.39	22.84	312.51
2	B2	Upper West Branch at Hibernia	16,665.60	26.04	3,347.24	121.02		10.83	253.16	55.88	71.94	181.43	7,066.85	5,758.74		189.05	187.35
3	B3	Lower West Branch at Coatesville	11,289.60	17.64	2,084.18	318.96		488.36	422.03	151.39	117.17	70.32	4,097.38	3,189.80	60.98	63.75	226.93
4	B4	Lower West Branch at Embreeville	10,937.60	17.09	797.11				166.78	8.98	121.99		3,866.45	5,681.63		131.46	166.31
5	B5	Buck Run	17,619.20	27.53	1,811.52	26.13			259.23	128.22	64.30	20.84	4,804.59	10,232.63	7.08	82.66	180.09
6	B6	Doe Run	14,444.80	22.57	402.18				169.56	34.09	14.68	6.82	2,483.85	11,219.20		45.54	71.33
7	B7	Broad Creek	4,121.60	6.44	1,159.44	47.66			103.76	13.34	19.31	16.30	1,175.45	1,534.79		5.21	48.48
8	B8	Upper East Branch at Struble Creek	21,145.60	33.04	2,981.01	89.27		38.47	188.14	37.53	34.08	110.87	7,764.09	9,325.19		356.90	222.79
9	B9	Upper East Branch at Shamona Creek	6,400.00	10.00	1,729.10	63.80		81.82	135.26	54.66	77.52	78.82	2,352.61	1,610.48		54.27	162.49
10	B10	Lower East Branch	13,395.20	20.93	3,179.00	330.98		231.58	244.94	306.31	107.80	318.12	4,941.21	3,365.48	33.57	126.07	207.07
11	B11	March Creek	12,787.20	19.98	2,192.85	3.12		9.16	252.80	74.90	15.29	43.96	5,023.02	4,424.86	15.38	576.86	151.73
12	B12	Beaver Creek	11,577.60	18.09	2,654.41	292.59		41.88	299.30	340.96	163.90	246.97	3,462.63	3,748.02		23.62	301.14
13	B13	Valley Creek	13,216.00	20.65	3,543.54	420.61		187.04	600.22	459.68	134.30	263.99	4,407.00	2,500.75	234.14	56.73	407.35
14	B14	Main Stem above Chadds Ford	15,718.40	24.56	4,476.06	229.63		9.30	221.23	165.04	165.40	279.99	4,598.48	5,024.21		149.51	315.12
15	B15	Pocopson Creek	5,849.60	9.14	1,479.08	26.93			12.96	9.45	51.25	69.73	1,299.20	2,848.14		16.22	38.27
16	B16	Main Stem below Chadds Ford	16,934.40	26.46	3,280.97	101.36	46.77	21.07	155.29	733.33	243.58	3,467.73	5,788.60	2,939.19		189.64	22.44
17	B17	Main Stem through Wilmington	3,878.40	6.06	221.10	777.50	111.89	747.80	303.84	270.18	241.11	504.34	537.56	60.90		98.34	
		Subtotal =	207,814.40	324.71	36,140.98	2,879.51	158.66	1,867.30	3,850.76	2,933.54	1,697.61	5,685.06	66,072.23	81,481.17	389.54	2,188.67	3,021.38
		Red Clay Creek Watershed															
18	R1	West Branch	11,180.80	17.47	1,547.00	38.35		130.80	55.00	131.20	114.20	29.19	2,389.00	6,540.00		45.93	164.60
19	R2	East Branch	6,374.40	9.96	1,237.00	24.50			54.78	148.30	52.68	244.30	1,428.00	3,018.00	16.11	25.14	126.90
20	R3	Burroughs Run	4,550.40	7.11	1,216.00				16.80	5.51		87.20	1,141.00	1,934.00		7.29	144.20
21	R4	Main Stem above Wooddale	7,968.00	12.45	3,097.00		13.13	25.74	22.27	52.01	37.56	498.10	2,791.00	1,169.00		265.80	
22	R5	Main Stem below Wooddale	4,550.40	7.11	2,519.00	96.70	30.81	20.69	171.06	350.62	157.54	515.79	584.80	55.58		47.02	
		Subtotal =	34,624.00	54.10	9,616.00	159.55	43.94	177.23	319.91	687.64	361.98	1,374.58	8,333.80	12,716.58	16.11	391.18	435.70
		White Clay Creek Watershed															
23	W1	West Branch	6,515.20	10.18	1,141.18				86.47	28.36	36.68	0.19	1,707.74	3,377.05		5.07	132.72
24	W2	Middle Branch	10,156.80	15.87	1,663.61				94.68	51.42	4.65	7.03	2,523.23	5,672.91		57.71	82.58
25	W3	East Branch above Avondale	11,993.60	18.74	764.38			5.70	242.63	139.10	20.50	153.96	2,683.74	7,820.49		49.81	115.82
26	W4	East Branch below Avondale	9,171.20	14.33	1,943.33			60.00	10.67	70.13	40.30	53.64	2,938.83	3,835.84	2.80	102.67	110.01
27	W5	Mill Creek	8,268.80	12.92	4,089.55	360.01	92.47		256.04	364.44	395.17	846.90	975.75	909.84		0.10	
28	W6	Pike Creek	4,249.60	6.64	2,364.73	319.79			101.75	67.24	103.41	388.78	548.76	358.04			
29	W7	Middle Run	2,489.60	3.89	517.13	0.71	3.14		56.60	11.98	34.58	81.29	1,049.46	736.44			
30	W8	Main Stem above Newark	6,476.80	10.12	979.07	131.59	100.28	8.00	37.44	10.63	78.17	305.94	3,508.93	1,272.62		49.22	
31	W9	Main Stem above Delaware Park	5,792.00	9.05	1,938.16	458.55	70.85	159.55	426.99	628.92	376.55	547.86	603.24	526.81		52.04	
32	W10	Main Stem at Churchmans Marsh	3,526.40	5.51	464.92	94.19	193.92	13.34	390.05	653.47	206.62	571.19	461.32	148.93		328.91	
		Subtotal =	68,640.00	107.25	15,866.05	1,364.84	460.66	159.55	1,703.31	2,025.67	1,296.63	2,956.76	17,001.01	24,658.96	2.80	645.54	441.14
		Christina River Watershed															
33	C1	East/West Branch above Coochs Bridge	13,478.40	21.06	3,805.59	310.00	23.95	436.41	675.34	645.74	132.96	888.79	2,772.58	3,780.45		11.72	
34	C2	Muddy Run	5,542.40	8.66	1,072.23	147.14		91.47	206.99	106.19	69.31	588.44	2,127.79	855.98		61.40	217.09
35	C3	Belltown Run	4,115.20	6.43	1,208.53	401.39			137.57	222.43	21.70	330.83	1,408.37	350.95		34.72	
36	C4	Little Mill Creek	5,907.20	9.23	2,175.44	688.39	203.93	309.18	277.19	351.09	282.30	694.62	843.03	49.29		35.63	
37	C5	Main Stem above Smalley's Pond	6,828.80	10.67	1,912.96	596.82	76.31		415.11	701.75	60.02	477.16	1,847.11	707.01		37.16	321.97
38	C6	Main Stem Lower Tidal	14,048.00	21.95	2,146.65	975.49		1,191.18	2,272.43	1,487.56	250.63	2,821.25	1,759.18	253.12		571.32	
		Subtotal =	49,920.00	78.00	12,321.40	3,119.23	304.19	2,028.24	3,984.63	3,514.76	816.92	5,801.09	10,758.06	5,996.80	0.00	751.95	539.06
		Totals =	360,998.40	564.06	73,944.43	7,523.13	967.45	4,232.33	9,858.61	9,161.62	4,173.14	15,817.49	102,165.09	124,853.51	408.45	3,977.35	4,437.28

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TABLE 2 - 9
PERCENT OF LAND USE BY SUBWATERSHED
Christina Basin Water Quality Management Strategy

No.	ID	Subwatershed	Drainage Area		LAND USE (% OF D.A.)													
			(Acres)	(Sq. Mi.)	Single Family Residential	Multi - Family Residential	Office	Industrial	Transport/ Utility	Commercial	Institutional	Public/Private Open Space	Wooded	Agricultural	Mining	Water	Vacant/Barren	% Urban/ Suburban
		Brandywine Creek Watershed																
1	B1	Upper West Branch at Honeybrook	11,833.60	18.49	6.78	0.25	0.00	0.00	0.53	0.76	0.46	0.04	20.31	67.75	0.32	0.19	2.64	8.77
2	B2	Upper West Branch at Hibernia	16,665.60	26.04	20.08	0.73	0.00	0.06	1.52	0.34	0.43	1.09	42.40	34.55	0.00	1.13	1.12	23.16
3	B3	Lower West Branch at Coatesville	11,289.60	17.64	18.46	2.83	0.00	4.33	3.74	1.34	1.04	0.62	36.29	28.25	0.54	0.56	2.01	31.73
4	B4	Lower West Branch at Embreeville	10,937.60	17.09	7.29	0.00	0.00	0.00	1.52	0.08	1.12	0.00	35.35	51.95	0.00	1.20	1.52	10.01
5	B5	Buck Run	17,619.20	27.53	10.28	0.15	0.00	0.00	1.47	0.73	0.36	0.12	27.27	58.08	0.04	0.47	1.02	12.99
6	B6	Doe Run	14,444.80	22.57	2.78	0.00	0.00	0.00	1.17	0.24	0.10	0.05	17.20	77.67	0.00	0.32	0.49	4.30
7	B7	Broad Creek	4,121.60	6.44	28.13	1.16	0.00	0.00	2.52	0.32	0.47	0.40	28.52	37.24	0.00	0.13	1.18	32.60
8	B8	Upper East Branch at Struble Creek	21,145.60	33.04	14.10	0.42	0.00	0.18	0.89	0.18	0.16	0.52	36.72	44.10	0.00	1.69	1.05	15.93
9	B9	Upper East Branch at Shamona Creek	6,400.00	10.00	27.02	1.00	0.00	1.28	2.11	0.85	1.21	1.23	36.76	25.16	0.00	0.85	2.54	33.47
10	B10	Lower East Branch	13,395.20	20.93	23.73	2.47	0.00	1.73	1.83	2.29	0.80	2.37	36.89	25.12	0.25	0.94	1.55	32.85
11	B11	March Creek	12,787.20	19.98	17.15	0.02	0.00	0.07	1.98	0.59	0.12	0.34	39.28	34.60	0.12	4.51	1.19	19.93
12	B12	Beaver Creek	11,577.60	18.09	22.93	2.53	0.00	0.36	2.59	2.95	1.42	2.13	29.91	32.37	0.00	0.20	2.60	32.76
13	B13	Valley Creek	13,216.00	20.65	26.81	3.18	0.00	1.42	4.54	3.48	1.02	2.00	33.35	18.92	1.77	0.43	3.08	40.45
14	B14	Main Stem above Chadds Ford	15,718.40	24.56	28.48	1.46	0.00	0.06	1.41	1.05	1.05	1.78	29.26	31.96	0.00	0.95	2.00	33.51
15	B15	Pocopson Creek	5,849.60	9.14	25.29	0.46	0.00	0.00	0.22	0.16	0.88	1.19	22.21	48.69	0.00	0.28	0.65	27.00
16	B16	Main Stem below Chadds Ford	16,934.40	26.46	19.37	0.60	0.28	0.12	0.92	4.33	1.44	20.48	34.18	17.36	0.00	1.12	0.13	27.06
17	B17	Main Stem through Wilmington	3,878.40	6.06	5.70	20.05	2.88	19.28	7.83	6.97	6.22	13.00	13.86	1.57	0.00	2.54	0.00	68.93
		Subtotal =	207,814.40	324.71	17.39	1.39	0.08	0.90	1.85	1.41	0.82	2.74	31.79	39.21	0.19	1.05	1.45	23.83
		Red Clay Creek Watershed																
18	R1	West Branch	11,180.80	17.47	13.84	0.34	0.00	1.17	0.49	1.17	1.02	0.26	21.37	58.49	0.00	0.41	1.47	18.04
19	R2	East Branch	6,374.40	9.96	19.41	0.38	0.00	0.00	0.86	2.33	0.83	3.83	22.40	47.35	0.25	0.39	1.99	23.80
20	R3	Burroughs Run	4,550.40	7.11	26.72	0.00	0.00	0.00	0.37	0.12	0.00	1.92	25.07	42.50	0.00	0.16	3.17	27.21
21	R4	Main Stem above Wooddale	7,968.00	12.45	38.87	0.00	0.16	0.32	0.28	0.65	0.47	6.25	35.03	14.67	0.00	3.34	0.00	40.76
22	R5	Main Stem below Wooddale	4,550.40	7.11	55.36	2.13	0.68	0.45	3.76	7.71	3.46	11.34	12.85	1.22	0.00	1.03	0.00	73.54
		Subtotal =	34,624.00	54.10	27.77	0.46	0.13	0.51	0.92	1.99	1.05	3.97	24.07	36.73	0.05	1.13	1.26	32.83
		White Clay Creek Watershed																
23	W1	West Branch	6,515.20	10.18	17.52	0.00	0.00	0.00	1.33	0.44	0.56	0.00	26.21	51.83	0.00	0.08	2.04	19.84
24	W2	Middle Branch	10,156.80	15.87	16.38	0.00	0.00	0.00	0.93	0.51	0.05	0.07	24.84	55.85	0.00	0.57	0.81	17.86
25	W3	East Branch above Avondale	11,993.60	18.74	6.37	0.00	0.00	0.05	2.02	1.16	0.17	1.28	22.38	65.21	0.00	0.42	0.97	9.77
26	W4	East Branch below Avondale	9,171.20	14.33	21.19	0.00	0.00	0.65	0.12	0.76	0.44	0.58	32.04	41.82	0.03	1.12	1.20	23.16
27	W5	Mill Creek	8,268.80	12.92	49.46	4.35	1.12	0.00	3.10	4.41	4.78	10.24	11.80	11.00	0.00	0.00	0.00	67.21
28	W6	Pike Creek	4,249.60	6.64	55.65	7.53	0.00	0.00	2.39	1.58	2.43	9.15	12.91	8.43	0.00	0.00	0.00	69.58
29	W7	Middle Run	2,489.60	3.89	20.77	0.03	0.13	0.00	2.27	0.48	1.39	3.27	42.15	29.58	0.00	0.00	0.00	25.07
30	W8	Main Stem above Newark	6,476.80	10.12	15.12	2.03	1.55	0.12	0.58	0.16	1.21	4.72	54.18	19.65	0.00	0.76	0.00	20.77
31	W9	Main Stem above Delaware Park	5,792.00	9.05	33.46	7.92	1.22	2.75	7.37	10.86	6.50	9.46	10.41	9.10	0.00	0.90	0.00	70.09
32	W10	Main Stem at Churchmans Marsh	3,526.40	5.51	13.18	2.67	5.50	0.38	11.06	18.53	5.86	16.20	13.08	4.22	0.00	9.33	0.00	57.18
		Subtotal =	68,640.00	107.25	23.11	1.99	0.67	0.23	2.48	2.95	1.89	4.31	24.77	35.93	0.00	0.94	0.64	33.33
		Christina River Watershed																
33	C1	East/West Branch above Coochs Bridg	13,478.40	21.06	28.23	2.30	0.18	3.24	5.01	4.79	0.99	6.59	20.57	28.05	0.00	0.09	0.00	44.74
34	C2	Muddy Run	5,542.40	8.66	19.35	2.65	0.00	1.65	3.73	1.92	1.25	10.62	38.39	15.44	0.00	1.11	3.92	30.55
35	C3	Belltown Run	4,115.20	6.43	29.37	9.75	0.00	0.00	3.34	5.41	0.53	8.04	34.22	8.53	0.00	0.84	0.00	48.40
36	C4	Little Mill Creek	5,907.20	9.23	36.83	11.65	3.45	5.23	4.69	5.94	4.78	11.76	14.27	0.83	0.00	0.60	0.00	72.58
37	C5	Main Stem above Smalley's Pond	6,828.80	10.67	28.01	8.74	1.12	0.00	6.08	10.28	0.88	6.99	27.05	10.35	0.00	0.54	4.71	55.10
38	C6	Main Stem Lower Tidal	14,048.00	21.95	15.28	6.94	0.00	8.48	16.18	10.59	1.78	20.08	12.52	1.80	0.00	4.07	0.00	59.25
		Subtotal =	49,920.00	78.00	24.68	6.25	0.61	4.06	7.98	7.04	1.64	11.62	21.55	12.01	0.00	1.51	1.08	52.26
		Totals =	360,998.40	564.06	92.96	10.08	1.48	5.71	13.24	13.39	5.39	22.63	102.18	123.87	0.24	4.63	4.43	

05/21/98

2.8 ZONING

The zoning map provides a delineation of potential or future land uses at the planned full-build out condition (Map 6). Certain classifications such as floodplain, agricultural, and low density residential zoning districts can provide protection to water resources. The zoning map provides an opportunity to review the land use plan and zoning ordinances of the governments in the watershed and identify possible modifications that may be more protective of water quality. Zoning is also needed to calculate estimates of pollutant loads for future land use scenarios. The following zoning classifications were mapped in the watershed:

- Low Density Residential (> 2 acres per dwelling)
- Medium Density Residential (1/4 acre to 2 acres per dwelling)
- High Density Residential, Townhouse, Apartment (less than 1/4 acre per dwelling)
- Commercial
- Industrial
- Office
- Institutional
- Agricultural
- Floodplain
- Diversified
- Historic

Data Sources

New Castle County Zoning - Digitized from New Castle County Department of Planning Maps dated 1995.

Chester County, Lancaster County, Delaware County Zoning - Digitized by the West Chester University in 1996 from various Township, Borough, and Municipal paper base maps.

Cecil County Zoning - Digitized from zoning maps of the Cecil County Office of Planning and Zoning, dated 1995.

2.9 FLOODPLAINS/WETLANDS/GROUNDWATER PROTECTION AREAS

This water resources map delineates the sensitive floodplains, wetlands, and ground water protection areas in the Christina Basin (Map 7). Floodplains and wetlands provide water quality benefits by cleansing runoff entering waterways. Federal, state, and local regulations exist that protect these floodplains and wetlands from development. Ground water protection areas are defined and regulated by the Delaware River Basin Commission in the Southeastern Pennsylvania Ground Water Protected Area and by the New Castle County Water Resource Protection Area program. New Castle County employs a Water Resource Protection Area (WRPA) ordinance as an overlay zoning district designed to protect the quality and quantity of ground and surface water supplies. WRPA's include the Recharge, Surface Water, and Cockeysville districts.

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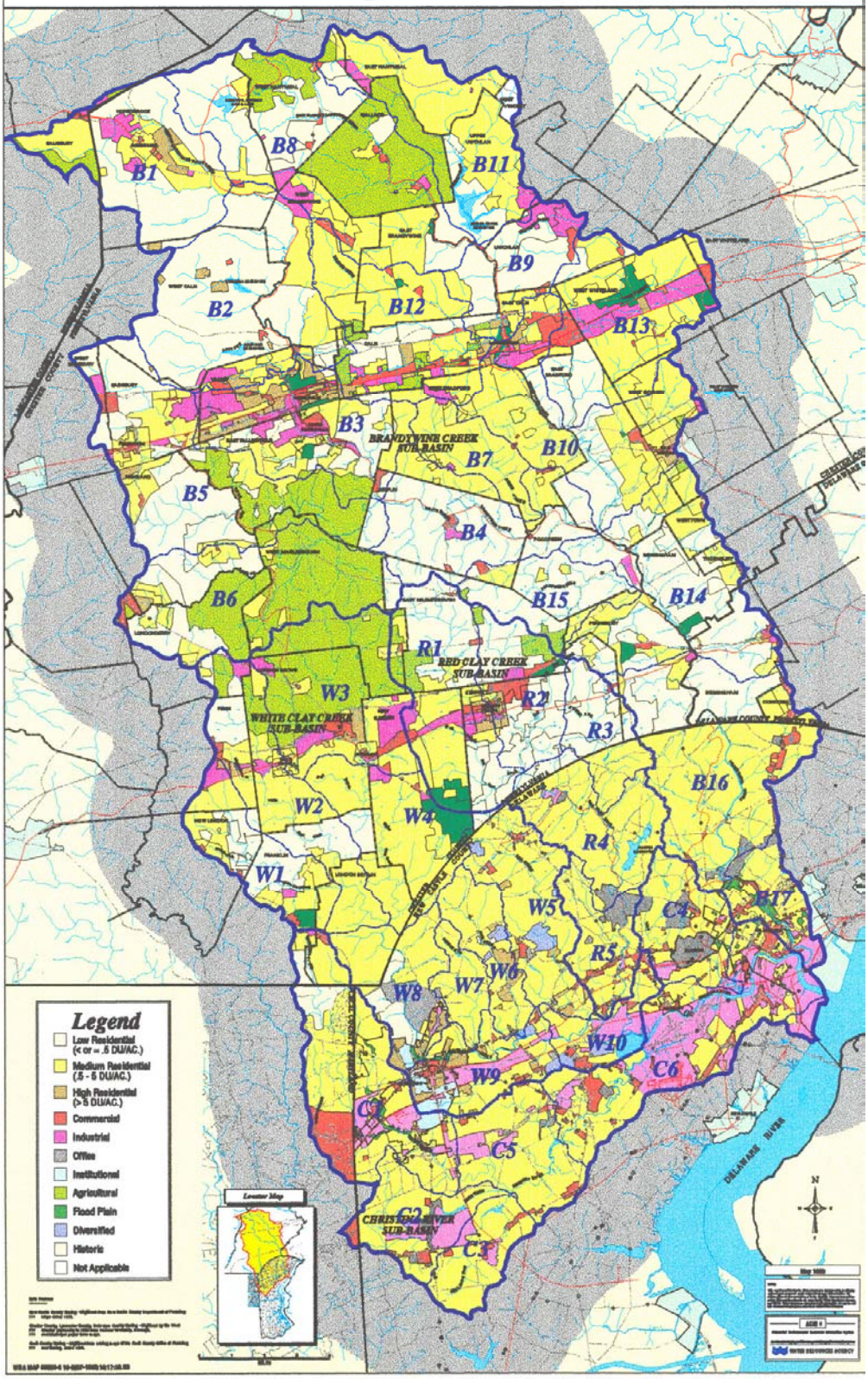
Christina Basin Water Quality Management Strategy
Map 6: Zoning



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Christina Basin Water Quality Management Strategy
Map 7: Water Resource Areas

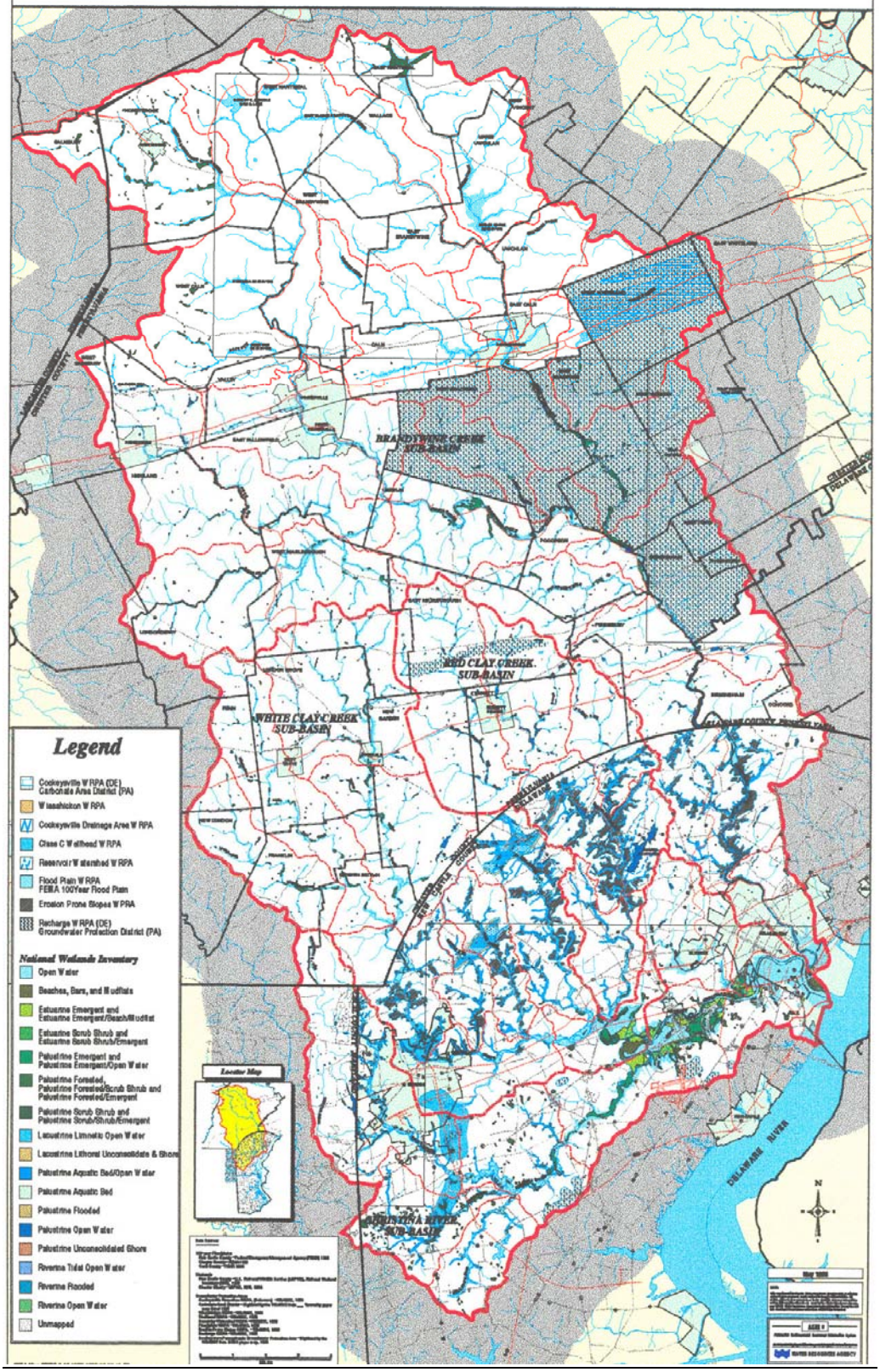

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TABLE 2 - 10
WATER RESOURCE PROTECTION AREA (WRPA) CRITERIA IN NEW CASTLE COUNTY
Christina Basin Water Quality Management Strategy

Land Use	Cockeysville Formation WRPA	Recharge WRPA	Wellhead WRPA	Reservoir Watershed WRPA
Residential/ Single Family	Min. 2 acres per dwelling	Min. 2 acres per dwelling on septic system; Min. 1 acre per dwelling on sewer	Min. 2 acres per dwelling	Min. 5 acres per dwelling
Residential/ Townhouse, Semi - detached	Max. 10% Impervious	Conditional Use	Conditional Use	Max. 5 acre clearing
Nonresidential, Commercial, Office, Institutional, Industrial	Max. 20% Impervious	Max. 20% Impervious	Max. 20% Impervious	Max. 10% Impervious

Note: Criteria compiled from the Water Resource Protection Area Ordinance administered by the New Castle County Department of Planning, with technical assistance from the Water Resources Agency for New Castle County.
Adopted by New Castle County Council in January, 1994.

05/21/98

Developments in the WRPA's are restricted through maximum percent impervious cover and minimum lot density controls. Table 2-10 summarizes the New Castle County WRPA program.

Data Sources

100-year Floodplains

New Castle County - Federal Emergency Management Agency (FEMA) 1995
Chester County - FEMA 1996
Cecil County - FEMA 1994

Wetlands

New Castle County - U.S. Fish and Wildlife Service (USFWS), National Wetland Inventory (NWI), 1995
Chester County - USFWS, NWI, 1994

Groundwater Protection Areas

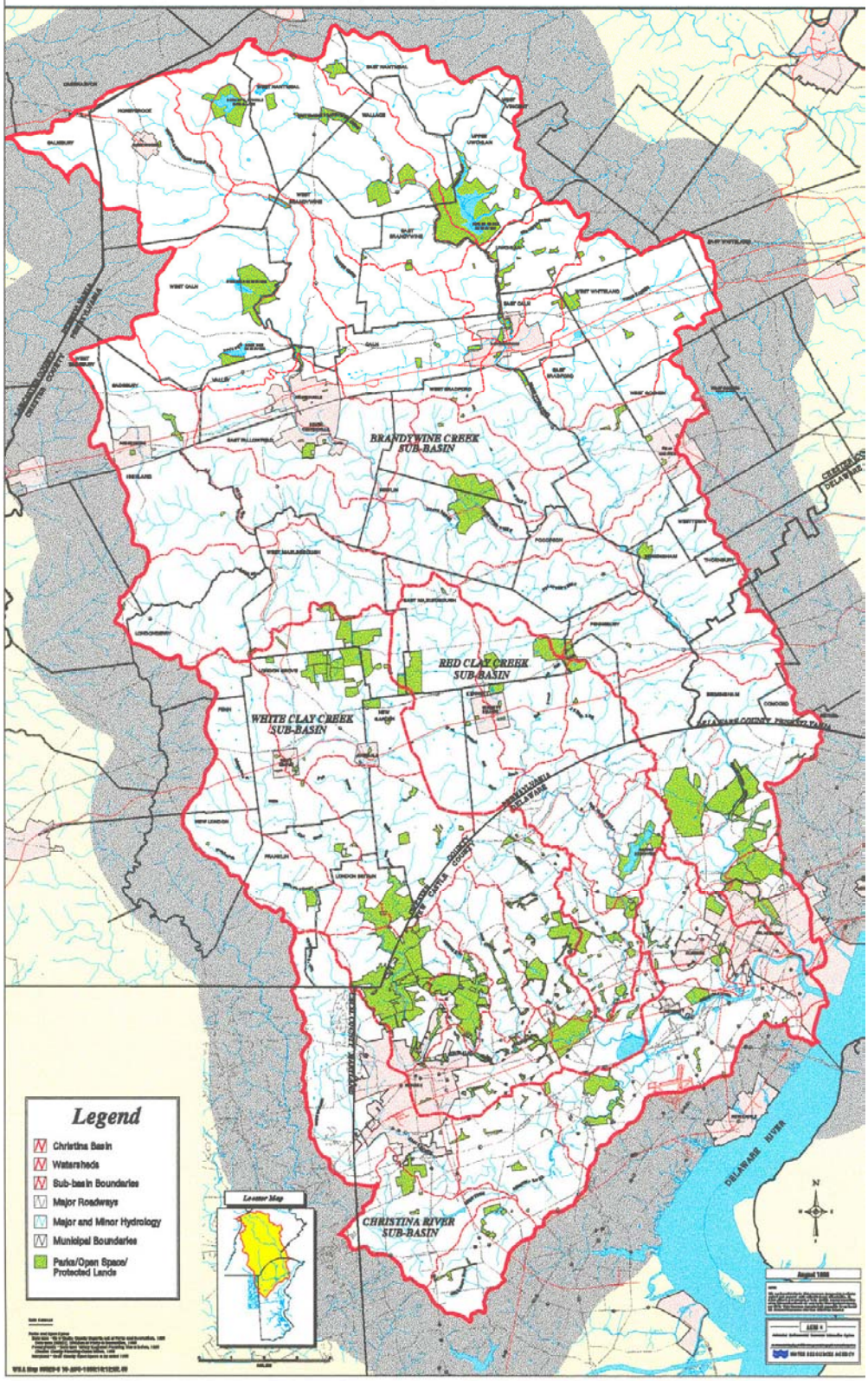
Cockeysville Formation WRPA, (Delaware) - WRANCC, 1993
Carbonate Rock District - Digitized by the WRANCC from a West Whiteland Township paper map dated 1995
Ground Water Protection District – Kigitized by the WRANCC in 1995 from an East Marlborough Township paper map.
Wissahickon WRPA - WRANCC, 1993
Wellhead WRPA - WRANCC, 1993
Reservoir Watershed WRPA - WRANCC, 1993
Floodplain WRPA - WRANCC, 1993
Erosion Prone Slope WRPA - WRANCC, 1993
Recharge WRPA - WRANCC, 1993
Southeastern Pennsylvania Groundwater Protection Area - Digitized by the WRANCC from DRBC paper map, 1995

2.10 PARKS/OPEN SPACE/PROTECTED LANDS

Map 8 delineates known public and privately owned parks, open space and protected lands in the Christina Basin. Under proper management, protected lands can provide water quality benefits by restricting development and providing natural filtration of stormwater runoff. Protected lands are effective BMP's. Open space can contribute to improved water quality of both ground and surface waters. Open lands that preserve vulnerable recharge areas, riparian corridors, and headwater tributaries are particularly helpful. These lands must be properly managed to ensure unintended uses do not occur. This inventory of protected lands should be updated to include recently acquired lands under the Chester County Open Space program. . Protected lands on the map include:

Christina Basin Water Quality Management Strategy

Map 8: Parks/Open Space/Protected Lands



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- Private Agricultural/Conservation Easements
- Privately Owned Open Space
- Municipal Parks and Open Space
- County Parks and Open Space
- Federal Open Space
- Conservation Areas

Data Sources

Parks and Open Space

Delaware - New Castle County Department of Parks and Recreation, 1995
Delaware DNREC, Division of Parks & Recreation, 1995
Pennsylvania - Delaware Valley Regional Planning Commission, 1995
Chester County Planning Commission, 1995
Maryland - Cecil County Open Space map dated 1995

2.11 HAZARDOUS WASTE SITES

Hazardous waste sites can be potential contaminant sources of pollutants in stormwater runoff. Map 9 provides locations of hazardous waste sites which could affect streams and water supplies. Contaminants from hazardous waste sites can negatively impact ground water quality which could also eventually affect surface water. Contaminant sources and risks to water supplies can be estimated by overlaying the watershed, floodplain, and surface water intake/well layers on the same map. Contaminated sites which are upgradient of public surface water intakes and community wells can be prioritized for containment and remediation actions. Most of the hazardous waste sites are situated in the lower Christina Basin along the urban corridor between Newark and Wilmington. The USEPA has remedial investigations underway for the superfund sites in the Pennsylvania portion of the Basin. The hazardous waste map should be updated to include leaking underground storage tank data which will be obtained from the PAPEP. The following potential contaminant sources are delineated on the map:

- State Superfund Sites
- Federal Superfund Sites
- RCRA Sites
- Hazardous Waste Sites
- Landfills (Active/Inactive)
- Leaking Underground Storage Tanks
- Gravel Pits and Borrow Pits

Data Sources

Potential Contaminant Sources

New Castle County, Delaware – DNREC Division of Air and Waste Management, 1998
Chester County – Chester County Planning Commission, 1996
Pennsylvania DEP, 1997

2.12 EXISTING BMP'S

Map 10 identifies the location of existing stormwater and agricultural BMP's which have been installed in the Delaware and Pennsylvania portions of the Christina Basin. Stormwater BMP's in New Castle County are the detention ponds installed since 1991 in accordance with the Delaware Sediment and Stormwater regulations. The Stormwater BMP's in Pennsylvania are the NPDES soil erosion permits issued to new developments since 1990. Agriculture BMP's in both states are conservation measures installed in accordance with programs administered by the USDA-Natural Resource Conservation Service, New Castle Conservation District, and Chester County Conservation District. Data for Stormwater BMP's are not yet available and will be compiled during a future phase of the project. The BMP map should be periodically updated to include new detention ponds and soil erosion permits.

Data Sources

Stormwater BMP's

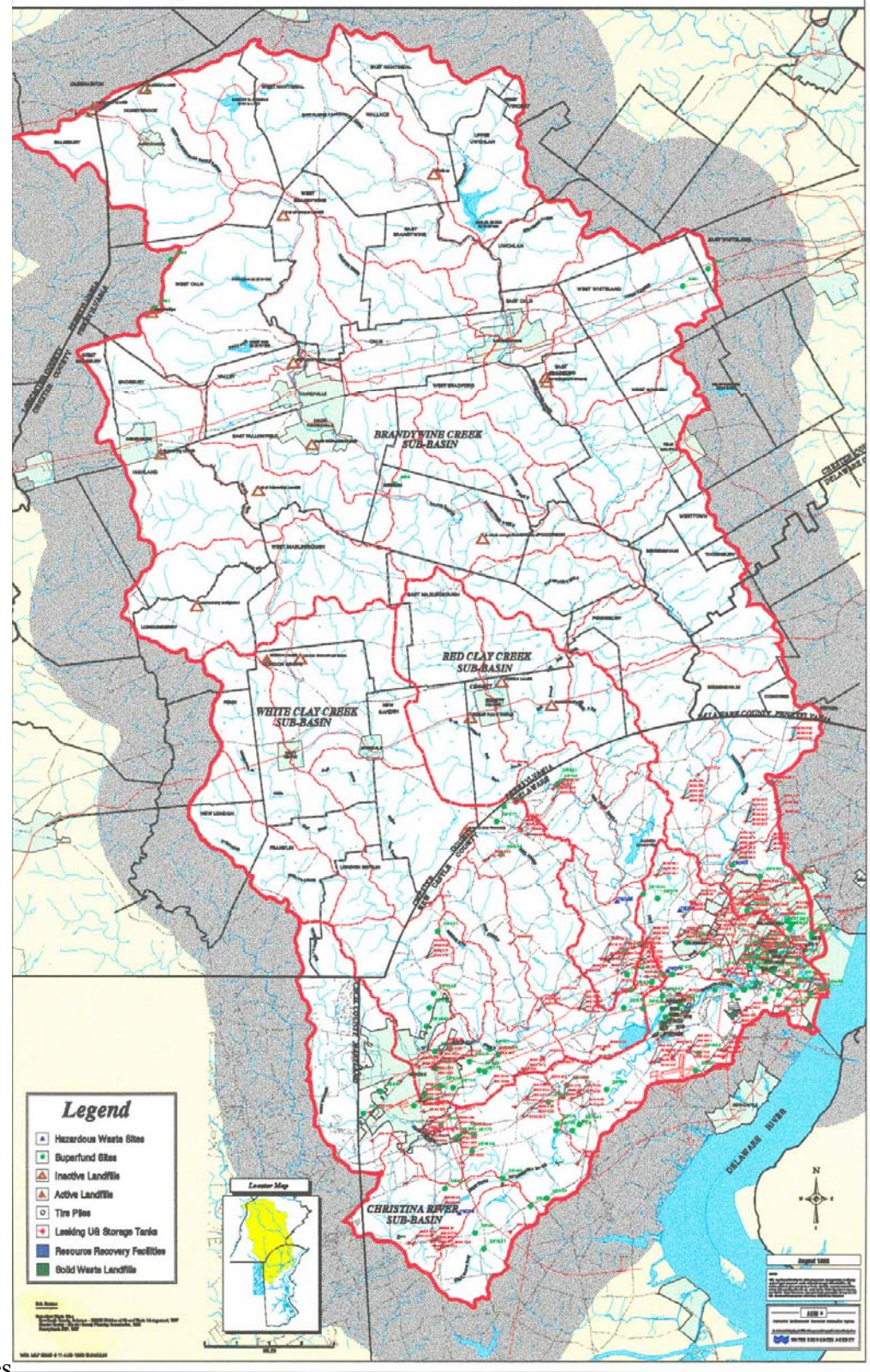
New Castle County Department of Public Works, 1996
Chester County Conservation District, 1998

Agricultural BMP's

Delaware DNREC - Division of Soil and Water Conservation, 1996, New Castle Conservation District and USDA – Natural Resources Conservation Service, 1998
Chester County Conservation District, 1998

Christina Basin Water Quality Management Strategy

Map 9: Potential Contaminant Sources



Sources

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Christina Basin Water Quality ManagementStrategy

Map 10: Best Management Practices (BMPs)

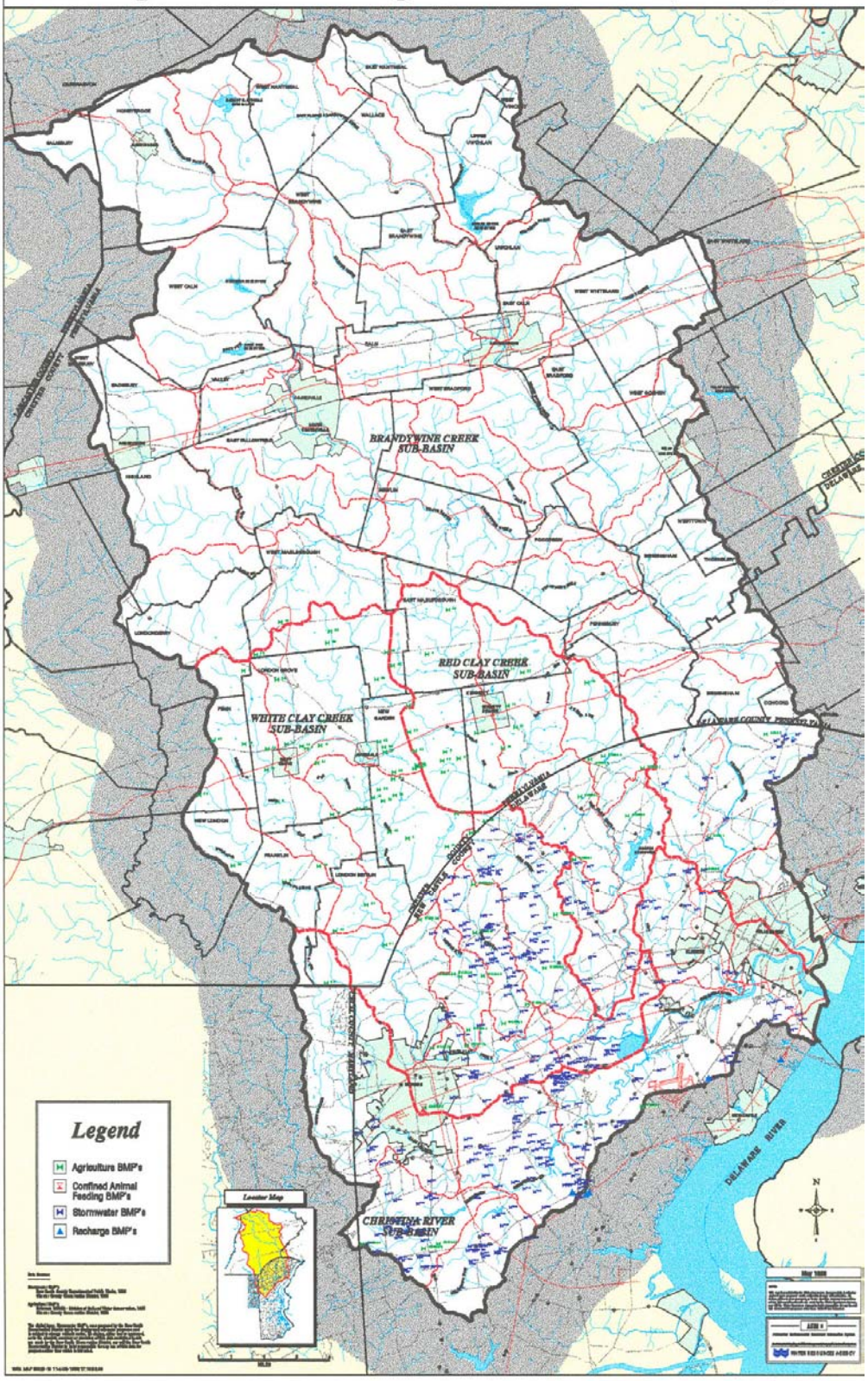

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TABLE 2 - 11
POPULATION DENSITY
Christina Basin Water Quality Management Strategy

Brandywine Creek Watershed		Area (sq. mi.)	Population	Pop. Density (p./sq. mi.)
B1. Upper West Branch at Honneybrook		18.49	1,000.00	To be included
B2. Upper West Branch at Hibernia		26.04	1,000.00	at a later date.
B3. Lower West Branch at Coatesville		17.64	1,000.00	?
B4. Lower West Branch at Embreeville		17.09	1,000.00	?
B5. Buck Run		27.53	1,000.00	?
B6. Doe Run		22.57	1,000.00	?
B7. Broad Creek		6.44	1,000.00	?
B8. Upper East Branch at Struble Lake		33.04	1,000.00	?
B9. Upper East Branch at Shamona Creek		10.00	1,000.00	?
B10. Lower East Branch		20.93	1,000.00	?
B11. Marsh Creek		19.98	1,000.00	?
B12. Beaver Creek		18.09	1,000.00	?
B13. Valley Creek		20.65	1,000.00	?
B14. Main Stem above Chadds Ford		24.56	1,000.00	?
B15. Pocopson Creek		9.14	1,000.00	?
B16. Main Stem below Chadds Ford		26.46	1,000.00	?
B17. Main Stem through Wilmington		6.06	1,000.00	?
	Subtotal	**324.71**	**17,000.00**	**?**
Red Clay Creek Watershed				
R1. West Branch		17.47	1,000.00	?
R2. East Branch		9.96	1,000.00	?
R3. Burris Run		7.11	1,000.00	?
R4. Main Stem above Wooddale		12.45	1,000.00	?
R5. Main Stem below Wooddale		7.11	1,000.00	?
	Subtotal	**54.10**	**5,000.00**	**?**
White Clay Creek Watershed				
W1. West Branch		10.18	1,000.00	?
W2. Middle Branch		15.87	1,000.00	?
W3. East Branch above Avondale		18.74	1,000.00	?
W4. East Branch below Avondale		14.33	1,000.00	?
W5. Mill Creek		12.92	1,000.00	?
W6. Pike Creek		6.64	1,000.00	?
W7. Middle Run		3.89	1,000.00	?
W8. Main Stem above Newark		10.12	1,000.00	?
W9. Main Stem above Delaware Park		9.05	1,000.00	?
W10. Main Stem at Churchmans Marsh		5.51	1,000.00	?
	Subtotal	**107.25**	**10,000.00**	**?**
Christina River Watershed				
C1. East / West Branch above Coochs Bridge		21.06	1,000.00	?
C2. Muddy Run		8.66	1,000.00	?
C3. Belltown Run		6.43	1,000.00	?
C4. Little Mill Creek		9.23	1,000.00	?
C5. Main Stem above Smalley's Pond		10.67	1,000.00	?
C6. Main Stem Lower Tidal		21.95	1,000.00	?
	Subtotal	**78.00**	**6,000.00**	**?**
	Total	**564.06**	**38,000.00**	**?**

Total Christina River Basin **564.06 sq. mi.**

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CHAPTER 3. WATER QUALITY ASSESSMENT

3.1 EXISTING DATA

Clean water in the Christina Basin is necessary to sustain the diverse ecological, aesthetic and recreational resources, and a safe and adequate water supply source for residents and businesses of New Castle County and Chester County. The waters of the basin provide uses for water supply, aquatic and terrestrial wildlife, recreation, and wildlife (Table 3-1). Ground and surface waters provide drinking water for over 0.5 million people in the basin.

This chapter summarizes an assessment of existing water quality data for the Christina Basin. Staff from the Delaware DNREC and PADEP reviewed existing water quality data and references to compile this assessment. The assessment summarizes water quality conditions on a watershed or stream-by-stream basis. The assessment catalogues existing water quality data and identifies data "gaps" which will require further water quality monitoring. The following references were reviewed for this water quality assessment:

Delaware Water Quality References

1. Stream Use Survey, Water Resources Agency for New Castle County, 1979.

2. Delaware Nonpoint Source Management Plan, Delaware Department of Natural Resources and Environmental Control, Division of Soil and Water Conservation, Revised May 1, 1995.

3. 1994 Delaware Watershed Assessment Report, State of Delaware Department of Natural Resources and Environmental Control, Division of Water Resources, Watershed Assessment Branch, April 1, 1994.

4. 1996 Watershed Assessment Report (305b), Christina River Priority Sub-basin, April 1, 1996.

5. State of Delaware Fish Consumption Advisory Areas for the Christina Basin, Delaware DNREC, issued April 1996.

6. Preliminary Assessment of Water Quality Data for the Christina River Basin, Delaware Department of Natural Resources and Environmental Control, Division of Water Resources, Watershed Assessment Branch, 1996.

7. Habitat Quality of Delaware Non-Tidal Streams, Appendix D, Delaware Section 305(b) Report, Delaware Department of Natural Resources and Environmental Control, March 31, 1994.

8. Tentative Determination for State of Delaware 1998 Clean Water Act Section 303(d) List of Waters Needing TMDL's, Delaware Department of Natural Resources and Environmental Control, March 2, 1998.

Pennsylvania Water Quality References

1. Synoptic Report on Toxic Substances Contamination of Red Clay Creek, Roy W. Weston, Inc., August 1988.

2. Red - White Clay Creeks, Final Watershed Protection Plan and Environmental Assessment, USDA Natural Resources Conservation Service and USDA - Forest Service, October 1996.

3. Assessment of Nonpoint Source Pollution for the Brandywine Creek Watershed, Chester County Conservation District and Brandywine Valley Association, November 1991.

4. Watershed Degraded by Nonpoint Source Pollution, Pennsylvania DEP, Bureau of Land and Water Conservation, August, 1994.

5. Preliminary Study of the Brandywine Creek Sub-basin Final Report, Science Applications International Corporation for the U.S. Environmental Protection Agency, Region III, September 30, 1993.

6. Water Resources Use and Service in Chester County, Phase 2 of the Chester County Water Resources Plan, Chester County Planning Commission, 1996.

7. Statewide GIS/Census Data Assessment of Nitrogen Loading from Septic Systems in Pennsylvania, Pennsylvania State University, 1995.

8. Pennsylvania Section 303(d) Report, Pennsylvania Department of Environmental Protection, 1996.

9. Limnological Studies of the Major Streams in Chester County, Pennsylvania, United States Geological Survey with the Chester County Water Resources Authority, June 1977.

10. Land Use, Organochlorine Compound Concentrations and Trends in Benthic - Invertebrate Communities in Selected Stream Reaches in Chester County, Pennsylvania, United States Geological Survey with the Chester County Water Resources Authority, 1995.

11. Groundwater Quality and its Relation to Hydrogeology, Land Use, and Surface Water Quality in the Red Clay Creek Basin, Piedmont Physiographic Province, Pennsylvania and Delaware, U.S. Geological Survey with the Red Clay Valley Association and the Chester County Water Resources Authority, 1996.

12. Land Scapes - Managing Change in Chester County, Chester County Board of Commissioners, July 12, 1996.

13. Various water resources and biological data collected under USGS/Chester County Cooperative Program (1969 - Present).

14. Christina Basin Point Source Monitoring Program, Pennsylvania Department of

Environmental Protection, 1998.

Tables 3-2 and 3-3 provide a synthesis of existing water quality conditions in the Christina Basin. Table 3-4 provides a summary of water quality on a subwatershed by subwatershed basis. The results of the water quality assessment are depicted on Map 11 - Stream Water Quality and Map 12 - Fish Consumption Advisories.

The water quality assessment indicates a data "gap" should be filled during the upcoming Phase III of the Christina Basin Strategy. The WRANCC would prepare a GIS watershed map and associated data which summarizes the biological health and habitat quality of streams based on existing macroinvertebrate and bioassessment data. The biological stream health map would integrate data for the Pennsylvania and Delaware portions of the Christina Basin utilizing work from the DNREC Watershed Assessment Branch Non-Tidal Habitat Assessment, the PADEP Unassessed Streams Inventory, and the USGS-CCWRA Benthic Invertebrate sampling programs for Chester County Streams.

3.2 DELAWARE WATER QUALITY

The following summary of water quality conditions in the Delaware portion of the Christina Basin is excerpted from the Preliminary Assessment of Water Quality Data for the Christina Basin, Delaware DNREC, 1996. The waters in the Delaware portion of the Christina Basin are stressed by high levels of bacteria, zinc, iron, phosphorus, nitrate nitrogen and declining levels of dissolved oxygen:

- Bacteria - Concentrations frequently exceeded the limit of 100 colonies per 100mL throughout the basin which violated DNREC primary recreation standards for swimming.

- Zinc - Criteria frequently exceeded along the Red Clay Creek and the lower reaches of the White Clay Creek. Zinc levels have not changed over the last 10 years signaling little improvement in water quality.

- Iron - Criteria violated along the lower and middle reaches of the Christina River. Water quality for iron in lower Christina River remains in poor condition.

- Phosphorus - Excessive concentrations support concern for nutrient enrichment in Brandywine, Christina, and Red Clay Creeks.

- Dissolved Oxygen - Concentrations have decreased steadily over 20-25 years although dissolved oxygen levels do not frequently violate criteria. This could become a problem.

- Nitrate-Nitrogen - Increasing trend from 1970 to 1990.

- Total Suspended Sediment - High levels a concern, yet decreasing trends over the years indicate stream water quality improvement.

- PCB's, Dioxin - High levels in water column and fish tissue led to total fish consumption advisory in tidal areas of Christina Basin.

3.3 PENNSYLVANIA WATER QUALITY

The water quality assessment indicates that certain parameters in the Pennsylvania portion of the Christina Basin are causing stressed stream conditions. These pollutants or stressors include:

- Copper, Lead, Mercury - Water quality standards were exceeded along the Brandywine Creek at Downingtown and Coatesville (SAIC, 1993). However, the Point Source Monitoring Program underway for almost the last 3 years has not found elevated Mercury levels near point sources (PADEP, 1998).

- Dissolved Oxygen - Low DO levels are a concern during dry years although levels have increased over the last several years and now rarely drop below 5 mg/l (SAIC, 1993).

- Total Suspended Sediment - Increased levels have been observed and are attributed to new construction, increased urban/suburban land uses, and continued agricultural activity (USDA-NRCS, 1996; CCPC, 1995).

- Nitrate-Nitrogen - High nitrate levels exist along 31 stream miles of White Clay and Red Clay Creeks (PADEP, 1995).

- Phosphorus - The upper Brandywine watershed above Downingtown and Chadds Ford is water quality limited for this nutrient (CCCD/BVA, 1991).

- Bacteria - Fecal coliform levels have generally declined but are still above water contact criteria for recreational uses (Appendix A, CCWRA/USGS, 1998).

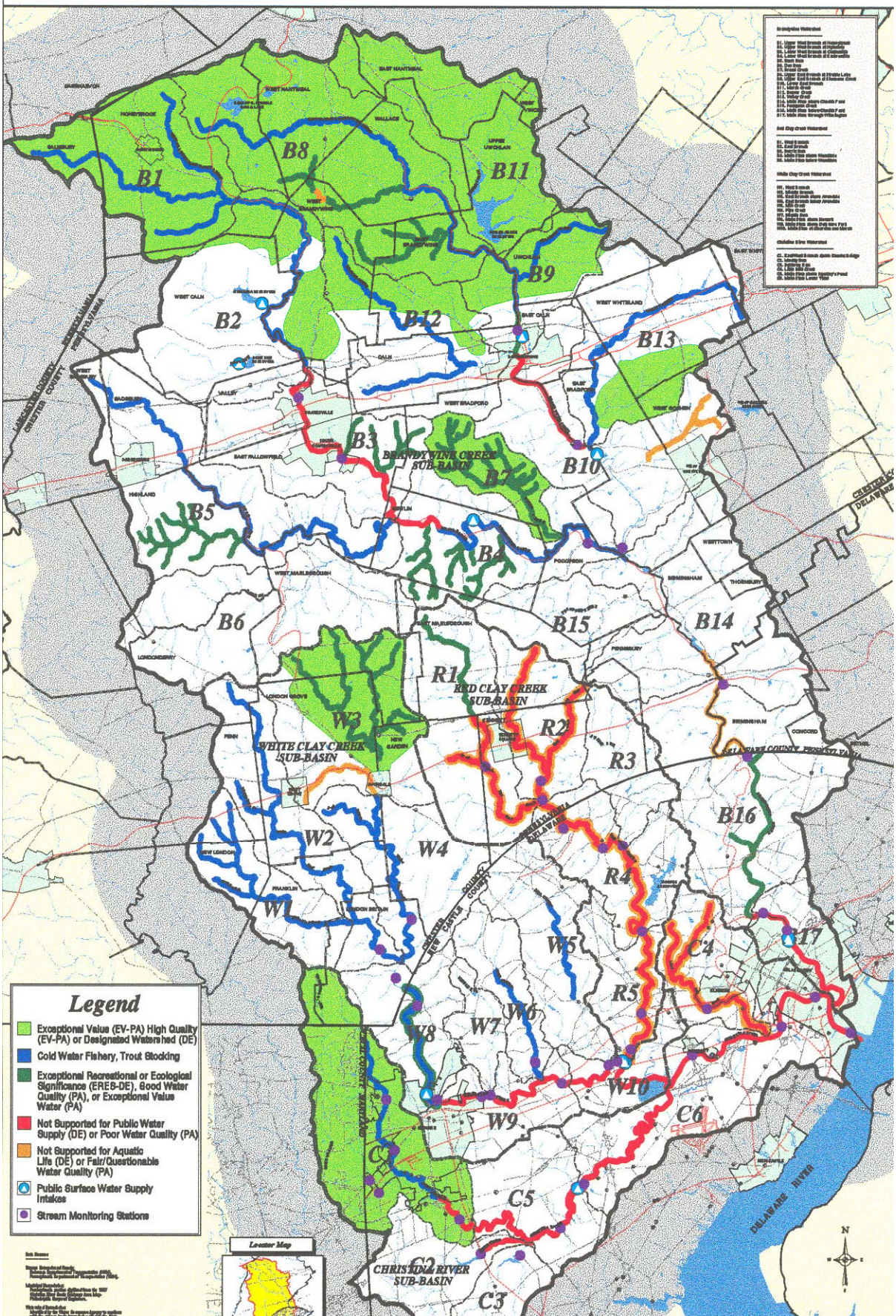
- Zinc - Elevated levels are reported along the Red Clay Creek which exceed toxic thresholds (Weston, 1988). Point Source Monitoring indicates zinc levels in the Red Clay Creek have declined (PADEP, 1998).

- PCB's, Chlordane, Pesticides - High levels of these organic contaminants have resulted in fish consumption advisories along the entire Red Clay Creek through Kennett Square and along the Brandywine Creek at Chadds Ford and below Coatesville (CCPC, 1995).

- Biological Diversity - Has improved significantly throughout the watershed since the 1970's and continued to improve in recent years. Rainfall extremes between the drought of 1995 and the excess rainfall of 1996 may have contributed to declines in observed diversity in 1996 (Appendix B, CCWRA/USGS, 1998).

Christina Basin Water Quality Management Strategy

Map 11: Stream Water Quality



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Christina Basin Water Quality Management Strategy

Map 12: Fish Consumption Advisories

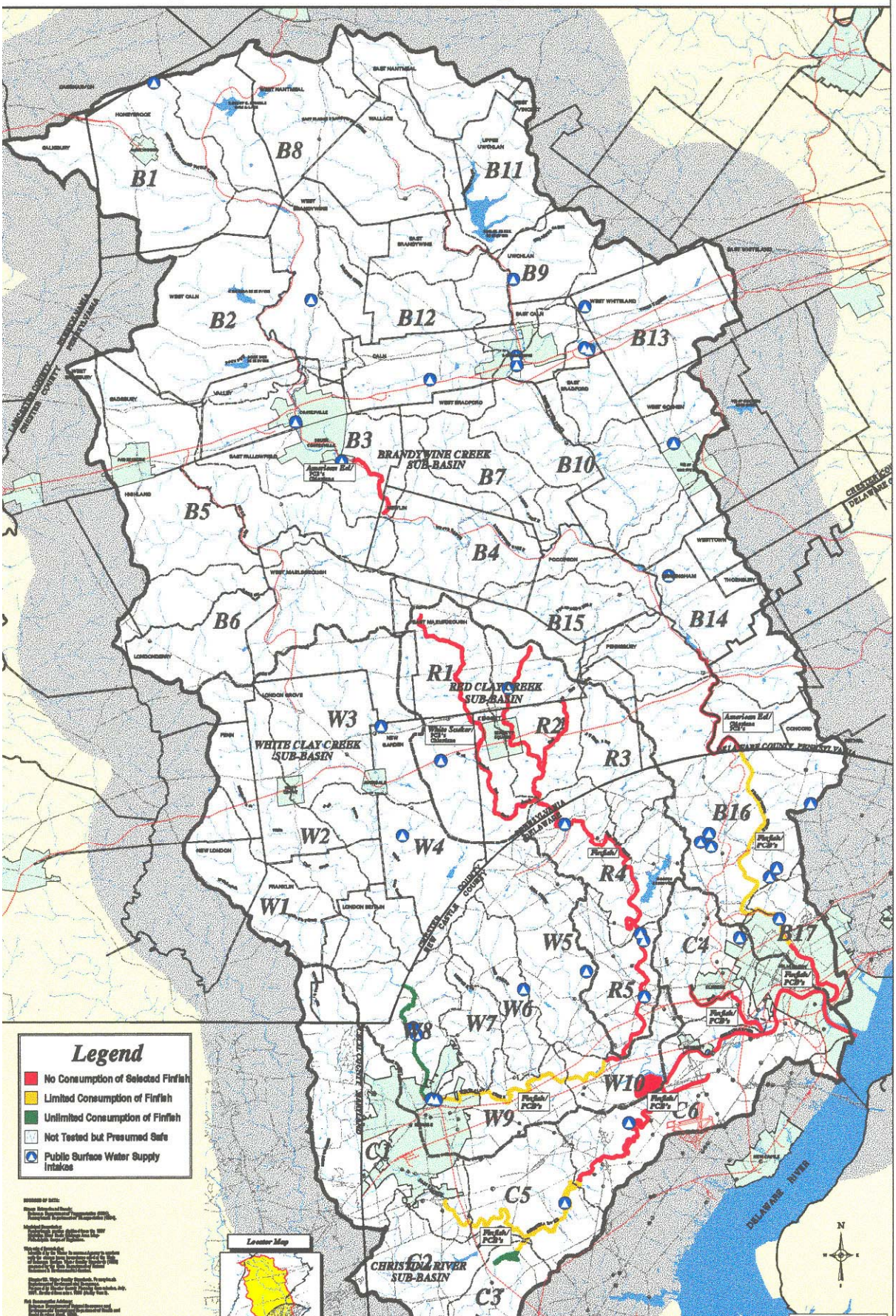

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TABLE 3 - 1
CITED SURFACE WATER USES
Christina Basin Water Quality Management Strategy

WATERSHED	DELAWARE	PENNSYLVANIA	MARYLAND
Brandywine Creek	* Water Supply City of Wilmington * Scenic Vistas, Aesthetic Values * Swimming and Tubing * Hiking, Nature Study * Photography, Birdwatching * Andranomous Fish, Herring, Shad, Striped Bass * Canoeing, Fishing * Put and Take Trout, Wilson Run/ Beaver Run	*Water Supply -Industrial -Live-stock -Potable -Wildlife *Irrigation *Boating *Swimming *Trout Fishery *Warmwater Fishery *Aesthetics *Hiking Trails *Nature Viewing *Tourism *Biodiversity	
Red Clay Creek	* Highly Scenic Stream * Recreational Stream * Sightseeing * Water Supply for United Water Delaware * Hiking Trails at Delaware Nature Society * 187 Bird Species	* Tourism * Aesthetics * Fish and Wildlife * Stream Biodiversity * Irrigation * Livestock Water Supplies * Domestic Water Supplies	
White Clay Creek	* Birdwatching, Bicycling * Public Water Supply for United Water Delaware and City of Newark * 177 Species of Bird Life * University of Delaware Open Space * Put and Take Trout Fishery * 2700 Trout Stamps issued annually	*Water Supply -Industrial -Live-stock -Potable -Wildlife *Irrigation *Boating *Swimming *Trout Fishery *Warmwater Fishery *Aesthetics *Hiking Trails *Nature Viewing *Tourism *Biodiversity	
Christina River	* Water Supply for United Water Delaware * Swimming/Fishing at Becks Pond * Put and Take Trout upstream from Smalleys Pond * Andranomous Fish, Alewife, Herring, Shad * Navigable for Ocean Going Vessels at mouth of river	*Irrigation *Warmwater Fishery *Aesthetics *Hiking Trails *Nature Viewing *Tourism *Biodiversity	*Warmwater Fishery *Fairhill Natural Resources Area *Bicycling *Equestrian *Nature Study *Tourism *Biodiversity

TABLE 3 - 2
WATER QUALITY SUMMARY FOR DELAWARE STREAMS
Christina Basin Water Quality Management Strategy

Watershed	Stream Use Survey WRANCC, 1979	DE NPS Assessment Report DNREC, 1995	DE Watershed Assessment Report DNREC (305b), 1994	DE Watershed Assessment Report DNREC (305b), 1996	DE Fish Consumption Advisory DNREC, 1996	Prel. Assessment - Christina Basin DNREC, 1996
Brandywine Creek - DE	* Lower reaches at Wilmington impacted by combined sewer overflow and stormwater runoff * Point source and NPS pollutants are a concern	* Not supported for primary recreation (swimming) due to high bacteria and nitrate levels	* 39% of nontidal streams in Piedmont have poor habitat conditions * High bacteria levels in 43% of samples * Excessive nitrogen and phosphorus levels	* Moderate nitrogen levels * High phosphorus levels * Low chlorophyll-a levels * Bacteria levels do not support primary recreation (swimming) * 82% of stream miles do not support aquatic life due to poor physical habitat	* Limited consumption of finfish, Nontidal Brandywine Creek due to levels of PCB's * No consumption of finfish, tidal segment	* Decreasing trend in dissolved oxygen levels * Downward trend in TSS levels * Bacteria criteria exceeded frequently * Phosphorus levels decreasing but criteria exceeded frequently * Nitrate levels increasing
Red Clay Creek - DE	* Stream bank erosion problems * Sewage fungus * Zinc chloride contamination from NVF * Severe organic pollution * No fish in stream below Yorklyn	* Fish consumption advisory for PCB's, Dioxin, Pesticides * Not supported for primary recreation (swimming) * Not supported for aquatic life * Threatened for public water supply use	* Bacterial contamination * Toxics a concern * Fish consumption advisory due to PCB's, dioxins, and pesticides * High nitrogen and phosphorus levels	* High nitrogen and phosphorus levels * High bacteria levels * Fish consumption advisory due to high levels of PCB's and dioxin * Zinc sediment contamination	* No consumption of finfish due to elevated levels of PCB's, entire reach	* Decreasing trend in DO levels * Downward trend in TSS levels * Bacteria standard exceeded frequently * Phosphorus levels decreasing, but criteria exceeded frequently * Nitrate levels increasing * Zinc criteria exceeded greatly and levels stable
White Clay Creek - DE	* Sedimentation and erosion problems in Mill Creek/Pike Creek watersheds * Point sources below Newark contribute to problem * Contamination by bacteria and zinc below Newark * Runoff from mushroom farms	* Not supported for primary recreation (swimming) due to bacteria	* Moderate bacteria levels * High nitrogen and phosphorus levels	* Moderate nitrogen concentrations * High bacteria levels	* No consumption of finfish, tidal segment * Limited consumption of finfish, Papermill Rd, Newark to Stanton (head of tide)	* Decreasing trend in DO levels * Downward trend in TSS levels * Bacteria standard exceeded frequently * Nitrate levels increasing * Zinc criteria exceeded between Newark and Stanton; Zinc levels not changing
Christina River - DE	* Stream banks in tidal area impinged by development industries * Point source, NPS, and CSO problems * Good quality above Newark * Tidal quality related to Delaware River	* Not supported for primary recreation due to toxics, bacteria, and phosphorus * Threatened for aquatic life in Little Mill Creek * Non designated for water supply in tidal areas	* High bacteria levels in 25 - 50% of samples * High nitrogen and phosphorus * Heavy metal levels above Smalleys Pond * Toxics a concern in tidal area	* Moderate phosphorus levels * High bacteria levels do not support primary recreation (swimming) * Sediment and turbidity problems	* No consumption of finfish; tidal Christina and Little Mill Creek * Limited consumption of finfish; nontidal segment - Newark to Smalleys Pond	* Decreasing trend in DO levels * Downward trend in TSS levels, although TSS twice as high in Lower Christina than Upper Christina * Bacteria standard exceeded frequently * Phosphorus levels decreasing but criteria exceeded frequently * Nitrate levels increasing * Iron criteria exceeded frequently

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TABLE 3 - 4
WATER QUALITY ASSESSMENT
Christina Basin Water Quality Management Strategy

Subwatershed	Subwatershed Area (sq. mi.)	Christina River Basin Designated Uses*								
		Water Supply	Irrigation	Water Sports/ Aesthetics	Boating/ Fishing	Wildlife	Trout Stocking/ Cold Water/ Migratory Fish/ Warm Water Fishery	High Quality/ Exceptional Value Water	Fish Consumption Advisory	Pollutants of Concern
PENNSYLVANIA										
Brandywine Creek Watershed										
B1. Upper West Branch at Honeybrook	18.49	F	F	F	F	F	TSF,MF	HQ		TSS, N, P
B2. Upper West Branch at Hibernia	26.94	F	F	F	F	F	TSF, MF	HQ (partial)		TSS, N, P
B3. Lower West Branch at Coatesville	17.64	F	F	P	P	P	MF	EV (partial)	NC	TSS, N, P, PCB
B4. Lower West Branch at Embreeville	17.09	F	F	F	P	P	MF	EV (partial)	NC	TSS, N
B5. Buck Run	27.53	F	F	F	F	F	TSF, MF			TSS, N, P
B6. Doe Run	22.57	F	F	F	F	F	WWF			
B7. Broad Run	6.44	F	F	F	F	F	CWF, MF	EV		
B8. Upper East Branch at Struble Lake	33.04	F	F	F	F	F	TSF, MF	HQ		
B9. Upper East Branch at Shamona Creek	10.00	F	F	F	F	F	TSF, MF	HQ		
B10. Lower East Branch	20.93	F	F	P	P	P	MF		NC	PCB, Metals
B11. Marsh Creek	19.98	F	F	F	F	F	WWF	HQ		
B12. Beaver Creek	18.09	F	F	F	F	F	TSF, MF	HQ		
B13. Valley Creek	20.65	F	F	F	F	F	LWF, MF	HQ (partial)		
B14. Main Stem above Chadds Ford	24.56	F	F	F	P	P	MF		NC	PCB, Chlordane
B15. Pocopson Creek	9.14	F	F	F	F	F	TSF			
B16. Main Stem below Chadds Ford	9.54	F	F	F	P	P	MF		NC	PCB, Chlordane
Red Clay Creek Watershed										
R1. West Branch	17.47	F	F	P	P	P	TSF		NC	PCB, Chlordane
R2. East Branch	9.96	F	F	P	P	P	TSF		NC	PCB, Zinc, Nutrients
R3. Burris Run	4.53	F	F				CWF			TSS
White Clay Creek Watershed										
W1. West Branch	10.18	F	F	F	F	F	CWF			N, TSS
W2. Middle Branch	15.87	F	F	F	F	F	TSF, MF			N, TSS
W3. East Branch above Avondale	18.74	F	F	F	F	F	CWF	EV		N, TSS
W4. East Branch below Avondale	14.33	F	F	P	F	F	CWF			N, TSS
Christina River Watershed										
C1. East / West Branch	2.40	F	F	F	F	F	WWF			N, TSS
MARYLAND										
Christina River Watershed										
C1. East / West Branch	8.13	F	F	F	F	F	WWF			N, TSS

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Designated Uses = Supported (F), Partially Supported (P), Non-Supported (N), Trout Stocking (TSF), Cold Water Fishery (CWF), Migratory Fish (MF), Warm Water Fishery (WWF), High Quality (HQ), Exceptional Value (EV), or Designated Watershed (DW).

Fish Consumption Advisory: No Consumption (NC), Limited Consumption (LC)

Pollutants of Concern: Total Suspended Sediment (TSS), Nitrate-Nitrogen (N), Phosphates (P), Polychlorinated Biphenyl (PCB)

TABLE 3 - 4 (con't)
WATER QUALITY ASSESSMENT
Christina Basin Water Quality Management Strategy

Subwatershed	Subwatershed Area (sq. mi.)	Designated Uses: Primary (Swimming)	Secondary (Fishing/Boating)	Aquatic Life	ERES	Public Water Supply	Cold Water Fishery	Fish Consumption Advisories	Pollutants of Concern
DELAWARE									
Brandywine Creek Watershed									
B16. Main Stem below Chadds Ford	16.92	N	F	P	F	F	Wilson Run/Beaver Run (F)	LC	Bact, N, Toxics
B17. Main Stem through Wilmington	6.06	N	F	P		N		NC	Bact, N, Toxics
Red Clay Creek Watershed									
R3. Burroughs Run	2.58	N	F	P		F			
R4. Main Stem above Wooddale	11.43	N	F	N		F	P	NC	PCB, Zinc
R5. Main Stem below Wooddale	7.11	N	F	N		F	P	NC	PCB, Zinc
White Clay Creek Watershed									
W5. Mill Creek	12.56	N	F	N		F	F		Bact
W6. Pike Creek	6.64	N	F	P		F	F		Bact
W7. Middle Run	3.89	N	F	P		F			Bact
W8. Main Stem above Newark	7.41	N	F	N	N	F	P		Bact
W9. Main Stem above Delaware Park	9.05	N	F	N		F		LC	Bact
W10. Main Stem at Churchmans Marsh	5.51	N	F	N				NC	PCB, Toxics
Christina River Watershed									
C1. East / West Branch above Coochs Bridge	10.53	N	F	N	DW	F	F		Bact
C2. Muddy Run	8.37	N	F	N		F			Bact
C3. Belltown Run	6.43	N	F	F		F			Bact
C4. Little Mill Creek	9.23	N	F	N		F		NC	Bact
C5. Main Stem above Smalley's Pond	10.67	N	F	N		F		LC	Toxics, P, Bact
C6. Main Stem Lower Tidal	21.95	N	F	F				NC	Toxics, P, Bact, PCB's

05/21/98

Designated Uses = Supported (F), Partially Supported (P), Non-Supported (N), Trout Stocking (TSF), Cold Water Fishery (CWF), Migratory Fish (MF), Warm Water Fishery (WWF), High Quality (HQ), Exceptional Value (EV), or Designated Watershed (DW).
Fish Consumption Advisory: No Consumption (NC), Limited Consumption (LC)
Pollants of concern: Total Suspended Sediments (TSS), Nitrate-Nitrogen (N), Phosphates (P), Polychlorinated Biphenyl (PCB)

3.4 STORMWATER ORDINANCE INVENTORY

Local governments in the Christina Basin administer stormwater and floodplain management programs through a series of ordinances, codes, and regulations. These ordinances are designed generally to protect the quality and quantity of ground and surface water during the land development and subdivision process. The purpose of this section is to inventory the existing stormwater ordinances and identify modifications that may further protect water quality.

Implementation of a unified water quality management program for the Christina River Basin is complex due to the type and multitude of governments in the watershed. In Pennsylvania, local government includes 53 different municipalities. The Delaware portion of the basin includes unincorporated New Castle County and four municipalities. In Maryland, the local government includes unincorporated Cecil County. Over sixty government jurisdictions are situated in the Christina Basin - each with its own individual approach and varying stormwater ordinance, code, regulation or management program. A key to successful watershed management will be to implement a unified set of stormwater management principles which provide consistent protection to water quality in each of the three states in the Christina Basin.

The stormwater ordinance inventory was conducted by contacting each local government and obtaining particular zoning, subdivision, and/or drainage codes. The Pennsylvania Department of Environmental Protection (PADEP) conducted the inventory for the local governments in the Commonwealth. The Water Resources Agency for New Castle County reviewed the ordinances for the Delaware and Maryland portions of the Christina Basin. The stormwater inventory includes a review of specific criteria such as design frequency (i.e. 100-year storm), soil erosion and sediment control, stream buffer provisions and others. Tables 3-5 and 3-6 and Figure 3-1 summarize the results of the stormwater ordinance inventory for the Christina Basin.

Type of Ordinance

The inventory indicates all of the stormwater regulations for the local boroughs, township, and municipalities are nested in the zoning code or subdivision and stormwater ordinance. Administratively, the zoning ordinance provides a suitable level of enforcement since the landuse classification (i.e. zoning) is tied directly to protection of stormwater quantity and quality. New Castle County and municipal governments in Delaware utilize the DNREC Stormwater and Sediment Regulations with some modification in the zoning code. At the local level in Pennsylvania, the stormwater codes are nested in subdivision ordinances. In Pennsylvania, Act 167 for Stormwater Management provides criteria for local stormwater ordinances.

Funding Source

Ideally, there should be a dedicated source of funding to administer a stormwater management program. Typical funding sources include development permit fees, user fees such as a stormwater utility, or development impact fees. The New Castle County Drainage Code and local municipalities in Pennsylvania administer a set of permit fees to fund stormwater ordinance review programs.

Designated Watersheds

East Bradford Township, the Pennsylvania DEP, Delaware DNREC and New Castle County have established criteria for designated or priority watersheds which provides greater visibility for funding programs.

Runoff Models

Nearly 80 percent of the local governments require the USDA-SCS TR-55 and/or TR-20 computer models to estimate stormwater runoff for developments. The SCS computer models are nationally recognized as the minimum standard practice for estimates of stormwater rate and volume for design of drainage facilities.

Design Frequencies

Over 60 percent of the stormwater ordinances require design for frequencies up to and including the 100-year storm event. Three townships in Pennsylvania require design for the 25-year event. Cecil County, Maryland requires design for the 10-year event. Over a third of the local ordinances do not require a minimum design frequency. Optimal stormwater ordinances require design for the 1-, 2-, 10-, 25-, 50- and 100-year storm events.

Percent Impervious Cover

Percent impervious cover is a key environment indicator which can be used to protect stream water quality. Studies indicate the health of resources in a watershed can be negatively impacted when the percent of impervious cover exceeds 10 to 15 percent (See Chapter 4). A majority of the stormwater ordinances set a threshold of maximum percent impervious during subdivision development. The percent impervious cover permitted by the stormwater ordinances ranges widely from 15 to 80 percent. New Castle County administers a Water Resource Protection Area program which establishes maximum impervious cover limits of 20 percent for residential land uses and 50 percent for commercial or manufacturing uses.

Post-Development Discharge

Half of the stormwater ordinances require the post-development discharge rate for new construction to be less than pre-development runoff. The balance of the ordinances include no such provisions. None of the ordinances control the volume of stormwater runoff.

Water Quality/Quantity

The stormwater ordinances of Newark and New Castle County require design of drainage facilities for quality as well as quantity purposes. The local ordinances in Pennsylvania require design for stormwater quantity purposes only.

Contractor Certification

The stormwater ordinance in New Castle County and several Pennsylvania municipalities require certification of consultants and contractors for the design and construction of stormwater facilities. Workshops and seminars provide valuable education towards progressive stormwater management techniques.

Soil Erosion and Sediment Control

High sediment loads can negatively affect habitat and water quality. Therefore, enforcement of Soil Erosion and Sediment Controls are needed to minimize the flow of sediment into streams

from new development. All of the ordinances include provisions for Soil Erosion and Sediment Control as part of the zoning code.

Forest Preservation

Trees and forests provide numerous water quality and quantity benefits. These woodlands minimize the quantity of stormwater runoff and improve the quality of runoff due to filtering and uptake processes. Over 60 percent of the municipalities have ordinances that include criteria to protect woodlands from development.

Riparian Buffer Areas

Riparian buffer areas generally protect the various physical, hydrological, and ecological functions of floodplains, wetlands, and other sensitive water resources. Close to 95 percent of the stormwater ordinances include stream buffer criteria which at a minimum include no development in the 100-year floodplain (flood hazard district). The most progressive ordinances establish buffers which extend 25 to 100 feet from the boundary of the flood hazard district.

Steep Slopes

Steep slopes are sensitive areas which generally have soils with low infiltration and high runoff characteristics. These slopes are susceptible to soil erosion during new construction. Most of the stormwater ordinances protect steep slopes ranging from 15 to 25 percent.

Cluster Development

Clustering of developments can minimize impacts to sensitive land and water resources. Clustering can minimize impacts to water quality by reducing percent impervious cover and protecting natural resources such as wetlands, floodplains, forests, and open space. Eighty percent of the municipal ordinances encourage clustered land development.

Stormwater Techniques

Most of the ordinances issue permits for specific stormwater techniques to reduce the quantity and improve the quality of stormwater runoff. Progressive stormwater management techniques include filter strips, bioswales, infiltration swales and detention basins. The New Castle County Drainage Code requires applicants to meet a "Runoff Reduction Hierarchy" for all subdivision site designs. Implementation of this hierarchy has the potential to minimize runoff volume and reduce pollutant loads to receiving streams. The following "Runoff Reduction Hierarchy" is part of the New Castle County stormwater ordinance:

- Minimize impervious surfaces to reduce runoff volume and decrease stormwater pollutant loads.

- Preserve natural drainage swales, overland flow paths, and depressional storage areas.

- Convey runoff via vegetated filter swales.

- Infiltrate runoff on-site where soils have favorable permeability.
- Detain excess stormwater in detention facilities.

Wetland Protection

Wetlands provide valuable water quality, infiltration, flow reduction, and sediment control benefits. Wetland protection is generally practiced at the State and Federal level although some local municipalities also have wetland protection provisions. The U.S. Army Corps of Engineers and Pennsylvania DEP regulates the fill of wetlands through the joint wetlands program of Section 404 of the Clean Water Act. The Delaware DNREC protects wetlands through the Subaqueous Lands Act. At the local level, 80% of the municipalities in the Christina Basin include provisions for wetland protection.

TABLE 3 - 5
STORMWATER ORDINANCE INVENTORY FOR PENNSYLVANIA
Christina Basin Water Quality Management Strategy

JURISDICTION Chester County Boroughs*	Name and Date of Ordinance Code	Funding Source	Designated Watershed	Runoff Model (TR20)	Design Frequency	% Impervious	Post-Develop. Discharge (cfs/acre) Quantity	Water Quantity	Water Quality
Avondale	Subd. & Land Dvlp. 2/8/77. Zoning Ord. of 1963, as amended.	N	N	N	UNK.	40-60	N	N	N
Coatesville*(CITY)	Subd. & Land Dvlp., 3/13/95. Zoning Ord. , May 1995 Update.	N	N	N	UNK.	45-70	N	N	N
Downingtown	Subd. & Land Dvlp., 10/25/90. Zoning Ord. 7/14/93 Update.	N	N	N	100yrs.	30-80	N	N	N
Honeybrook	Subd. & Land Dvlp., 6/14/95 Zoning Ord. of 1974, as amended.	N	N	TR 55	UNK.	20-50	Y	N	N
Kennett Square	Subd. & Land Dvlp.,9/11/78, as amen., Zoning Ord., 2/20/94.	N	N	N	UNK.	60	N	N	N
Modena	Subd. & Land Dvlp., March 1982 Zoning Ord. 1981.	N	N	No incr.	UNK.	35-75	N	N	N
Parkesburg	Subd. & Land Dvlp., 12/3/79 Zoning Ord., 12/27/77, as amended.	N	N	No incr.	UNK.	30-70	N	N	N
South Coatesville	Subd. & Land Dvlp., Sept. 1982 Zoning Ord., May 1982.	N	N	No incr.	UNK.	20-70	N	N	N
West Chester	Subd. & Land Dvlp., 8/28/91 Zoning Ord., 10/6/88, as amended.	N	N	TR 55	UNK.	45-55	Y	N	N
West Grove	Subd. & Land Dvlp., 1974, as amended Zoning Ord., 1971, as amended.	N	N	PaDot/SCS	UNK.	75	N	N	N
Chester County Townships									
Birmingham	Subdiv. & Land Dvlp., 1/18/79, as ame. Zoning Ord., 3/2/78, as amended.	N	N	SCS	25yrs.	10-30	N	N	N
Caln	Subdiv. & Land Dvlp., 1978, as amend. Zoning Ord., 5/12/92.	N	N	SCS	25yrs.	45-70	N	N	N
East Bradford	Subdiv. & Land Dvlp., 1978, as amend. 4/9/96.	N	Y(BSC)	No increase 24 hr. 100 yr.	100yrs.	15-50e	N	N	N
East Brandywine	Subdiv. & Land Dvlp., 6/18/85, as am. Zoning Ord., 4/27/89, as amended.	N	N	TR55	100yrs.	10-75	Y	N	N
East Fallowfield	Subdiv. & Land Dvlp., 1982, as amend. Zoning Ord., 10/3/90, as amended.	N	N	TR55	100yrs.	15-60	Y	N	N
East Marlborough	Stormwater Mngm. Ord., 1981. Zoning Ord., 1992. Subd. Dvlp., 1992.	N	N	TR55	100yrs.	10-65 FN(2)	Y	N	N
Franklin	Subdiv. & Land Dvlp., 1984, as amend. Zoning Ord., 1996	N	N	No incr.	100yrs.	15-65	N	N	N
Highland	Subdiv. & Land Dvlp., 1979, as amend. Zoning Ord., 1979, as amended.	N	N	SCS	UNK.	20-70	N	N	N
Honeybrook	Subdiv. & Land Dvlp., 6/14/95. Zoning Ord., 1979, as amended.	N	N	TR 55	100yrs.	15-60	Y	N	N
Kennett	Subdiv. & Land Dvlp., 8/15/83, as ame. Zoning Ord., 7/15/85, as amended.	N	N	SCS	100yrs.	15-60	N	N	N
London Britain	Subdiv., & Land Dvlp., 12/14/81, as am. Zoning Ord., 11/12/79, as amended.	N	N	SCS	100yrs.	05-50	N	N	N
London Grove	Subdiv. & Land Dvlp., 7/16/90 LGT Zoning, 3/30/95, see FN(1).	N	N	TR 55	100yrs.	15-65	Y	Y	Y
Londonderry	Subdiv. & Land Dvlp., 1989, as amen. Zoning Ord., 1979, as amended.	N	N	TR55	100yrs.	15-65	Y	N	N
New Garden	Subdiv. & Land Dvlp., 1991. Zoning Ord., 1989, as amended.	N	N	TR55	100yrs.	20-75	Y	Y	Y
New London	Subdiv. & Land Dvlp., May 1983. Zoning Ord., 1982, as amended.	N	N	TR55	100yrs.	15-80 FN(2)	Y	N	N
Newlin	Sub. &land Dvlp., 4/14/75, to 10/27/86. Zoning Ord., of 1980, to 11/12/90.	N	N	N	UNK.	25-60	N	N	N
Penn	Subdiv. & Land Dvlp., April 1976 Zoning Ord., 1968, to 6/5/96	N	N	Y	UNK.	20-60	Y	N	N
Pennsbury	Subdiv. & Land Dvlp., 10/18/93 Zoning Ord., Oct., 1982, as amended.	N	N	TR 55	100yrs.	15-60	Y	N	N
Pocopson	Subdv. & Land Dvlp., 9/18/80 am. thru Subdiv. & Land Dvlp., 11/5/79, am. thru Sept. 1992. Zoning Ord., 9/5/78, am. thru 9/25/92. Storm Ord. FN(3).	N	N	TR55	100yrs	10-40	Y	N	N
Sadsbury		N	N	SCS	UNK.	UNK.	N	N	N
Thornbury	Subdiv. & Land Dvlp., 12/21/83, am. th. 12/6/94. Zo.Ord. 8/1/50, to 11/7/95.	N	N	TR55	100yrs.	15-55 FN(4)	Y	N	N
Upper Uwchlan	Subdiv. & Land Dvlp., 6/7/89. Zoning Ord., 1989, to 12/16/91.	N	N	TR55	100yrs.	15-70	Y	N	N
Uwchlan	Sub. & Land Dvlp., of 1979, to 12/9/91. Zoning Ord., 7/11/94.	N	N	N	UNK.	25-80	N	N	N
Wallace	Subdiv. & Land Dvlp., 12/20/95. Zoning Ord., 12/20/95.	N	N	TR55	100yrs.	UNK.	Y	N	N
West Bradford	Subdiv. & Land Dvlp., April 1989. Zoning Ord., 1977, 9/12/95 amendm..	N	N	SCS	100yrs.	12-25	N	N	N
West Brandywine	Subdiv. & Land Dvlp., 1987, as amend. Zoning Ord., 1984, as amended.	N	N	TR55	100yrs.	15-50	Y	N	N
West Caln	Subdiv. & Land Dvlp., 1983, to 2/11/91. Zoning Ord., 1978, amend. to 2/11/91.	N	N	SCS	100yrs.	15-70	N	N	N
West Goshen	Subdiv. & Land Dvlp., 5/10/88. Zoning Ord., 1990 Update, as amend..	N	N	SCS	UNK.	N	N	N	N
West Marlborough	Subdiv. & Land Dvlp., 10/9/90. Zoning Ord., 1988, amend. to 8/2/94.	N	N	TR55	100yrs.	10-20	Y	N	N
West Nantmeal	Subdi. & Land Dvlp., 1994, to 7/10/95. Zoning Ord., 1990, amend. to 7/8/96.	N	N	TR55	100yrs.	12-60	Y	N	N
West Whiteland	Sub. & Land Dvlp., last amen. 6/25/96. Zoning Ord., revised to 12/12/95.	N	N	TR55	100yrs.	15-80	Y	N	N
Westtown	Subdiv. & Land Dvlp., 8/21/95. Zoning Ord., 1976, amend. to 5/20/96. Stormwater Ordinance (FN3).	N	N	TR55	100yrs.	20-75	Y	N	N
Delaware County Township									
Birmingham	Subdiv. & Land Dvlp., Dec.,1985 Zoining Ord., 12/30/85, as amended	N	N	TR55	100yrs.	15 (FN4) to 75 tot..	Y	N	N

TABLE 3 - 5 (con't)
STORMWATER ORDINANCE INVENTORY FOR PENNSYLVANIA
Christina Basin Water Quality Management Strategy

JURISDICTION Chester County Boroughs*	Certification	SE&SC	Watershed Plan	Woodland Preservation	Buffer Area (ft)	Steep Slope (%)	Cluster Develop.	Filter Strips	Bio-Swales	Infiltration Basins	Detention Basins	Wetland Protection
Avondale	N	Y	Y	N	FHD	unk.	N	N	N	N	N	N
Coatesville*(CITY)	N	Y	N	Y	FHD & 100'	15	Y	N	N	Y	Y	Y
Downingtown	N	Y	N	Y	FHD & 25'	20	N	N	N	Y	Y	Y
Honeybrook	N	Y	N	N	N	15	N	N	N	Y	Y	Y
Kennett Square	N	Y	N	N	FHD	15	N	N	N	N	N	Y
Modena	N	Y	N	N	FHD & 50'	25	Y	N	N	N	Y	N
Parkesburg	N	Y	N	N	FHD	25	N	N	N	N	N	N
South Coatesville	N	Y	N	N	FHD	25	N	N	N	N	Y	N
West Chester	N	Y	N	N	FHD	unk.	Y	N	N	Y	Y	Y
West Grove	N	Y	Y	N	N	15	Y	N	N	N	N	Y
Chester County Townships												
Birmingham	N	Y	N	Y	N	15	Y	N	N	Y	Y	Y
Caln	N	Y	N	N	N	15	Y	N	N	Y	Y	N
East Bradford	N	Y	N	Y	FHD & 50'	20	Y	N	N	Y	Y	Y
East Brandywine	N	Y	N	Y	FHD	15	Y	N	N	Y	Y	Y
East Fallowfield	N	Y	N	Y	FHD	15	Y	N	N	Y	Y	Y
East Marlborough	N	Y	Y	Y	FHD	20	Y	Y	Y	Y	Y	Y
Franklin	N	Y	Y	Y	FHD	15	Y	N	N	N	Y	Y
Highland	N	Y	N	N	FHD	15	Y	N	N	N	Y	Y
Honeybrook	N	Y	N	N	FHD & 50'	15	N	N	N	Y	Y	Y
Kennett	N	Y	N	Y	FHD	15	Y	N	N	Y	Y	Y
London Britain	N	Y	Y	Y	FHD	12	Y	N	N	Y	Y	Y
London Grove	N	Y	Y	Y	FHD & 75'	15	Y	N	N	Y	Y	Y
Londonderry	N	Y	Y	Y	FHD	15	Y	N	N	Y	Y	Y
New Garden	N	Y	Y	Y	FHD	25	Y	N	N	Y	Y	Y
New London	N	Y	Y	Y	FHD	15	Y	N	N	Y	Y	Y
Newlin	N	Y	N	Y	FHD	20	N	N	N	N	N	Y
Penn	N	Y	Y	N	FHD & 25'	20	Y	N	N	Y	Y	N
Pennsbury	N	Y	N	Y	FHD	15	Y	N	N	Y	Y	Y
Pocopson	N	Y	N	Y	FHD	20	Y	N	N	Y	Y	Y
Sadsbury	N	Y	N	Y	FHD	15	N	N	N	N	Y	Y
Thornbury	N	Y	N	Y	FHD	25	Y	N	N	Y	Y	Y
Upper Uwchlan	N	Y	N	Y	FHD	25	N	N	N	Y	Y	Y
Uwchlan	N	Y	N	N	FHD & 50'	unk.	Y	N	N	N	N	Y
Wallace	N	Y	N	Y	FHD & 50'	20	Y	Y	N	Y	Y	Y
West Bradford	N	Y	N	N	FHD	20	Y	N	N	Y	Y	N
West Brandywine	N	Y	N	Y	FHD	15	Y	N	N	Y	Y	N
West Caln	N	Y	N	Y	FHD & 50'	15	Y	N	N	Y	Y	Y
West Goshen	N	Y	N	N	unk.	20	N	N	N	N	Y	Y
West Marlborough	N	Y	Y	Y	FHD	15	N	N	N	Y	Y	Y
West Nantmeal	N	Y	N	Y	FHD	15	Y	N	N	Y	Y	Y
West Whiteland	N	Y	N	Y	FHD	25	Y	N	N	Y	Y	Y
Westtown	N	Y	N	Y	FHD	25	Y	N	N	Y	Y	Y
Delaware County Township												
Birmingham	N	Y	N	Y	FHD	25	Y	N	N	Y	Y	Y

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TABLE 3 -6
STORMWATER ORDINANCE INVENTORY FOR DELAWARE AND MARYLAND
Christina Basin Water Quality Management Strategy

JURISDICTION	Name of Ordinance/Code	Date of Ordinance/Code	Funding Source	Criteria for Designated Watersheds	Runoff Model (TR20)	Design Frequency	% Impervious
DELAWARE							
DNREC	Delaware Sediment and StormwaterRegulations Chapter 40, Title 7,Delaware Code	01/23/91	Fees	Yes	CS TR-20, TR-55	10-year / 100-year	No
New Castle County	Chapter 12 New Castle County Drainage Code	last revised 07/09/96	Permit Fees	Yes	TR-55, TR-20	100-year	No
New Castle County	Article XX, Chapter 23, Water Resource Protection Area District	01/11/94	N	No	No	100-year	10%-50%
Municipalities							
Newark	Chapter 32, Zoning, of the Code of the City of Newark	Revised 1996	Fees	No	No	FHD 100-year	50% (excluding buildings)
Newport	Town of Newport Zoning and Subdivision Ordinances	undated	Fees	No	No	FHD 100-year	No
Elsmere	Zoning, Chapter 225 from the Code of the Town of Elsmere	1996	Fees	No	No	FHD 100-year	No
Wilmington	See DNREC Sediment and Stormwater Regulations					FHD 100-year	
MARYLAND							
Cecil County	Zoning Ordinance, Cecil County Office of Planning and Zoning	Dec. 1, 1990		No		10 - year	

JURISDICTION	Post-Development Discharge (cfs/acre)	Water Quantity	Water Quality	Contractor Certification	SE&SC	Available Watershed Plans	Woodland Presevation	Buffer Area (ft)	Steep Slope (%)	Cluster Development	Filter Strips	Bio-Swales	Infiltration Basins	Detention Basins	Wetland Protection
DELAWARE															
DNREC	Yes	Yes	Yes	Yes	Yes	No	No	20	No	No	No	No	Yes	Yes	Yes
New Castle County	Yes	Yes	Yes	Yes	Yes	No	Harvest Permit	10	15 - 25%	Yes	Yes	Yes	Yes	Yes	No
New Castle County	Yes	Yes	Yes	No	Yes	No	No	300 (wellhead area)	Erodible soils	No	No	No	No	No	No
Municipalities															
Newark	No	Yes	Yes	No	Yes	No	No	No	No	Yes	No	No	No	No	No
Newport	No	Yes	No	No	No	No	Yes	50	No	Yes	No	No	No	No	No
Elsmere	No	No	No	No	No	No	Yes	50	No	No	No	No	No	No	No
Wilmington					Yes										
MARYLAND															
Cecil County	Yes	Yes	Yes	Yes	Yes	No	Yes	110	15 - 25 %	Yes	Yes	Yes	Yes	Yes	Yes

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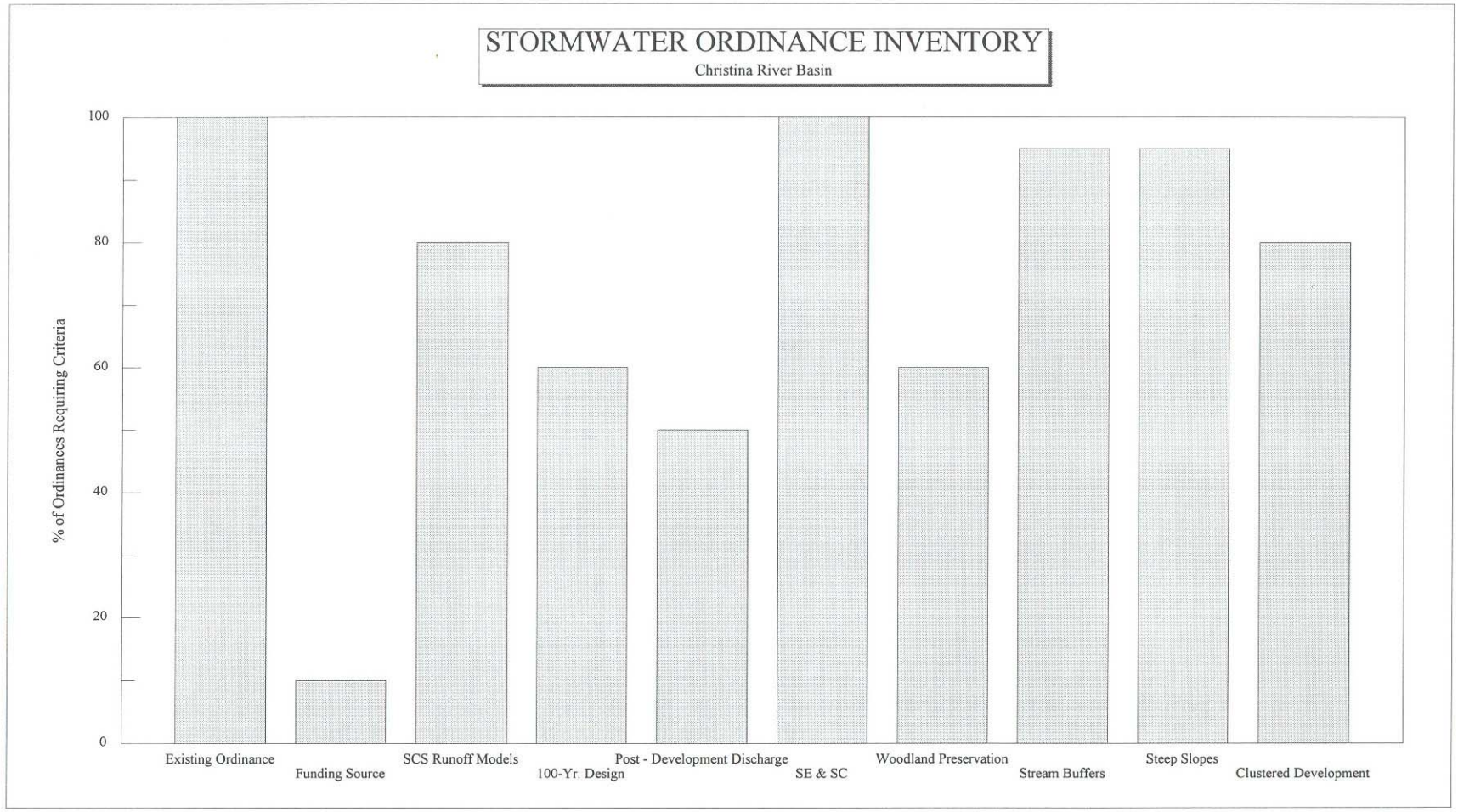

Figure 3 - 1 Stormwater Ordinance Inventory Results

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CHAPTER 4. WATERSHED POLLUTANT POTENTIAL AND PRIORITIZATION

4.1 PRIORITIZATION APPROACH

This chapter summarizes an approach for developing a preliminary prioritization of watersheds in the Christina Basin. The prioritization strategy is designed to identify optimal locations for BMP demonstration projects and determine the relative pollution potential in subwatersheds due to NPS loads. With a land area of 565-square miles, the Christina Basin is a large watershed with varying water quality concerns. The basin includes 4 watersheds that are subdivided into 38 subwatersheds each with different land use, soil, and topographic characteristics which affect stream and ground water quality. Subwatersheds in rural areas may have a low percent impervious cover yet exhibit high sediment and nutrient loads. Urban subwatersheds may have a high percent impervious cover which contribute high toxic and nutrient loads. The purpose of this exercise is to prioritize subwatersheds for BMP implementation according to estimates of the following environmental indicators:

- Total Suspended Sediment Loads
- % Impervious Cover
- % Agricultural Area
- % Wooded Area
- Stream Water Quality
- Fish Consumption Advisories.

Watershed prioritization is an effective screening tool for water quality management with the following limitations. These estimates serve only as indicators of relative pollutant loads. The watershed prioritization will be updated with the adoption of TMDL's during upcoming phases of the Christina Basin Strategy. This watershed prioritization does not account for several factors:

1. Conservation BMP's that are in place in the watershed that reduce sediment and pollutant loads.

2. Improvements in stormwater management ordinances and techniques that have improved runoff quality.

3. Contaminant loading factors used are derived from other U. S. urban areas and may not be typical of those found throughout this watershed.

4. Sediment/pollutant loads from active construction of new land development are significant but cannot be quantified for use here. It is known that stabilized development yields substantially lower sediment loads than construction sites. Constructions activities are generally temporary, but remnant sediment loads downstream of the site may take years to disperse.

5. Sediment loads from stream bank erosion and channel downcutting are not quantified in this analysis.

4.2 TOTAL SUSPENDED SEDIMENT LOADS

According to the water quality assessment in Chapter 3, total suspended sediment (TSS) is a concern in the Christina Basin. High TSS loads in streams contribute to water treatment problems and to habitat loss and excessive turbidity resulting in impairments in recreational, fish/wildlife, and water supply designated uses of the streams. Soil erosion causes impaired flood carrying capacity and increased channel downcutting and bank erosion. Many pollutants such as metals, nutrients, organics, and toxins bind to sediment thus further contributing to poor water quality. Thus, total suspended sediment loads were selected as an environmental indicator of watershed pollutant potential for the prioritization strategy.

As a screening tool, the Water Resources Agency for New Castle County computed total suspended sediment loads according to the following "Simplified Method" (Shueler, 1987):

$$L = (A)\ (P)\ (R)\ (C)\ (0.226)$$

Where:

L = Annual Total Suspended Sediment Pollutant Load (lb/yr.)
A = Subwatershed Area (acres)
P = Annual Precipitation (41 inches)
R = Runoff Coefficient for Existing Land Uses (Table 4-1)
C = Mean Pollutant Concentration (mg/l) from Literature Values (Table 4-1)
0.226 = Conversion Factor

This formula estimates the Unit Annual Pollutant Load (lb/acre/year) by dividing the annual TSS pollutant load (lb) by subwatershed area (acres).

Table 4-2 summarizes the estimates of total suspended sediment by subwatershed. The TSS loads for the Christina Basin range from 311 to 975 lb/ac/yr depending on the type of land use. The Christina Basin TSS loads were verified by comparing to loads generated at monitoring stations and from modeling in other watersheds in the Mid-Atlantic region (Table 4-2a). Based on the verification analysis, the estimated annual TSS loads in the Christina Basin seem to be accurate.

TABLE 4 - 1
TOTAL SUSPENDED SEDIMENT (TSS) POLLUTANT LOAD VARIABLES
Christina Basin Water Quality Management Strategy

Land Use	[1] Mean TSS Concentration (C) (mg/l)	[2] Runoff Coefficient (R)	[3] Annual Load (L) (lb/ac/yr)
Single Family Residential	140	0.3	389.0
Multi - Family Residential	180	0.65	1084.0
Office	175	0.6	973.0
Industrial	251	0.72	1674.0
Transportation/Utility	350	0.9	2918.0
Commercial	168	0.85	1323.0
Institutional	128	0.55	652.0
Public/Private Open Space (Protected Lands)	20	0.2	37.0
Wooded	20	0.2	37.0
Agriculture	300	0.3	833.0
Mining, Water, Vacant	---	---	---

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[1] NURP/ USEPA (1983), Bannerman (1992), USEPA (1993)
[2] WRANCC (1997) based on % impervious cover
[3] L= (41 in/yr)(R)(C)(0.226)

TABLE 4-2
TOTAL SUSPENDED SEDIMENT (TSS) LOADS
Christina Basin Water Quality Management Strategy

Subwatershed ID	Subwatershed	(L) Annual Pollutant TSS Load (lb)	(A) Drainage Area (ac.)	TSS Unit Pollutant Load (lb/ac/yr)
	Brandywine Creek Watershed			
B1	Upper West Branch at Honeybrook	7,455,266	11,834	630
B2	Upper West Branch at Hibernia	7,382,836	16,666	443
B3	Lower West Branch at Coatesville	6,297,828	11,290	558
B4	Lower West Branch at Embreeville	5,769,903	10,938	528
B5	Buck Run	10,413,790	17,619	591
B6	Doe Run	10,154,572	14,445	703
B7	Broad Creek	2,160,094	4,122	524
B8	Upper East Branch at Struble Creek	10,010,899	21,146	473
B9	Upper East Branch at Shamona Creek	2,829,942	6,400	442
B10	Lower East Branch	6,175,866	13,395	461
B11	Marsh Creek	5,596,940	12,787	438
B12	Beaver Creek	6,115,145	11,578	528
B13	Valley Creek	6,854,616	13,216	519
B14	Main Stem above Chadds Ford	7,349,163	15,718	468
B15	Pocopson Creek	3,114,493	5,850	532
B16	Main Stem below Chadds Ford	5,844,215	16,934	345
B17	Main Stem through Wilmington	3,781,074	3,878	975
	Subtotal =	**107,306,642**	**207,814**	**516**
	Red Clay Creek Watershed			
R1	West Branch	6,814,883	11,181	610
R2	East Branch	3,477,264	6,374	546
R3	Burroughs Run	2,187,919	4,550	481
R4	Main Stem above Wooddale	2,516,248	7,968	316
R5	Main Stem below Wooddale	2,302,915	4,550	506
	Subtotal =	**17,299,228**	**34,624**	**500**
	White Clay Creek Watershed			
W1	West Branch	3,637,499	6,515	558
W2	Middle Branch	5,819,499	10,157	573
W3	East Branch above Avondale	7,839,631	11,994	654
W4	East Branch below Avondale	4,316,756	9,171	471
W5	Mill Creek	4,385,433	8,269	530
W6	Pike Creek	2,053,717	4,250	483
W7	Middle Run	1,064,741	2,490	428
W8	Main Stem above Newark	2,011,672	6,477	311
W9	Main Stem above Delaware Park	4,393,590	5,792	759
W10	Main Stem at Churchmans Marsh	2,794,437	3,526	792
	Subtotal =	**38,316,974**	**68,640**	**558**
	Christina River Watershed		0	
C1	East/West Branch above Coochs Bridge	8,771,920	13,478	651
C2	Muddy Run	2,334,363	5,542	421
C3	Belltown Run	1,972,624	4,115	479
C4	Little Mill Creek	3,864,931	5,907	654
C5	Main Stem above Smalley's Pond	4,320,808	6,829	633
C6	Main Stem Lower Tidal	13,033,070	14,048	928
	Subtotal =	**34,297,716**	**49,920**	**687**
	Christina Basin Total=	**197,220,560**	**360,998**	**546**

Source: Christina Basin TSS Simplified Modes, WRANCC 1998

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INERT TABLE 2

TABLE 4-2a
VERIFICATION OF TSS LOADS
Christina Basin Water Quality Management Strategy

Project	TSS Load (lb/ac/yr)	Reference
Christina Basin Strategy Screening Model	311 to 975	Table 4-2
Octoraro Creek Watershed Study Model	416 to 941	OCWA, 1989
Brandywine Creek, Chadds Ford Gage No. 01481000 Monitoring Station	298 to 895	USGS, 1990-1996
Susquehanna River at Harrisburg Gage No. 01570500 Monitoring Station	150 to 1,100	SRBC/USGS, 1996

The annual sediment load model indicates that half the sediment in the Christina Basin is generated by agricultural/rural land uses and the other half is generated by urban and suburban land uses (Table 4-3 and Figure 4-2). As shown in Figure 2-1, both categories of land use are also equally represented by total land use area. Transportation, industrial, commercial, and multi-family uses are the greatest contributors of TSS per unit area of land. Figure 4-1 rates the Total Suspended Sediment Loads for each of the subwatersheds in ascending order.

Map 13 categorizes the predicted annual TSS for each of the subwatersheds in the Christina Basin. The subwatersheds in highly urban areas (Lower Christina River and Brandywine Creek near Wilmington and White Clay Creek below Newark) and agricultural areas (rural headwaters of the Brandywine, White and Red Clay Creeks, and the Christina River) exhibit the highest TSS Loads exceeding 600 pounds per acre per year. The lowest TSS loads are in subwatersheds with high percentages of open space (protected lands) and wooded area such as the White Clay Creek above Newark and the Brandywine Creek below Chadds Ford. Subwatersheds with high TSS pollutant loads would be targeted for agricultural conservation programs, urban development BMP's, roadway sediment control programs and stormwater runoff reduction to reduce instream erosion. Subwatersheds would be prioritized depending on watershed pollutant potential according to the following TSS load criteria.

Watershed Pollutant Potential	TSS Load (lb/ac/yr)
High	> 600
Medium	401-600
Low	0-400

TABLE 4-2a
VERIFICATION OF TSS LOADS
Christina Basin Water Quality Management Strategy

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Watershed Pollutant Potential	TSS Load (lb/ac/yr)
High	> 600
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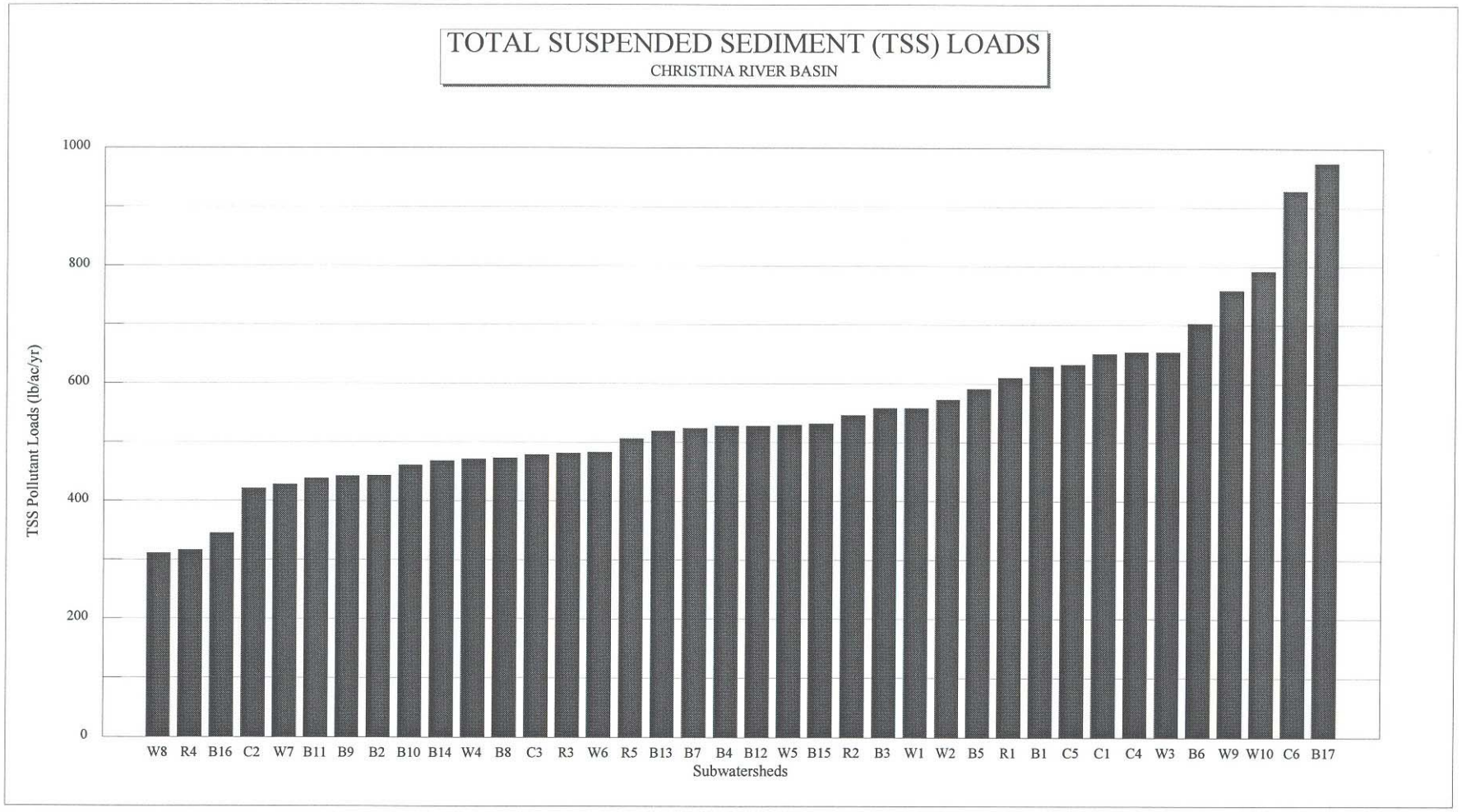
Low	0-400



Source: Christina Basin TSS Simplified Model, WRANNC 1998

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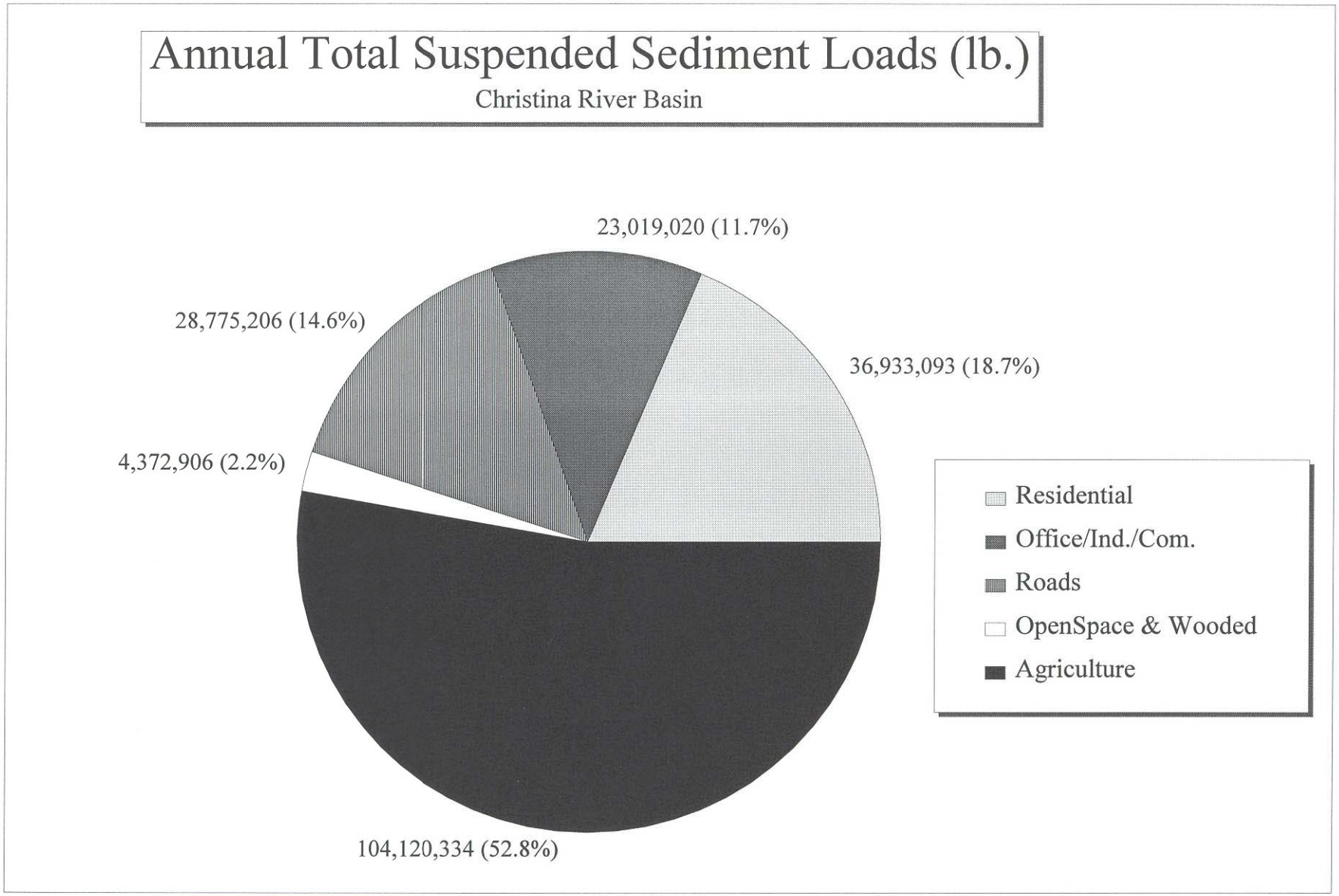
Figure 4 - 1 Total Suspended Sediment Loads By Subwatershed



Source: Christina Basin TSS Simplified Model, WRANCC 1998

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Figure 4-2. Annual Total Suspended Sediment Loads in the Christina Basin

TABLE 4-3
ANNUAL SUSPENDED SEDIMENT LOADS
Christina Basin Water Quality Management Strategy

Land Use	Annual TSS Load (lbs)	% of Total Load
Agriculture	104,000,000	53
Residential	37,000,000	19
Transportation/ Utility/ Roads	29,000,000	14
Office/ Industrial/ Commercial/ Institutional	23,000,000	12
Open Space/ Wooded	4,000,000	2
Total	197,000,000	100

Source: Christina Basin TSS Simplified Model, WRANCC 1998

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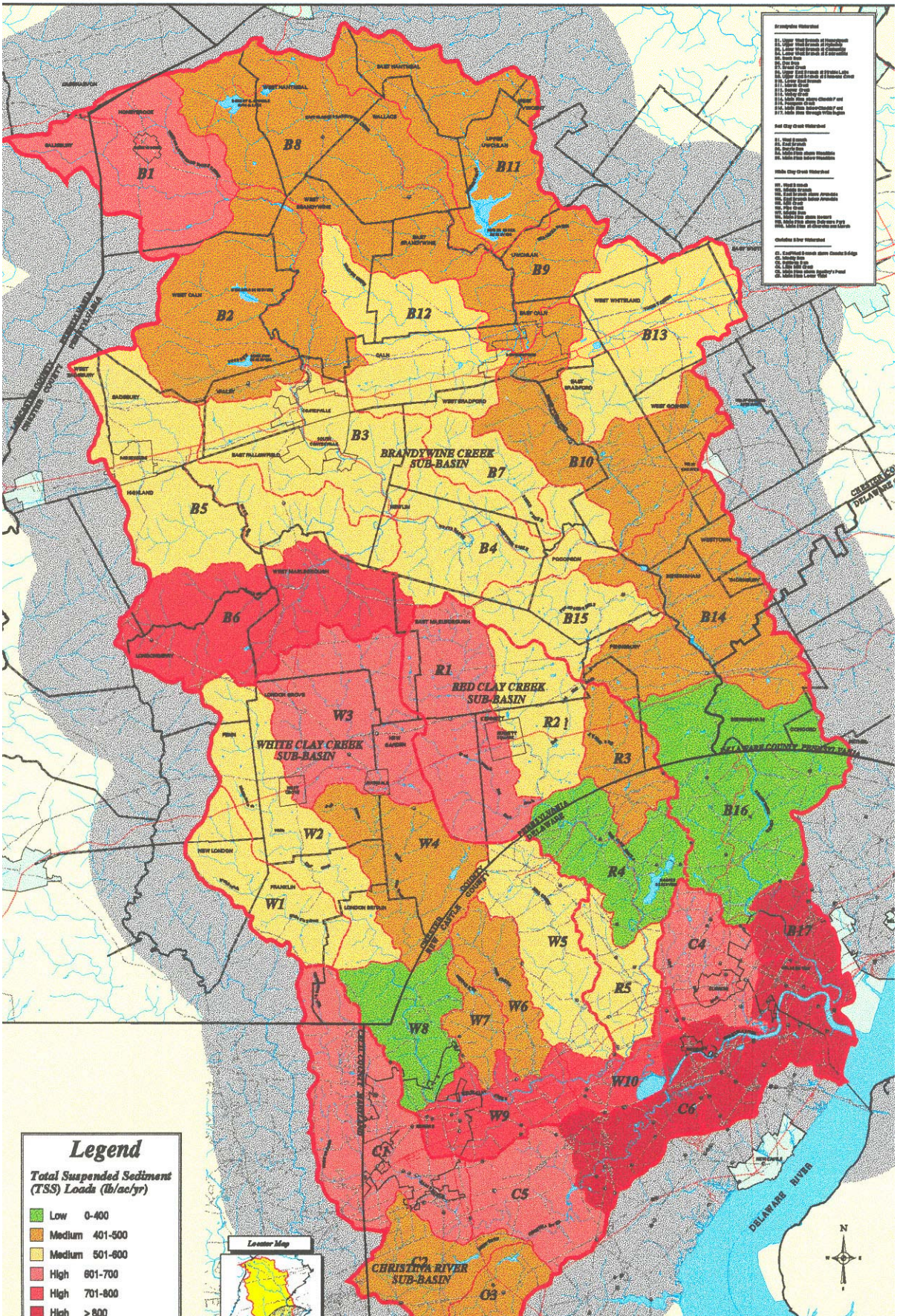
Christina Basin Water Quality Management Strategy

Map 13: Total Suspended Sediment Loads (lb/ac/yr)



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4.3 PERCENT IMPERVIOUS COVER

Percent impervious cover is a key indicator of potential watershed and stream health. The percent impervious cover can be used to correlate the link between land use and water pollution potential. Many studies indicate stream water quality, habitat, and wetlands become impaired when the percent impervious cover in a watershed exceeds 10 to 20 percent. The Delaware DNREC demonstrated that stream health is impaired in Piedmont streams in New Castle County where the watershed percent impervious cover exceeds 8 to 15 percent (DNREC, 1994). Wetlands suffer impairment when the percent impervious cover exceeds 10 percent (APA Journal, 1996). Fish habitat, spawning, and diversity suffers when impervious exceeds 10 to 12 percent (Watershed Protection Techniques, 1994-1996). Aquatic insect diversity declines above 8 to 15 percent (DNREC, 1994). Wetland plants and amphibian populations diminish when the impervious is more than 10 percent (APA Journal, 1996, Coastlines, 1997, Watershed Protection Techniques 1994 - 1996). Perhaps more than any other watershed indicator, the percent impervious cover appears to provide a correlation between the intensity of land use and stream water quality.

Using the Geographic Information System (GIS), the Water Resources Agency computed the percent impervious cover of each of the 38 subwatersheds using the 1995 land use data compiled from Map 5. Percent impervious cover factors were computed for each of the 13 land use categories by digitizing pavement and roof areas from aerial photographic maps and then comparing to tables in SCS, TR55 (Table 4-4). The appendix provides a spreadsheet which tabulates the percent impervious calculations for each subwatershed.

Figure 4-3 shows the percent impervious cover ranging from 2.5% to 49.2% for each of the subwatersheds in the Christina Basin. Subwatersheds with dense urban land uses near Wilmington exhibit percent impervious cover exceeding 40%. Rural watersheds in the upper Brandywine and headwaters of the White Clay and Red Clay Creeks exhibit low percent impervious cover (<10%) due to the high amounts of agricultural, rural, wooded, and open space land uses. Figure 4-7 summarizes the percent impervious cover of each of the 4 watersheds - the Brandywine Creek, Red Clay Creek, White Clay Creek, and the Christina River. Note that all of the 4 watersheds exceed 10% impervious cover indicating potentially stressed conditions. The Christina River watershed exceeds 20% impervious cover indicating higher potential for unhealthy stream water quality. Map 14 delineates the percent impervious cover of each subwatershed in the Christina Basin.

Based on percent impervious cover, the pollutant potential of the subwatersheds can be categorized according to the following criteria:

Watershed Pollutant Potential	% Impervious
High	> 20
Medium	11-20
Low	0-10

TABLE 4-4
ESTIMATED PERCENT IMPERVIOUS COVER
OF LAND USE CATEGORIES
Christina Basin Water Quality Management Strategy

Land Use	% Impervious Cover
Single Family Residential	30
Multi-family Residential	65
Office	60
Industrial	72
Transportation/ Utility	90
Commercial	85
Institutional	35
Open Space/ Protected Lands	0
Wooded	0
Agriculture	0
Mining	60
Water	100
Barren Land	0

Data Sources: WRANCC, Arc-Info GIS (1997) and USDA-SCS, TR-55 (1975) 5/21/98

TABLE 4-5
PERCENT IMPERVIOUS COVER BY SUBWATERSHED
Christina Basin Water Quality Management Strategy

ID	Subwatershed	Drainage Area		%
		(Acres)	(Sq. Mi.)	Impervious
	Brandywine Creek Watershed			
B1	Upper West Branch at Honeybrook	11,833.60	18.49	3.95
B2	Upper West Branch at Hibernia	16,665.60	26.04	9.57
B3	Lower West Branch at Coatesville	11,289.60	17.64	16.45
B4	Lower West Branch at Embreeville	10,937.60	17.09	5.44
B5	Buck Run	17,619.20	27.53	5.82
B6	Doe Run	14,444.80	22.57	2.46
B7	Broad Creek	4,121.60	6.44	12.12
B8	Upper East Branch at Struble Creek	21,145.60	33.04	7.36
B9	Upper East Branch at Shamona Creek	6,400.00	10.00	13.82
B10	Lower East Branch	13,395.20	20.93	15.09
B11	March Creek	12,787.20	19.98	12.14
B12	Beaver Creek	11,577.60	18.09	14.59
B13	Valley Creek	13,216.00	20.65	20.23
B14	Main Stem above Chadds Ford	15,718.40	24.56	13.22
B15	Pocopson Creek	5,849.60	9.14	8.98
B16	Main Stem below Chadds Ford	16,934.40	26.46	12.87
B17	Main Stem through Wilmington	3,878.40	6.06	49.28
	Subtotal =	**207,814.40**	**324.71**	**13.14**
	Red Clay Creek Watershed			
R1	West Branch	11,180.80	17.47	7.63
R2	East Branch	6,374.40	9.96	9.82
R3	Burroughs Run	4,550.40	7.11	8.61
R4	Main Stem above Wooddale	7,968.00	12.45	16.39
R5	Main Stem below Wooddale	4,550.40	7.11	31.59
	Subtotal =	**34,624.00**	**54.10**	**14.81**
	White Clay Creek Watershed			
W1	West Branch	6,515.20	10.18	7.21
W2	Middle Branch	10,156.80	15.87	6.78
W3	East Branch above Avondale	11,993.60	18.74	5.26
W4	East Branch below Avondale	9,171.20	14.33	8.96
W5	Mill Creek	8,268.80	12.92	27.50
W6	Pike Creek	4,249.60	6.64	26.42
W7	Middle Run	2,489.60	3.89	9.54
W8	Main Stem above Newark	6,476.80	10.12	8.96
W9	Main Stem above Delaware Park	5,792.00	9.05	38.24
W10	Main Stem at Churchmans Marsh	3,526.40	5.51	47.52
	Subtotal =	**68,640.00**	**107.25**	**18.64**
	Christina River Watershed			
C1	East/West Branch above Coochs Bridge	13,478.40	21.06	21.61
C2	Muddy Run	5,542.40	8.66	15.50
C3	Belltown Run	4,115.20	6.43	23.89
C4	Little Mill Creek	5,907.20	9.23	36.97
C5	Main Stem above Smalley's Pond	6,828.80	10.67	29.99
C6	Main Stem Lower Tidal	14,048.00	21.95	43.81
	Subtotal =	**49,920.00**	**78.00**	**28.63**
	Christina BasinTotal =	**360,998.40**	**564.06**	**16.17**

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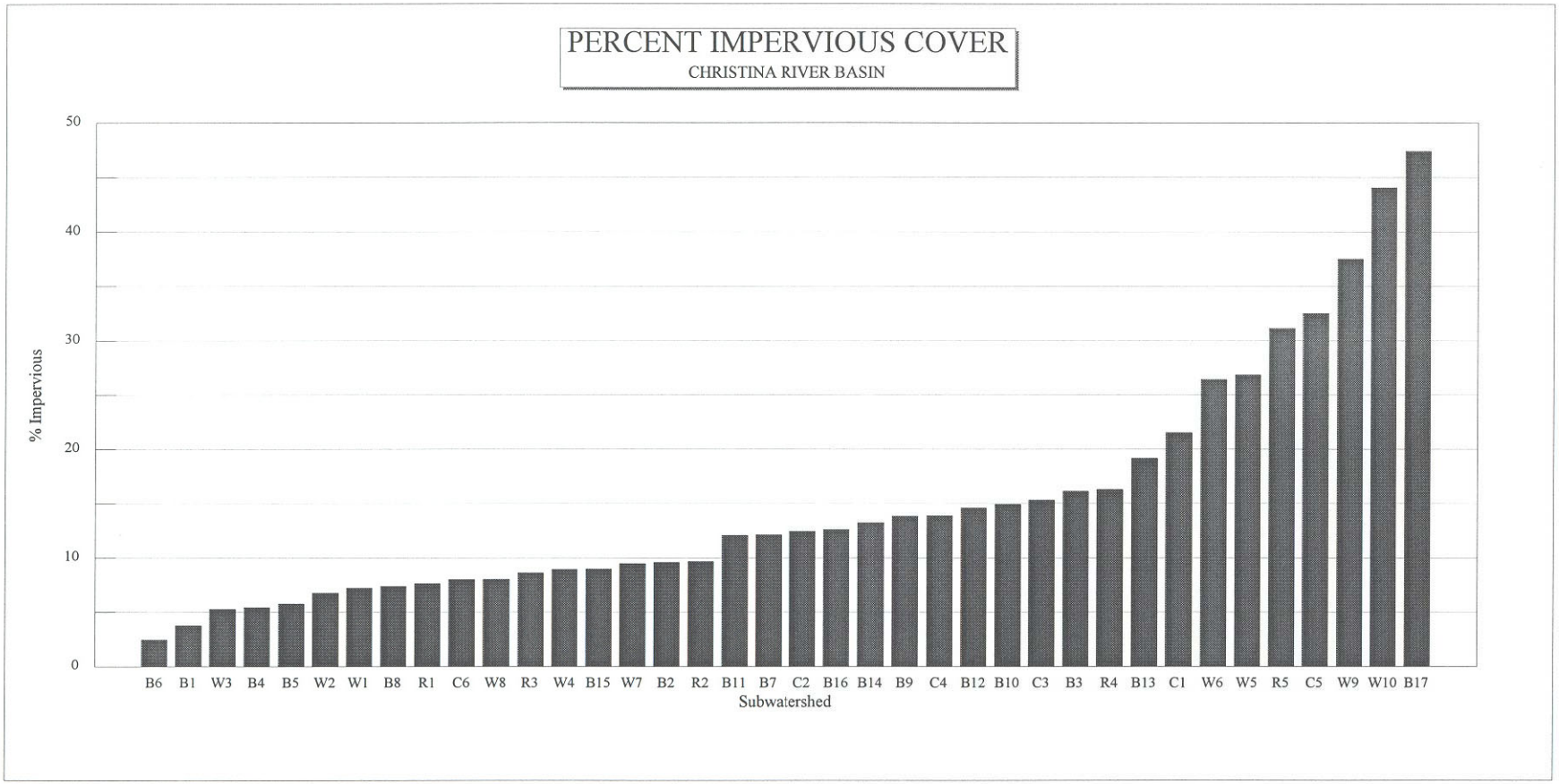

Source: WRANCC, 1998

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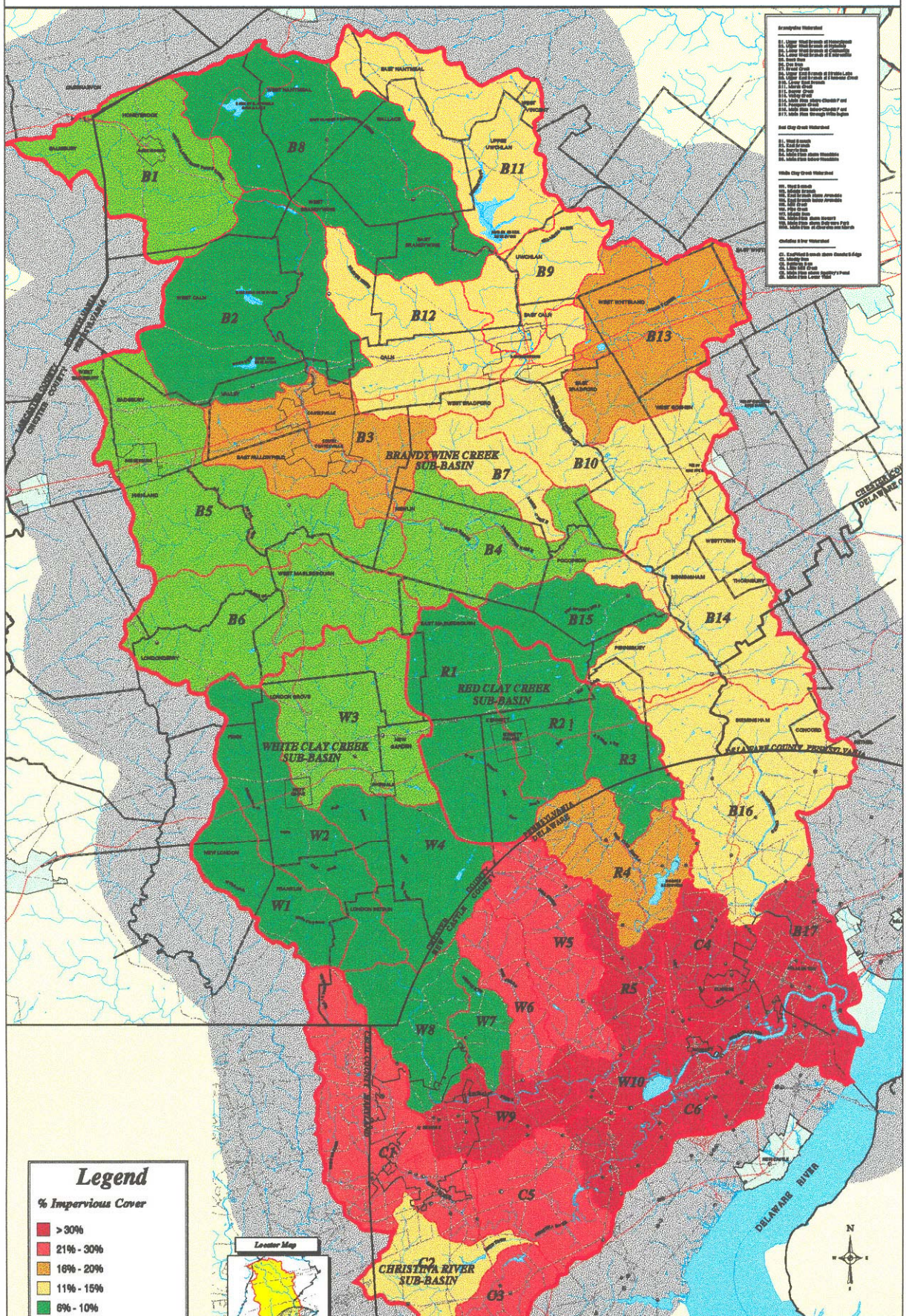
Figure 4 - 3 Percent Impervious Cover by Subwatershed

Christina Basin Water Quality Management Strategy

Map 14: % Impervious Cover



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4.4 AGRICULTURAL AREA

The extent of agriculture in subwatersheds can also affect stream water quality. Subwatersheds without conservation plans and practices with larger amounts of agriculture can exhibit undesirable water quality characteristics such as higher sediment, bacteria, and nutrient loads. Watersheds can be prioritized depending on the percentage of agricultural land and existing implementation of conservation BMP's. Subwatersheds with large percentages of agricultural area and lack of conservation plans would be prioritized for agricultural BMP conservation programs.

Figure 4-4 summarizes the percent agricultural area for each subwatershed in ascending order. Map 15 shows the percent agricultural area for each subwatershed. Watersheds with large agricultural areas include the headwaters of the Red Clay, White Clay and Brandywine Creeks in Pennsylvania with over 30% of the land in agriculture. The portion of the Christina Basin in Delaware has relatively little agricultural land. Agricultural BMP activities could be prioritized based on pollutant potential according to the following criteria:

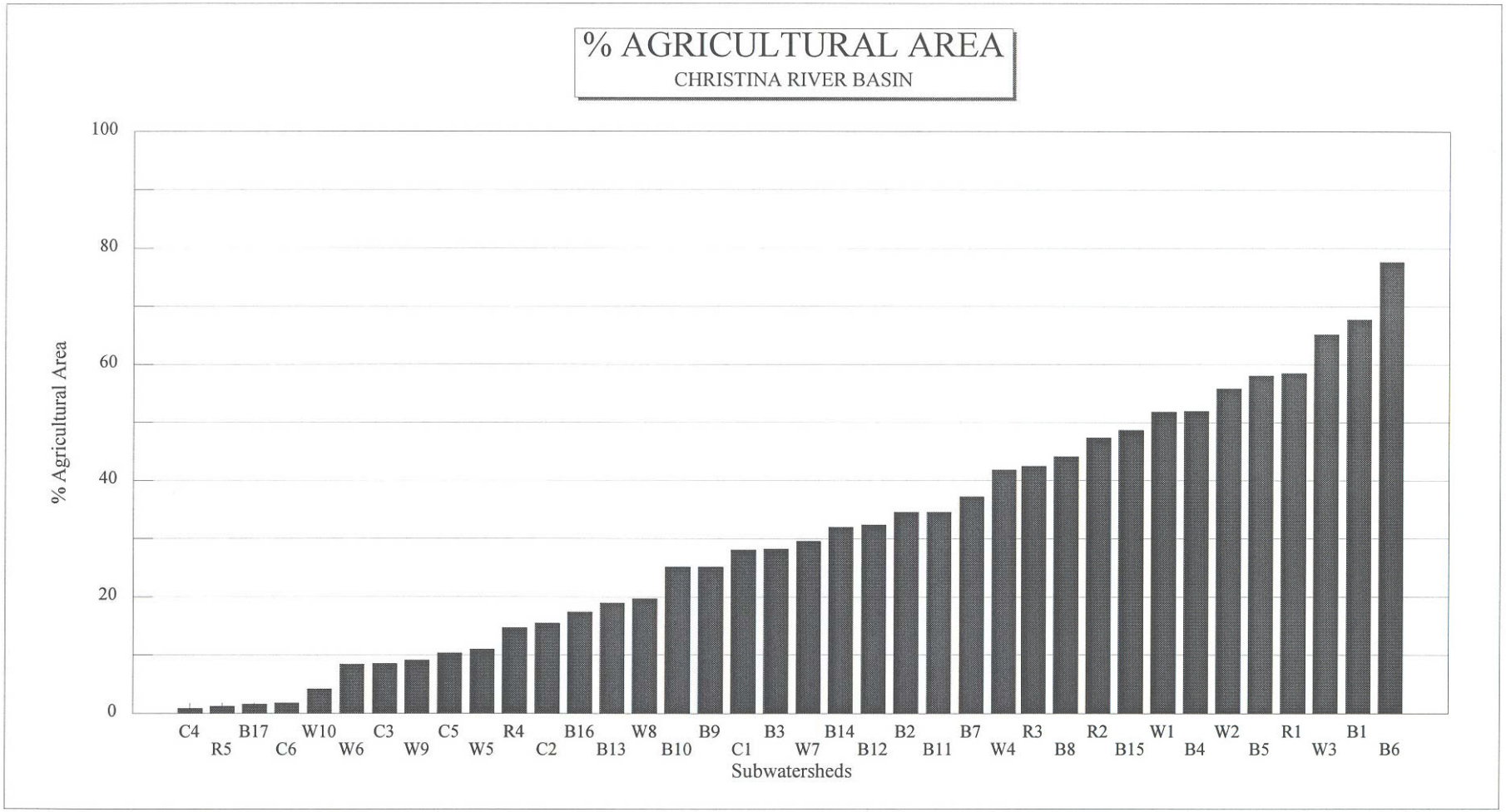
Watershed Pollutant Potential	% Agriculture
High	>40
Medium	21-40
Low	0-20

4.5 WOODED LAND

Highly wooded watersheds usually exhibit good stream health. Wooded and forested areas provide the ability to reduce runoff quantity by 30% when compared to non-wooded areas and reduce certain pollutant loads in stormwater runoff by over 50% (WRANCC, 1997). Conservation of forests, preservation of wooded riparian buffers, and reforestation practices are effective BMP's that can maintain or improve stream, stormwater, and water quality.

Figure 4-5 depicts the percent wooded area of each of the 38 subwatersheds in the Christina Basin. Map 16 indicates the percentage of wooded land ranges from 10 to 55% in the subwatersheds of the Christina Basin. Subwatersheds with highly wooded areas exceeding 30% include the headwaters of the Brandywine Creek above Coatesville and Downingtown, the Brandywine Creek above Wilmington, Red Clay Creek near Wooddale, the White Clay Creek and Middle Run above Newark, and the Muddy Run and Belltown subwatersheds in the Christina River watershed near Newark.

Subwatersheds with large percentages of forests would be targeted for woodland conservation and protected land (open space) acquisition. Subwatersheds with a low percentage of forested cover would be prioritized for reforestation BMP's. The following pollutant potential categorization is suggested based on the wooded area of a particular subwatershed:



Source: WRANCC, 1998

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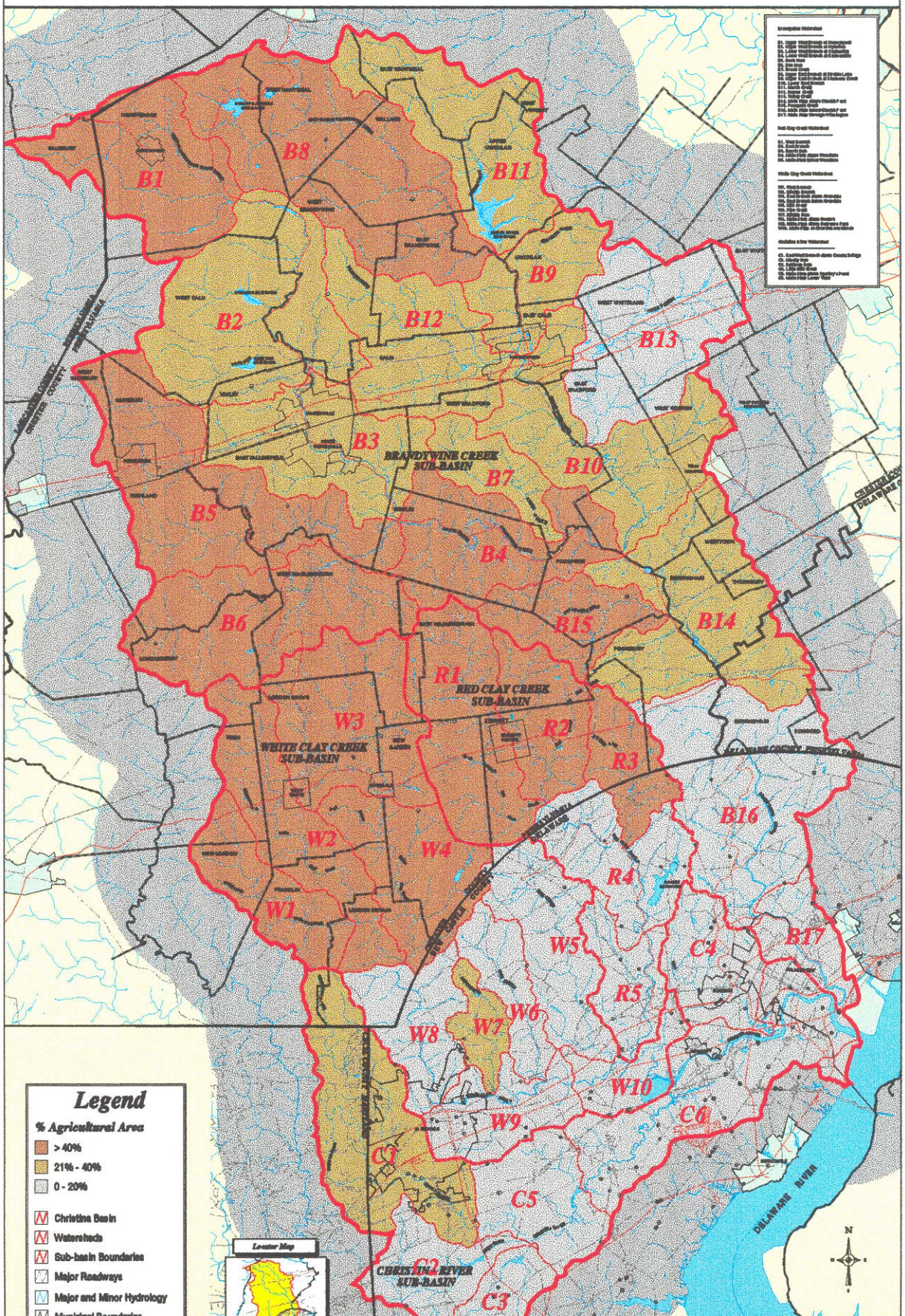
Figure 4 - 4 Percent Agricultural Area by Subwatershed

Christina Basin Water Quality Management Strategy

Map 15: % Agricultural Area



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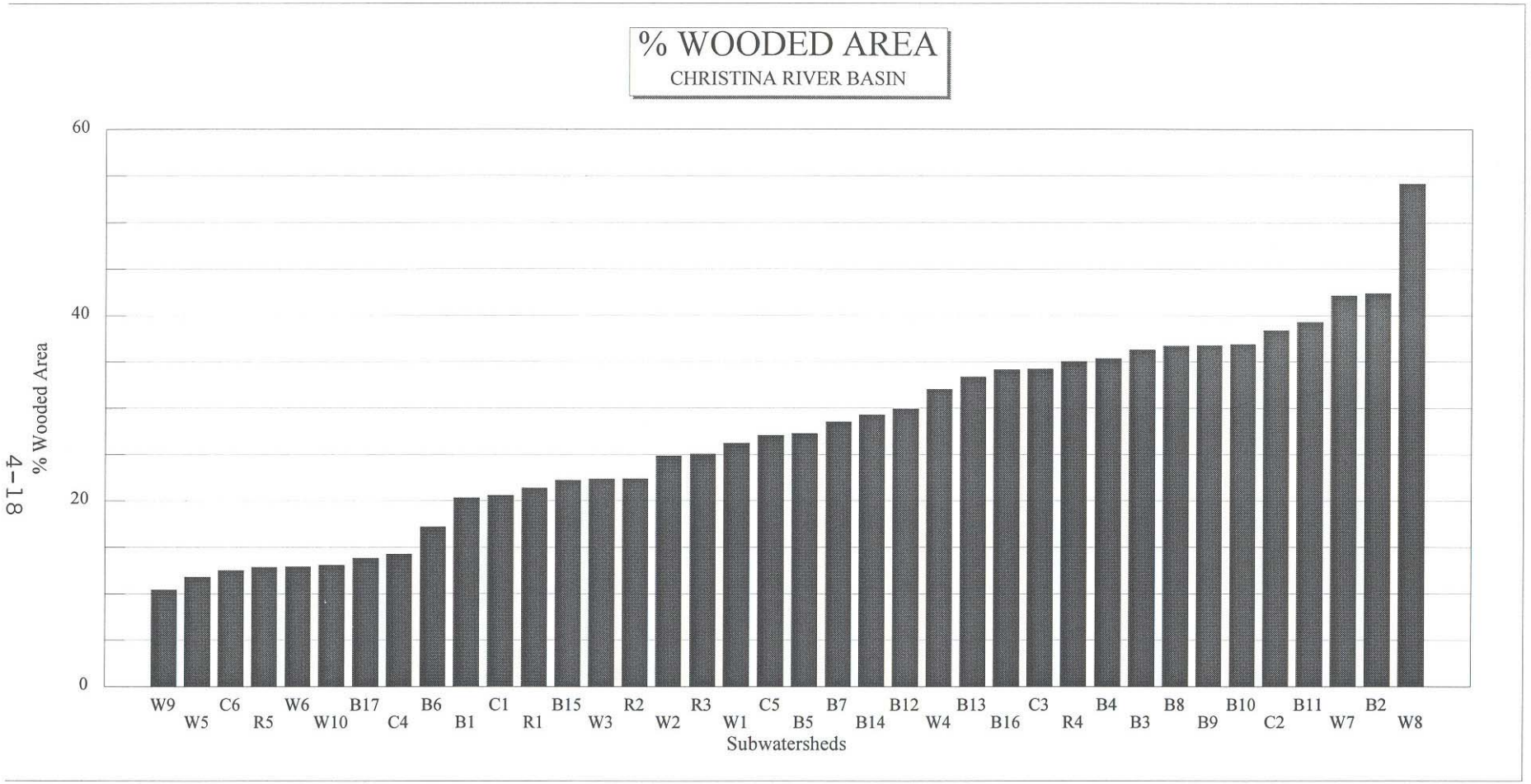

Source: WRANCC, 1998

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Figure 4 - 5 Percent Wooded Area by Subwatershed

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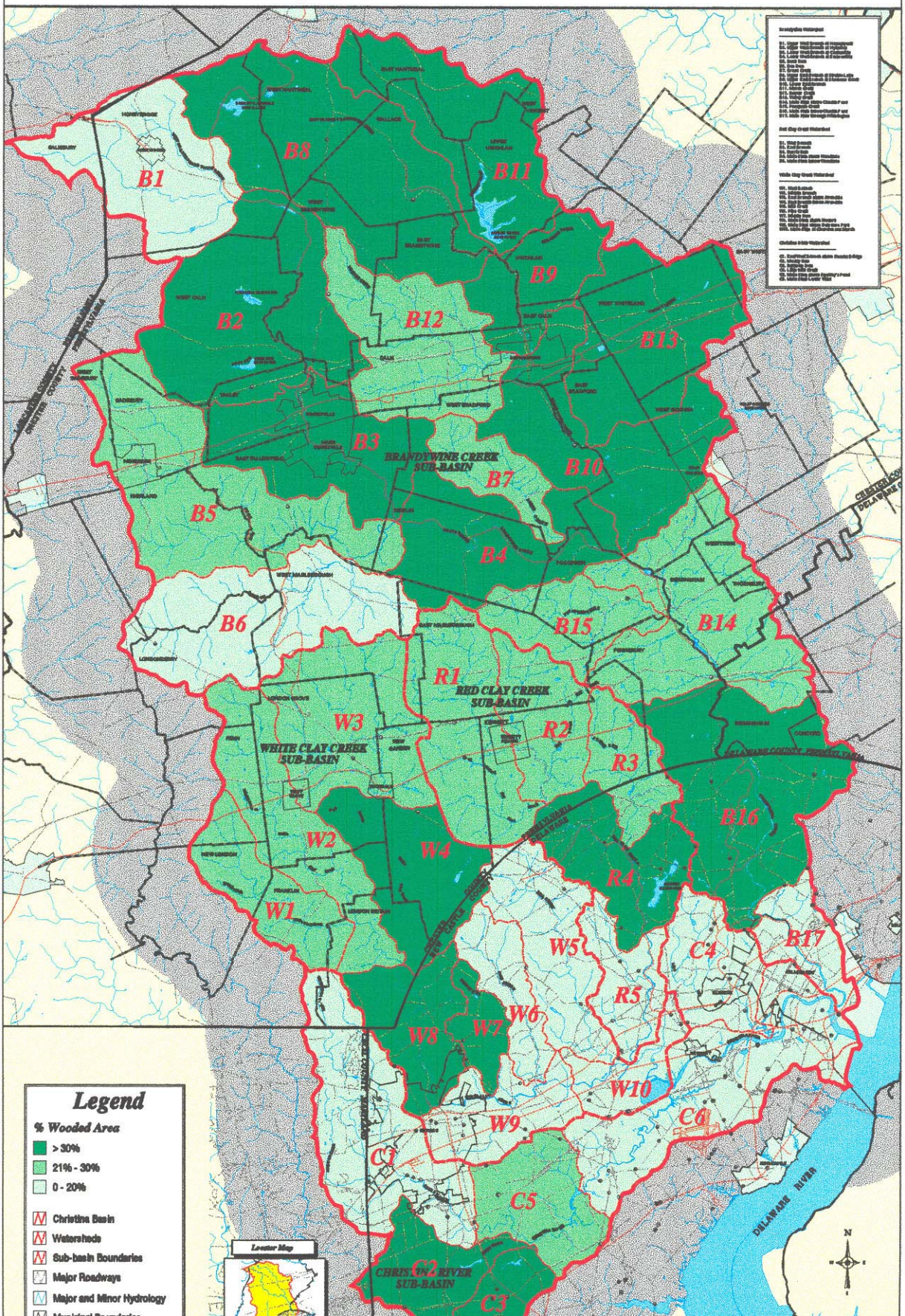
Christina Basin Water Quality Management Strategy

Map 16: % Wooded Area



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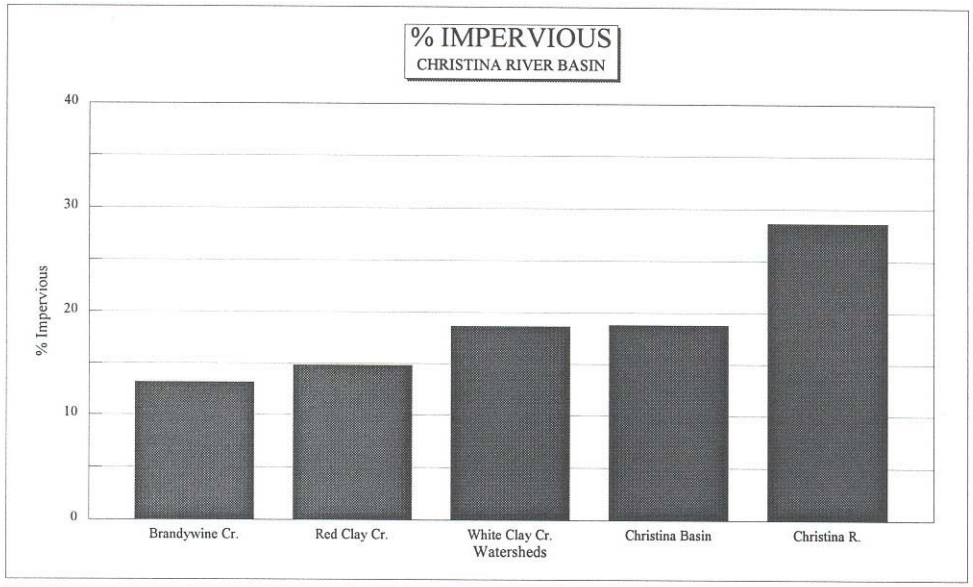

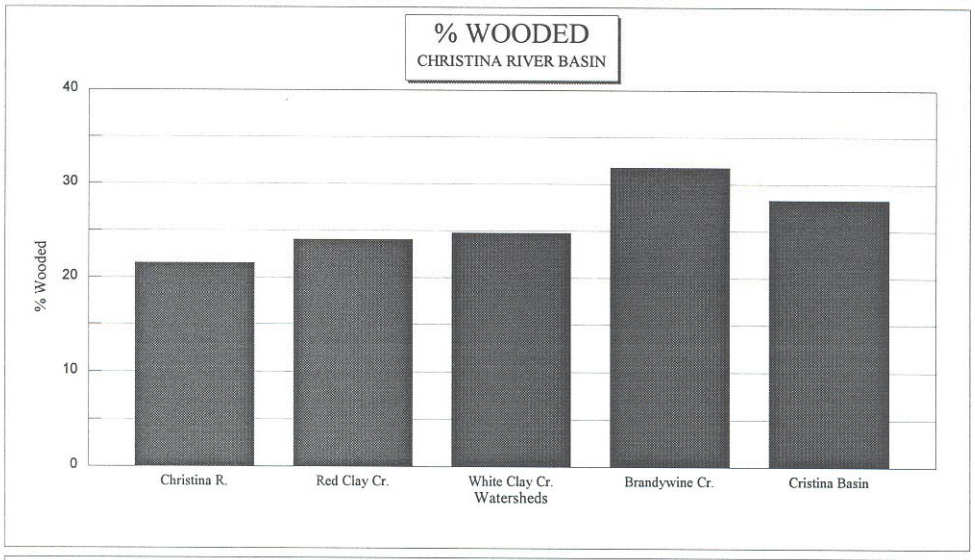

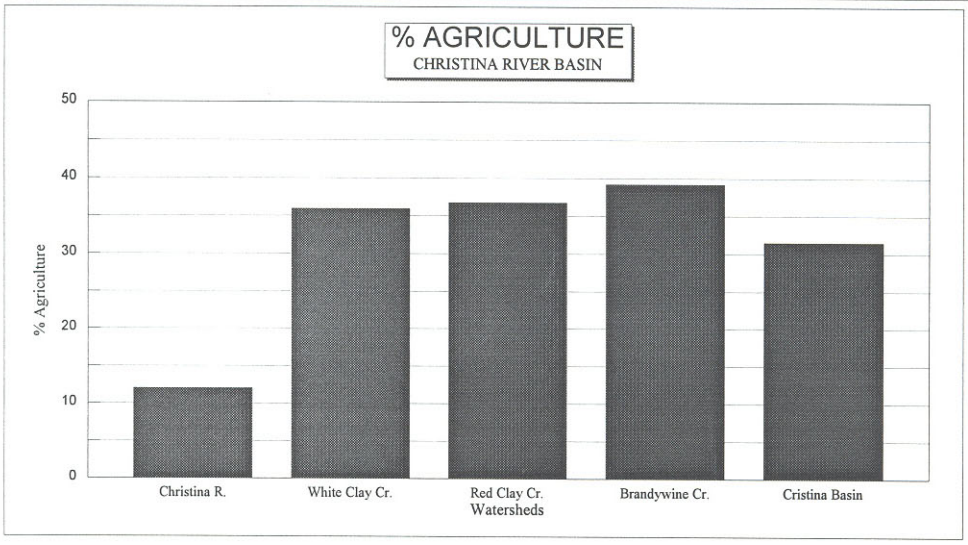

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Figure 4 - 6 Watershed Indicators

Watershed Pollutant Potential	% Wooded Area
High	0-20
Medium	21-30
Low	>30

4.6 PRIORITY WATERSHED CATEGORIES

Table 4-6 summarizes a suggested watershed categorization strategy based on Total Suspended Sediment Loads, % Impervious Cover, % Agriculture, % Wooded Area, Stream Water Quality, and Fish Consumption Advisories.

BMP's can be identified depending on the pollutant potential of a particular subwatershed. According to the criteria in Table 4-6, watersheds with low pollutant potential should be considered for prevention and preservation efforts such as subdivision ordinances, open space, and riparian buffer conservation to protect and prevent degradation of water quality. Watersheds with high pollutant potential would be targeted for restoration, remediation and retrofitting BMP management techniques designed to improve and restore water quality. This watershed prioritization approach is a preliminary screening tool. The final results of the stormwater monitoring and modeling efforts for the TMDL approach will be used as the basis for final watershed management criteria. However, the following preliminary ranking provides interim guidance to identify demonstration BMP's and conduct public education and outreach efforts until the TMDL's are adapted in later phases. The following subwatersheds are prioritized based on pollution potential:

Brandywine Creek Watershed

High Pollution Potential

- B1 West Branch at Honeybrook (PA)
- B6 Doe Run (PA)
- B17 Main Stem through Wilmington (DE)

Medium Pollution Potential

- B3 West Branch at Coatesville
- B4 West Branch at Embreeville
- B5 Buck Run
- B7 Broad Creek
- B8 East Branch at Struble Lake
- B9 East Branch at Shamona Creek
- B10 Lower East Branch
- B11 Marsh Creek
- B12 Beaver Creek

B14 Main Stem above Chadds Ford
B15 Pocopson Creek

Lower Pollution Potential

B2 West Branch at Hibernia
B13 Valley Creek
B16 Main Stem below Chadds Ford

Red Clay Creek Watershed

High Pollution Potential

R5 Main Stem below Wooddale (DE)

Medium Pollution Potential

R1 West Branch
R2 East Branch
R3 Burrough's Run

Low Pollution Potential

R4 Main Stem above Wooddale

White Clay Creek Watershed

High Pollution Potential

W3 East Branch above Avondale (PA)
W5 Mill Creek (DE)
W6 Pike Creek (DE)
W9 Main Stem above Delaware Park (DE)
W10 Main Stem at Churchmans Marsh (DE)

Medium Pollution Potential

W1 West Branch
W2 Middle Branch
W4 East Branch below Avondale

Low Pollution Potential

W7 Middle Run
W8 Main Stem above Newark

Christina River Basin

High Pollution Potential

C1 East/West Branch above Cooch's Bridge (DE/MD)
C4 Little Mill Creek (DE)
C5 Main Stem above Smalley's Pond (DE)
C6 Main Stem - Tidal (DE)

Medium Pollution Potential

C3 Belltown Run (DE)

Low Pollution Potential

C2 Muddy Run (DE)

Of the 38 subwatersheds in the Christina Basin, 13 are identified as high priorities based on pollutant potential. These include 3 agricultural and 10 urban/suburban subwatersheds. The major emphasis should be on locating retrofit urban BMP's in the densely developed areas in the lower portion of the basin and funding agricultural BMP's in the northern headwater areas.

It is important to emphasize that the "medium potential" subwatersheds represent significant cumulative pollutant potential and must also be addressed by BMP's in this strategy. The subwatersheds with low pollution potential would be addressed using BMP's to protect water quality during new development.

These results also are consistent with DNREC's designation of the White Clay Creek and Christina River as priority watersheds for BMP implementation. The prioritization results also indicate the West Branch of the Brandywine Creek in Pennsylvania may warrant additional priority among State and Federal water quality programs.

TABLE 4-6
WATERSHED POLLUTANT POTENTIAL
Christina Basin Water Quality Management Strategy

Watershed Pollution Potential	BMP Implementation Strategies	Goal	TSS Load (lb/ac/yr)	% Impervious	% Agriculture	% Wooded	Stream Water Quality	Fish Consumption Advisory
HIGH	-Remediation -Retrofitting -Restoration -Reforestation	Improve Water Quality	>600	>20	>40	0 - 20	Not Supported for Aquatic Life, Wildlife, or Water Supply	No Consumption of Selected Finfish
MEDIUM	-Conservation	Improve Water Quality	401 - 600	11 - 20	21 - 40	21 - 30	Not Supported for Swimming, Fishing, Boating or Water Sports	Limited Consumption of Finfish
LOW	-Prevention -Preservation -Perpetuation	Protect Water Quality	0 - 400	0 - 10	0 - 20	>30	Exceptional Recreational or Ecological Significance, Exceptional Value Water, High Quality Water, Cold Water Fishery	Unlimited Consumption of Finfish or Not Tested but Presumed Safe

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TABLE 4-7
PRIORITY WATERSHED STRATEGY
Christina Basin Water Quality Management Strategy

ID	Subwatershed	Drainage Area (Acres)	Drainage Area (Sq. Mi.)	TSS Load (lb/ac/yr)	% Impervious	% Agriculture	% Wooded	Stream Water Quality	Fish Consumption Advisory	Watershed Pollutant Potential
	Brandywine Creek Watershed									
B1	Upper West Branch at Honeybrook	11,833.60	18.49	630 (H)	4 (L)	68 (H)	20 (H)	F,HQ		HIGH
B2	Upper West Branch at Hibernia	16,665.60	26.04	443 (M)	10 (L)	35 (M)	42 (L)	F		LOW
B3	Lower West Branch at Coatesville	11,289.60	17.64	558 (M)	16 (M)	28 (M)	36 (L)	P	NC	MEDIUM
B4	Lower West Branch at Embreeville	10,937.60	17.09	528(M)	5 (L)	52 (H)	35 (L)	P	NC	MEDIUM
B5	Buck Run	17,619.20	27.53	591(M)	6 (L)	58 (H)	27 (M)	F		MEDIUM
B6	Doe Run	14,444.80	22.57	703 (H)	2 (L)	78 (H)	17 (H)	F		HIGH
B7	Broad Creek	4,121.60	6.44	524 (M)	12 (M)	37 (M)	29 (M)	F/ EV		MEDIUM
B8	Upper East Branch at Struble Creek	21,145.60	33.04	473 (M)	7 (L)	44 (H)	37 (L)	F/ HQ		MEDIUM
B9	Upper East Branch at Shamona Creek	6,400.00	10.00	442 (M)	14 (M)	25 (M)	37 (L)	F/ HQ		MEDIUM
B10	Lower East Branch	13,395.20	20.93	461 (M)	15 (M)	25 (M)	37 (L)	P	NC	MEDIUM
B11	Marsh Creek	12,787.20	19.98	438 (M)	12 (M)	35 (M)	39 (L)	F		MEDIUM
B12	Beaver Creek	11,577.60	18.09	528 (M)	15 (M)	32 (M)	30 (M)	F/ HQ		MEDIUM
B13	Valley Creek	13,216.00	20.65	519 (M)	20 (M)	19 (L)	33 (L)	F/ HQ		LOW
B14	Main Stem above Chadds Ford	15,718.40	24.56	468 (M)	13 (M)	32 (M)	29 (M)	P	NC	MEDIUM
B15	Pocopson Creek	5,849.60	9.14	532 (M)	9 (L)	49 (M)	22 (M)	F		MEDIUM
B16	Main Stem below Chadds Ford	16,934.40	26.46	345 (L)	13 (M)	17 (L)	34 (L)	P/ ERES	NC/ LC	LOW
B17	Main Stem through Wilmington	3,878.40	6.06	975 (H)	49 (H)	2 (L)	14 (H)	P	NC	HIGH
	Subtotal =	207,814.40	324.71	516	13					
	Red Clay Creek Watershed									
R1	West Branch	11,180.80	17.47	610 (H)	8 (L)	58 (H)	21 (M)	P	NC	MEDIUM
R2	East Branch	6,374.40	9.96	546 (M)	10 (L)	47 (H)	22 (M)	P	NC	MEDIUM
R3	Burrough's Run	4,550.40	7.11	481 (M)	9 (L)	42 (H)	25 (M)	P		MEDIUM
R4	Main Stem above Wooddale	7,968.00	12.45	316 (M)	16 (M)	15 (L)	35 (L)	N	NC	LOW
R5	Main Stem below Wooddale	4,550.40	7.11	506 (M)	32 (H)	1 (L)	13 (H)	N	NC	HIGH
	Subtotal =	34,624.00	54.10	500	15					
	White Clay Creek Watershed									
W1	West Branch	6,515.20	10.18	558 (M)	7 (L)	52 (H)	26 (M)	F		MEDIUM
W2	Middle Branch	10,156.80	15.87	573 (M)	7 (L)	56 (H)	25 (M)	F		MEDIUM
W3	East Branch above Avondale	11,993.60	18.74	654 (H)	5 (L)	65 (H)	22 (M)	F/ EV		HIGH
W4	East Branch below Avondale	9,171.20	14.33	471 (M)	9 (L)	42 (H)	32 (L)	F		MEDIUM
W5	Mill Creek	8,268.80	12.92	530 (M)	28 (H)	11 (L)	12 (H)	N/ CWF		HIGH
W6	Pike Creek	4,249.60	6.64	483 (M)	26 (H)	8 (L)	13 (H)	P/ CWF		HIGH
W7	Middle Run	2,489.60	3.89	428 (M)	10 (L)	30 (M)	12 (H)	P		MEDIUM
W8	Main Stem above Newark	6,476.80	10.12	311 (L)	9 (L)	20 (L)	54 (L)	N/ ERES/ CWF		LOW
W9	Main Stem above Delaware Park	5,792.00	9.05	759 (H)	38 (H)	9 (L)	10 (H)	N	LC	HIGH
W10	Main Stem at Churchmans Marsh	3,526.40	5.51	792 (H)	48 (H)	4 (L)	13 (H)	N	NC	HIGH
	Subtotal =	68,640.00	107.25	558	19					
	Christina River Watershed									
C1	East/West Branch above Coochs Bridge	13,478.40	21.06	651 (M)	22 (H)	28 (M)	21 (M)	N/ CWF		HIGH
C2	Muddy Run	5,542.40	8.66	421 (M)	16 (M)	15 (L)	38 (L)	N		LOW
C3	Belltown Run	4,115.20	6.43	479 (M)	24 (H)	9 (L)	34 (L)	F		MEDIUM
C4	Little Mill Creek	5,907.20	9.23	654 (H)	37 (H)	1 (L)	14 (H)	N	NC	HIGH
C5	Main Stem above Smalley's Pond	6,828.80	10.67	633 (H)	30 (H)	10 (L)	27 (M)	N	LC	HIGH
C6	Main Stem Lower Tidal	14,048.00	21.95	928 (H)	44 (H)	2 (L)	13 (H)	F	NC	HIGH
	Subtotal =	49,920.00	78.00	687	29					
	Totals =	360,998.40	564.06	546	16	31	28			

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Designated Uses = Supported (F), Partially Supported (P), Non-Supported (N), Trout Stocking (TSF), Cold Water Fishery (CWF), Migratory Fish (MF), Warm Water Fishery (WWF), High Quality (HQ), Exceptional Value (EV), or Designated Watershed (DW).

Fish Consumption Advisory: No Consumption (NC), Limited Consumption (LC)

Pollants of concern: Total Suspended Sediments (TSS), Nitrate-Nitrogen (N), Phosphates (P), Polychlorinated Biphenyl (PCB)

Watershed Pollution Potential: High (H), Medium (M), Low (L)

CHAPTER 5. STORMWATER QUALITY MONITORING PLAN

The United States Geological Survey (USGS) prepared a recommended stormwater monitoring plan for the Christina River Basin. The purpose of the monitoring plan is to characterize stormwater and nonpoint source pollutant loads from representative land uses in the Christina Basin. The sampling plan is designed to collect pollutant load data over a range of hydrologic conditions - including base flow and high flow. The pollutant data will be input to calibrate a watershed model (HSPF) which will be used to simulate nonpoint source loading for a Total Maximum Daily Load (TMDL) of the Christina Basin.

Appendix C includes the full stormwater monitoring plan prepared by the USGS. Stormwater sampling will be conducted for 6 storms over one year beginning in the Fall of 1997. Base flow sampling will be conducted for 4 seasons. High flow grab sampling will be conducted for 2 seasons. Sampling and laboratory analyses will include nutrients, sediment, oxygen-demand constituents, metals, and others. The USGS has installed stormwater sampling stations at the following locations in the Christina Basin:

Large basin sites

One water-quality site will be established at a downstream location in each of the four major drainages to represent cumulative loads to the Christina River estuary. These sites are at the gage furthest downstream on the free-flowing or non-tidal reaches of the streams. Data collected at these sites can be used to calculate both total loads and concentrations of selected constituents for the one-year study period in each of the streams.

Overall basin nonpoint source water quality sampling sites:

1. White Clay Creek near Newark, DE
   USGS station 01479000 DA = 89.1 $mi.^2$

2. Red Clay Creek near Wooddale, DE
   USGS station 01480000 DA = 47.0 $mi.^2$

3. Brandywine Creek at Chadds Ford, PA
   USGS station 01481000 DA = 287 $mi.^2$

4. Christina River at Cooch's Bridge, DE
   USGS station 01478000 DA = 20.5 $mi.^2$

Subbasins sites having a single, dominant land use

One water-quality site will be established for each land-use category. The four primary land-use categories are: urban, residential, agricultural, and forested. Residential and agricultural land uses are further subdivided for a total of 7 categories. Residential is subdivided into sewered and non-sewered uses. Agricultural is subdivided into row crop, livestock, and mushroom uses. Some

proposed sites are at existing USGS streamflow-measurement stations. At the other proposed sites, temporary gages will need to be installed to measure streamflow.

Urban nonpoint source water quality sampling site

5. Little Mill Creek near Newport, DE (USGS station 01480095). DA = 5.24 mi.^{2} and

   Use stormwater data for commercial and industrial sites from NPDES study for New Castle County, DE.

Residential, nonpoint source water quality sampling site

6. Sewered - Unnamed tributary to Valley Creek at U. S. Rt. 30/Fairview Road near East Caln/West Whiteland township line. DA = 1.47 mi.^{2} (need to install gage)
   And

   Use stormwater data from New Castle County study.

7. Non-sewered - Unnamed tributary to Broad Run north of Rt. 162 and 1.5 mile west of Marshallton. DA = 1.37 mi.^{2} (need to install gage)

Agricultural nonpoint source water quality sampling site

8. Row crop - Doe Run at Rt. 841 near Springdell. DA = 11.7 mi.^{2} (need to install gage)

9. Livestock - West Branch Brandywine Creek near Honeybrook, PA (USGS station 01480300). DA = 18.7 mi.^{2}

10. Mushroom - Trout Run at Rt. 41 at Toughkenamon. DA = 1.31mi.^{2}

Forested nonpoint source water quality sampling site

11. Marsh Creek near Glenmoore, PA (USGS station 01480675). DA = 8.57 mi.^{2}

CHAPTER 6. PUBLIC EDUCATION AND OUTREACH PROGRAM

Public education and outreach programs are some of the most cost effective best management practices (BMP's) that can be implemented to protect and improve water quality. The Christina Basin public education program is directed by the Chester County Conservation District with assistance by the Brandywine Valley Association (BVA). The public outreach program includes a series of demonstration BMP's designed to show progress, implement methods to reduce stormwater pollutant loads, and improve water quality in the Christina Basin. The following public education and demonstration BMP projects have been implemented to date for the Christina Basin Strategy:

- Public Education/Outreach Programs
  - Christina Basin Task Force
  - Christina Basin Tour of the Watershed
  - Christina Basin Brochure
  - Basin Scapes Homeowner's Guides
  - Storm Drain Stenciling Project

- BMP Demonstration Projects
  - Friendfield Farms Riparian Corridor Protection Plan (PA)
  - Hills of Sullivan Infiltration BMP (PA)
  - Pocopson Township Maintenance Building Infiltration/Wetland BMP (PA)
  - Modern Mushrooms Tree Plantation (PA)
  - East Marlborough Wetland Treatment (PA)
  - Hy Tech Compost and Mushroom Farm (PA)
  - Buck Run Riparian Planting (PA)
  - Buck and Doe Run Farms Reforestation Project (PA)
  - Buck Run Farms Riparian Planting (PA)
  - Sadsbury Township Stream Restoration (PA)
  - City of Newark Bioengineering Demonstration Project (DE)

- USDA-NRCS Conservation Activities
  - Pennsylvania
  - Delaware

6.1 PUBLIC EDUCATION/OUTREACH PROGRAMS

Christina Basin Task Force

During the summer of 1996, the Chester County Conservation District retained the Brandywine Valley Association (BVA) to oversee the Christina Basin Task Force public education and outreach efforts. One of the purposes of the Christina Task Force is to provide a central forum for discussion among watershed organizations, local stakeholders and public groups that represent the four watersheds in the Basin. The Christina Basin Task Force is chaired by the BVA and meets quarterly to discuss watershed programs along the Brandywine, Red Clay, White Clay Creeks and

the Christina River. The Task Force provides the public outreach function for the overall program. It promotes ownership in the Basin Program and allows opportunity for partnerships to be formed with other individuals and organizations that are not represented on the overall Basin Committee. Topics on the agenda include progress reports on the Christina Basin Water Quality Management Strategy and TMDL approach, review of NPDES discharge permit applications, subdivision development proposals and other issues that affect the Basin. In addition to Federal, State, and local agencies listed on the cover of this report, the Christina Basin Task Force includes the following public environmental organizations:

- Brandywine Conservancy
- Brandywine Valley Association
- Delaware Nature Society
- Green Delaware
- Wilmington River-City Steering Committee
- Red Clay Valley Association
- White Clay Watershed Association
- Christina Conservancy

Water purveyors and wastewater treatment operators invited to participate on the Christina Basin Task Force include:

- Delaware
  - Artesian Water Company
  - City of Newark
  - United Water Delaware
  - City of Wilmington

- Pennsylvania
  - Avondale Borough
  - Borough of Downingtown
  - City of Coatesville Authority
  - Downingtown Area Regional Authority
  - Philadelphia Suburban Water Company
  - West Chester Area Municipal Authority
  - West Grove Borough

Christina Basin Tour of the Watershed

The Christina Basin Task Force schedules an annual tour of the watershed to review demonstration projects and other conservation work. Members of the public and agencies are invited to attend the bus tours. Over 40 people attended each tour on dates in June, 1996 and September, 1997. The Task Force intends to sponsor another tour in early fall 1998.

Christina Basin Brochure

The BVA published a three-color brochure summarizing the Christina Basin Water Quality Management Strategy. The popular brochure includes a map of the watershed, mission statement, explanation of the Christina Basin, troubled waters, and contacts for members of the Committee. Over 1,000 brochures have been distributed at meetings, conventions, seminars and through the mail.

Basin Scapes Homeowner's Guides

The BVA published a series of Basin Scapes Homeowner's Guides which advocate environmentally sound landscapes benefiting people, wildlife and the Christina Basin. The Basin Scapes Guides are adapted from the Chesapeake Bay "Bay Scapes" materials which advocate a "holistic" approach to watershed management through principles inspired by the relationships in the natural world. The Basin Scapes have become so popular that other areas like the Northampton County Conservation District (PA) have adapted the materials for their watershed. The color-coded Basin Scapes brochures provide information to homeowners on the following topics:

1. Basin Scapes for Wildlife Habit (Orange) - Recommends native trees and shrubs to attract species such as hummingbirds and butterflies.

2. Integrated Past Management (Yellow) - Encourages natural biological controls to control pests and reduce chemical pesticide use.

3. Conservation Landscaping (Purple) - Promotes landscaping management with natural lawn care and tree/shrub selection that work with nature to reduce pollution and enhance wildlife habitat.

4. Basin Scaping for the Long Term (Blue) - Incorporates native plantings in landscaping to minimize water use and lawn chemical use and provide cover and food for wildlife and reduce runoff.

5. Using Beneficial Plants (Green) - Lists the beneficial native plants that require less fertilizer and pesticides to reduce pollutants carried by rainwater.

6. Creating Landscape Diversity (Grey) - Advocates landscape diversity using ground covers, gardens, and hedges that increase infiltration and reduce runoff from land into local waterways.

7. Basin Scaping to Conserve Water (Tan) - Identifies opportunities to save and conserve water supplies in home landscapes.

Storm Drain Stenciling Project

The Chester County Conservation District sponsored a storm drain stenciling project to heighten public awareness about connection between illicit dumping and clean water. The CCCD prepared a stencil with a fish message which says "DON'T DUMP." In the Christina Basin, volunteers painted the fish message on street storm drains to remind everyone that nonpoint source pollution can harm aquatic life and humans. Volunteers were reminded that many home care lawn and garden products, if not applied correctly or disposed of properly, end up in the curb sidestorm drain. A door hanger was distributed to residences within the towns explaining where you can go to safely dispose and recycle this material. A "fish-shaped" door hanger was designed to remind the public that household chemicals, pesticides, fertilizers, used motor oil, and yard or pet wastes should never be dumped down the storm drain. Otherwise, debris, litter, and chemicals washed down storm drains ends up in local waterways like the Brandywine Creek. Over 300 storm drains were painted and 1500 fish messages have been distributed. The stenciling program attracted national attention and there were three requests from other organizations in the U.S. for information.

The following municipalities have participated in the Christina Basin Storm Drain Stenciling Project:

- West Chester Borough
- Parkesburg Borough
- Kennett Square Borough
- Avondale Borough
- Kennett Township
- West Goshen Township
- Uwchlan Township

6.2 BMP DEMONSTRATION PROJECTS

Friendfield Farm

Located in the head waters of the East Bank of the White Clay Creek, in London Township, Pennsylvania, Friendfield Farm has a horse operation. Approximately 1000 feet of White Clay Creek runs through the property. The landowners working with Landscape Architect, Jessie Farrell, and Nurseryman, Jim Plyer, developed a riparian corridor protection plan, fencing for livestock exclusion, native tree plantation, and wetland enhancement protection Best Management Practices. A portion of the cost of the project was funded by Phase I of the Christina Basin Program.

Hills of Sullivan

The Hills of Sullivan residential development is located along the Main Branch of the White Clay Creek in New Garden Township, Chester County. New homes are being developed on the hillside overlooking the creek. The local township along with developer, Judd Builders Inc., were concerned the typical stormwater management basin may cause more water quality impacts than the preconstruction overland flow conditions. As an alternative, most of the runoff from the lawn areas are diverted to a series of shallow level spreaders which cascade the stormwater safely off the hillside. Some infiltration takes place within the spreaders. Technical assistance was provided by the Christina Basin program.

Pocopson Township

In 1995, Pocopson Township, Pennsylvania began constructing a new township garage along the banks of the Pocopson Creek in the Brandywine Watershed. Pocopson Township supervisors, known for trend setting, were not comfortable with just putting up a simple garage building. Working with L.A. Kelly Gutshall and Landstudies in Oxford, Pocopson installed an innovative system to control stormwater from the buildings and parking areas. Infiltration beds were designed to handle the majority of stormwater from the building. A basin was enhanced for water quality and wetland planting. A low maintenance species of native grass was established to minimize cost and staffing time. The Christina Basin Program funded a portion of the cost for this project.

Modern Mushroom, Inc.

Modern Mushroom Farms, a leader in the agricultural industry for installing Best Management Practices for water quality, were working to resolve problems in using grass fields to spray areas with runoff water. Modern Mushrooms is situated along the Red Clay Creek in New Garden Township, Pennsylvania. Spray drift onto adjoining properties and frozen ground in the winter severely limited the use of one of their larger spray fields. A decision was made to establish a tree plantation on the field. A mixture of hybrid poplar and pine tree stock was planted in the late 1996. It is expected that once the trees are established the spray drift will no longer be a problem; the tree cover and drift will provide additional infiltration and the spray fields can be utilized in a limited capacity further into the winter. The Christina Basin Program provided partial funding for the plantings.

East Marlborough Wetland Treatment

East Marlborough Wetland Treatment was a stop on the tour. The BMP project demonstrated alternative methods of municipal waste utilization by enhanced wetland treatment for domestic septage and land application of wastewater by Spray Irrigation. The township had many areas of failing on lot septic systems in and around Unionville and also new developments in which on site septic systems would not be acceptable. The system provides needed ground water recharge and was an alternative to traditional stream discharge of treated effluent.

Hy Tech Compost and Mushroom Farm

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I-EQIP	
Agriculture Waste Structure	
Spray Irrigation System	

Conservation Reserve Program	
Private Lands	224 acs

District Cost Share Program	
Water Control/Quality Structures	
Stream Bank Stabilization	
Wetland Pond Installation	
Manure Storage Structure	
Pasture Management	

Conservation Practices Installed/Proposed - no Program Affiliation	
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Intensive Grazing/Waterway	30 acs
Agriculture Waste Structure	
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THE STORM DRAIN SYSTEM

Storm drain systems are designed to reduce flooding caused by rain storms. Unlike the sanitary sewer system which accepts sewage and transports it to a treatment plant, water from storm drains generally is not treated. This means that debris, litter or chemicals washed down storm drains ends up in local waterways like the Brandywine!

Help protect Chester County's Waterways, State and National Scenic Rivers and the Home to Many Endangered Species!

For more information or to get involved with the Storm Drain Stenciling Project, please call: the Chester County Conservation District at (610) 696-5126 or the Chester County Health Department's Division of Solid Waste Management at (610) 344-5937.

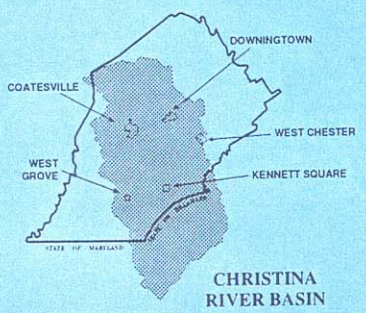

Figure 6 - 1 Storm Drain Stenciling Project, Chester County

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Christina Basin Water Quality Management Strategy

Bioengineering Techniques	Length (LF)	Post Construction Condition	2-years After Construction	2-year Overall Condition
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CHAPTER 6. PUBLIC EDUCATION AND OUTREACH PROGRAM

Public education and outreach programs are some of the most cost effective best management practices (BMP's) that can be implemented to protect and improve water quality. The Christina Basin public education program is directed by the Chester County Conservation District with assistance by the Brandywine Valley Association (BVA). The public outreach program includes a series of demonstration BMP's designed to show progress, implement methods to reduce stormwater pollutant loads, and improve water quality in the Christina Basin. The following public education and demonstration BMP projects have been implemented to date for the Christina Basin Strategy:

- Public Education/Outreach Programs
  - Christina Basin Task Force
  - Christina Basin Tour of the Watershed
  - Christina Basin Brochure
  - Basin Scapes Homeowner's Guides
  - Storm Drain Stenciling Project

- BMP Demonstration Projects
  - Friendfield Farms Riparian Corridor Protection Plan (PA)
  - Hills of Sullivan Infiltration BMP (PA)
  - Pocopson Township Maintenance Building Infiltration/Wetland BMP (PA)
  - Modern Mushrooms Tree Plantation (PA)
  - East Marlborough Wetland Treatment (PA)
  - Hy Tech Compost and Mushroom Farm (PA)
  - Buck Run Riparian Planting (PA)
  - Buck and Doe Run Farms Reforestation Project (PA)
  - Buck Run Farms Riparian Planting (PA)
  - Sadsbury Township Stream Restoration (PA)
  - City of Newark Bioengineering Demonstration Project (DE)

- USDA-NRCS Conservation Activities
  - Pennsylvania
  - Delaware

6.1 PUBLIC EDUCATION/OUTREACH PROGRAMS

Christina Basin Task Force

During the summer of 1996, the Chester County Conservation District retained the Brandywine Valley Association (BVA) to oversee the Christina Basin Task Force public education and outreach efforts. One of the purposes of the Christina Task Force is to provide a central forum for discussion among watershed organizations, local stakeholders and public groups that represent the four watersheds in the Basin. The Christina Basin Task Force is chaired by the BVA and meets quarterly to discuss watershed programs along the Brandywine, Red Clay, White Clay Creeks and

the Christina River. The Task Force provides the public outreach function for the overall program. It promotes ownership in the Basin Program and allows opportunity for partnerships to be formed with other individuals and organizations that are not represented on the overall Basin Committee. Topics on the agenda include progress reports on the Christina Basin Water Quality Management Strategy and TMDL approach, review of NPDES discharge permit applications, subdivision development proposals and other issues that affect the Basin. In addition to Federal, State, and local agencies listed on the cover of this report, the Christina Basin Task Force includes the following public environmental organizations:

- Brandywine Conservancy
- Brandywine Valley Association
- Delaware Nature Society
- Green Delaware
- Wilmington River-City Steering Committee
- Red Clay Valley Association
- White Clay Watershed Association
- Christina Conservancy

Water purveyors and wastewater treatment operators invited to participate on the Christina Basin Task Force include:

- Delaware
  - Artesian Water Company
  - City of Newark
  - United Water Delaware
  - City of Wilmington

- Pennsylvania
  - Avondale Borough
  - Borough of Downingtown
  - City of Coatesville Authority
  - Downingtown Area Regional Authority
  - Philadelphia Suburban Water Company
  - West Chester Area Municipal Authority
  - West Grove Borough

Christina Basin Tour of the Watershed

The Christina Basin Task Force schedules an annual tour of the watershed to review demonstration projects and other conservation work. Members of the public and agencies are invited to attend the bus tours. Over 40 people attended each tour on dates in June, 1996 and September, 1997. The Task Force intends to sponsor another tour in early fall 1998.

Christina Basin Brochure

The BVA published a three-color brochure summarizing the Christina Basin Water Quality Management Strategy. The popular brochure includes a map of the watershed, mission statement, explanation of the Christina Basin, troubled waters, and contacts for members of the Committee. Over 1,000 brochures have been distributed at meetings, conventions, seminars and through the mail.

Basin Scapes Homeowner's Guides

The BVA published a series of Basin Scapes Homeowner's Guides which advocate environmentally sound landscapes benefiting people, wildlife and the Christina Basin. The Basin Scapes Guides are adapted from the Chesapeake Bay "Bay Scapes" materials which advocate a "holistic" approach to watershed management through principles inspired by the relationships in the natural world. The Basin Scapes have become so popular that other areas like the Northampton County Conservation District (PA) have adapted the materials for their watershed. The color-coded Basin Scapes brochures provide information to homeowners on the following topics:

1. Basin Scapes for Wildlife Habit (Orange) - Recommends native trees and shrubs to attract species such as hummingbirds and butterflies.

2. Integrated Past Management (Yellow) - Encourages natural biological controls to control pests and reduce chemical pesticide use.

3. Conservation Landscaping (Purple) - Promotes landscaping management with natural lawn care and tree/shrub selection that work with nature to reduce pollution and enhance wildlife habitat.

4. Basin Scaping for the Long Term (Blue) - Incorporates native plantings in landscaping to minimize water use and lawn chemical use and provide cover and food for wildlife and reduce runoff.

5. Using Beneficial Plants (Green) - Lists the beneficial native plants that require less fertilizer and pesticides to reduce pollutants carried by rainwater.

6. Creating Landscape Diversity (Grey) - Advocates landscape diversity using ground covers, gardens, and hedges that increase infiltration and reduce runoff from land into local waterways.

7. Basin Scaping to Conserve Water (Tan) - Identifies opportunities to save and conserve water supplies in home landscapes.

Storm Drain Stenciling Project

The Chester County Conservation District sponsored a storm drain stenciling project to heighten public awareness about connection between illicit dumping and clean water. The CCCD prepared a stencil with a fish message which says "DON'T DUMP." In the Christina Basin, volunteers painted the fish message on street storm drains to remind everyone that nonpoint source pollution can harm aquatic life and humans. Volunteers were reminded that many home care lawn and garden products, if not applied correctly or disposed of properly, end up in the curb sidestorm drain. A door hanger was distributed to residences within the towns explaining where you can go to safely dispose and recycle this material. A "fish-shaped" door hanger was designed to remind the public that household chemicals, pesticides, fertilizers, used motor oil, and yard or pet wastes should never be dumped down the storm drain. Otherwise, debris, litter, and chemicals washed down storm drains ends up in local waterways like the Brandywine Creek. Over 300 storm drains were painted and 1500 fish messages have been distributed. The stenciling program attracted national attention and there were three requests from other organizations in the U.S. for information.

The following municipalities have participated in the Christina Basin Storm Drain Stenciling Project:

- West Chester Borough
- Parkesburg Borough
- Kennett Square Borough
- Avondale Borough
- Kennett Township
- West Goshen Township
- Uwchlan Township

6.2 BMP DEMONSTRATION PROJECTS

Friendfield Farm

Located in the head waters of the East Bank of the White Clay Creek, in London Township, Pennsylvania, Friendfield Farm has a horse operation. Approximately 1000 feet of White Clay Creek runs through the property. The landowners working with Landscape Architect, Jessie Farrell, and Nurseryman, Jim Plyer, developed a riparian corridor protection plan, fencing for livestock exclusion, native tree plantation, and wetland enhancement protection Best Management Practices. A portion of the cost of the project was funded by Phase I of the Christina Basin Program.

Hills of Sullivan

The Hills of Sullivan residential development is located along the Main Branch of the White Clay Creek in New Garden Township, Chester County. New homes are being developed on the hillside overlooking the creek. The local township along with developer, Judd Builders Inc., were concerned the typical stormwater management basin may cause more water quality impacts than the preconstruction overland flow conditions. As an alternative, most of the runoff from the lawn areas are diverted to a series of shallow level spreaders which cascade the stormwater safely off the hillside. Some infiltration takes place within the spreaders. Technical assistance was provided by the Christina Basin program.

Pocopson Township

In 1995, Pocopson Township, Pennsylvania began constructing a new township garage along the banks of the Pocopson Creek in the Brandywine Watershed. Pocopson Township supervisors, known for trend setting, were not comfortable with just putting up a simple garage building. Working with L.A. Kelly Gutshall and Landstudies in Oxford, Pocopson installed an innovative system to control stormwater from the buildings and parking areas. Infiltration beds were designed to handle the majority of stormwater from the building. A basin was enhanced for water quality and wetland planting. A low maintenance species of native grass was established to minimize cost and staffing time. The Christina Basin Program funded a portion of the cost for this project.

Modern Mushroom, Inc.

Modern Mushroom Farms, a leader in the agricultural industry for installing Best Management Practices for water quality, were working to resolve problems in using grass fields to spray areas with runoff water. Modern Mushrooms is situated along the Red Clay Creek in New Garden Township, Pennsylvania. Spray drift onto adjoining properties and frozen ground in the winter severely limited the use of one of their larger spray fields. A decision was made to establish a tree plantation on the field. A mixture of hybrid poplar and pine tree stock was planted in the late 1996. It is expected that once the trees are established the spray drift will no longer be a problem; the tree cover and drift will provide additional infiltration and the spray fields can be utilized in a limited capacity further into the winter. The Christina Basin Program provided partial funding for the plantings.

East Marlborough Wetland Treatment

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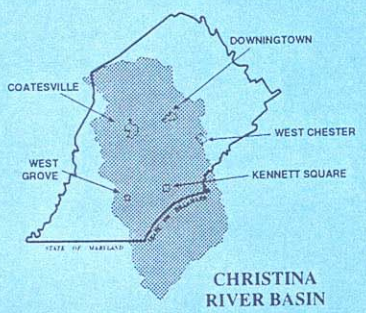

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CHAPTER 8. REFERENCES

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APPENDIX A

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APPENDIX B

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APPENDIX C

NONPOINT-SOURCE WATER-QUALITY-MONITORING PLAN FOR THE CHRISTINA RIVER BASIN

APPENDIX D

MAP 1 - GEOLOGY
MAP 2 - SOILS

APPENDIX E

MAP 3 - OUTFALLS/INTAKES

APPENDIX F

MAP 5 - LAND USE SUMMARIES

APPENDIX G

MAP 9 - HAZARDOUS WASTE, SUPERFUND, AND LANDFILL SITES

APPENDIX H

MAP 10 - EXISTING BEST MANAGEMENT PRACTICES

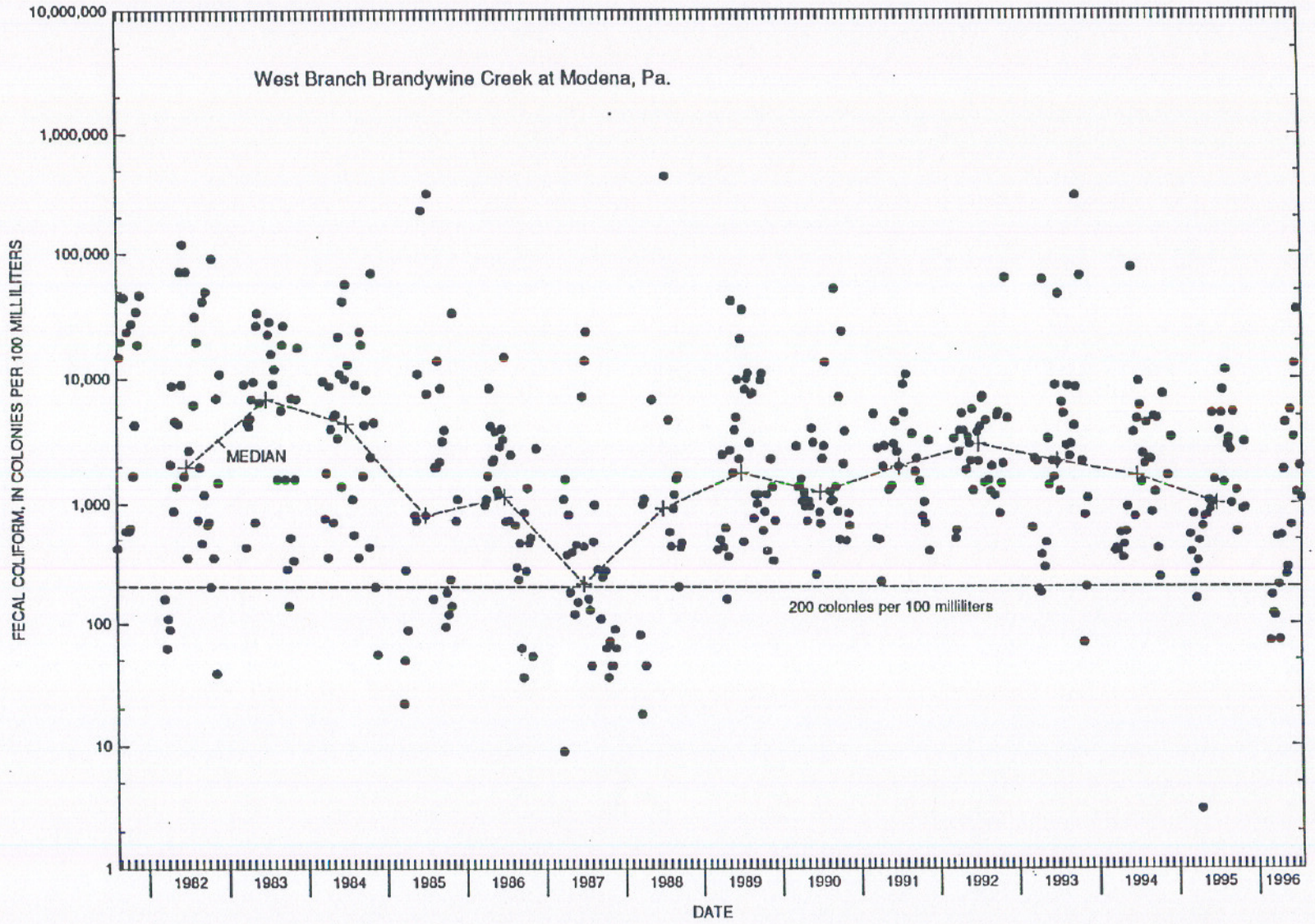
APPENDIX I

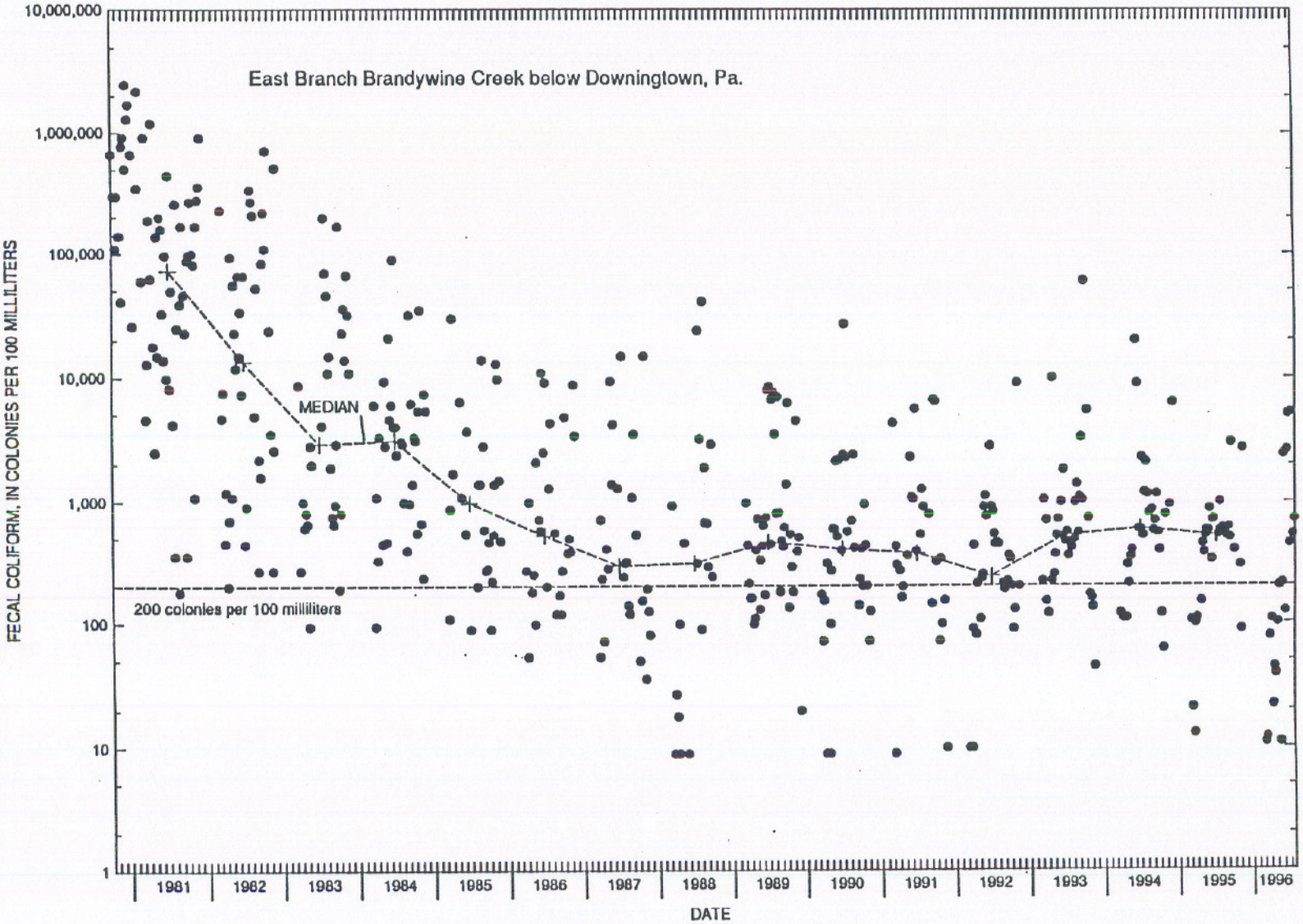
MAP 13 - TOTAL SUSPENDED SEDIMENT LOADS
MAP 14 - PERCENT IMPERVIOUS AREA FOR SUBWATERSHEDS

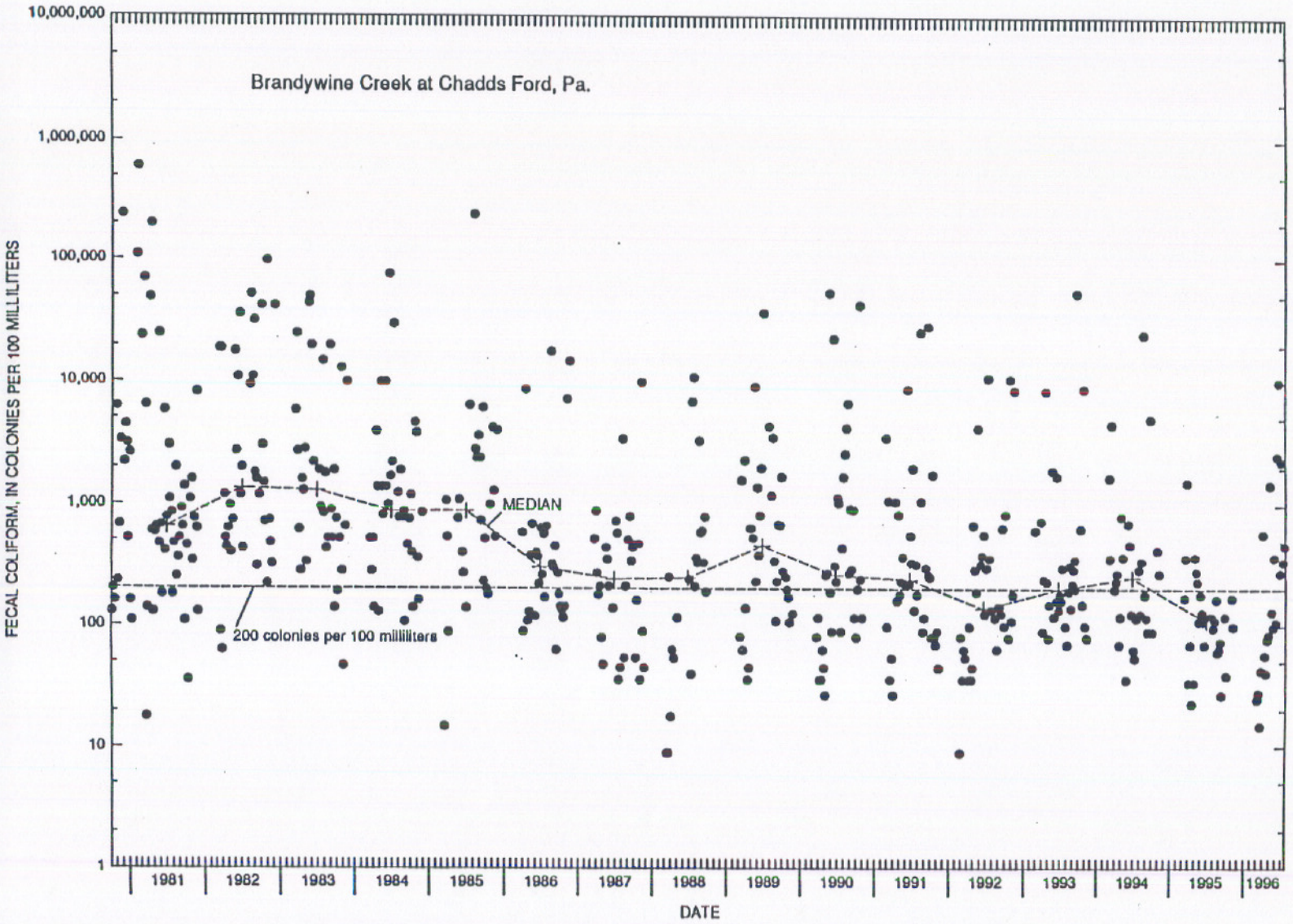
APPENDIX A

Fecal Coliform Bacteria Historic Trends for Brandywine Creek Basin (1981 to 1996)

Provisional data and calendar year median for fecal coliform counts as measured by U.S. Geological Survey for West Branch Brandywine Creek (at Modena), East Branch Brandywine Creek (below Downingtown), and mainstem Brandywine Creek (at Chadds Ford). Counts are reported as colonies per 100 milliliters. Human health criteria for skin contact of 200 colonies per 100 milliliters is also shown. Samples collected weekly from March through November at USGS stream gage stations. Bacteria monitoring conducted by USGS in conjunction with USGS/Chester County Water Resources Authority cooperative stream monitoring programs.


West Branch Brandywine Creek at Modena, Pa.
FECAL COLIFORM, IN COLONIES PER 100 MILLILITERS
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
MEDIAN
200 colonies per 100 milliliters
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
DATE


East Branch Brandywine Creek below Downingtown, Pa.
FECAL COLIFORM, IN COLONIES PER 100 MILLILITERS
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
MEDIAN
200 colonies per 100 milliliters
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
DATE


Brandywine Creek at Chadds Ford, Pa.
FECAL COLIFORM, IN COLONIES PER 100 MILLILITERS
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
MEDIAN
200 colonies per 100 milliliters
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
DATE

APPENDIX B

Biological Diversity Indices and Historic Trends (1971 through 1996)

U.S. Geological Survey provisional data and historic trends of biological diversity as expressed by Brillouin's Diversity Index. Data are presented for 15 biological monitoring stations in Brandywine Creek (10 stations), White Clay Creek (3 stations) and Red Clay Creek (2 stations). Monitoring program is conducted under USGS/Chester County Water Resources Authority cooperative programs.

Study Objectives and Methods of the Stream Conditions of Chester County Program

The major goal of the Stream Conditions of Chester County program is to assess the water-quality of streams in Chester County and to further the understanding of stream changes in response to urbanization.

Biological samples consisted of benthic macroinvertebrates collected from a riffle area. During each visit benthic macroinvertebrates were sampled by collecting 10 rocks (45-90 mm in diameter) at random (Lium, 1974). All invertebrates from the rocks were composited in a container and stored in 70 percent alcohol for later identification. A complete description of the sampling technique is described in a report by Moore (1987, p. 7). Benthic macroinvertebrate samples were analyzed at the U.S. Geological Survey office in Malvern, Pennsylvania. Total individuals, taxa richness, Brillouin's diversity index, EPT taxa, percent EPT, and percent dominate taxa were calculated for each benthic macroinvertebrate sample. Taxa richness is the number of different organisms (taxa) present in the sample. Brillouin's diversity index can be calculated by the following formula:

$$H = (C/N) \log_{10}(N!/N_1!N_2!....N_s!)$$

Where

H = diversity
C = 3.3219
N = Total number of individuals
s = number of taxa
N_i (i = 1, 2,...., s) = number of individuals in the i^{th} taxa

Brillouin's Diversity index is based on the different kinds of taxa present in a community and their relative abundances. In general, diversity is high if a community has many taxa and their abundances are evenly distributed; diversity is low if the taxa are few and their abundances are unevenly distributed (Moore, 1987). Brillouin's diversity can range from zero to infinity but usually is below five. Brillouin's diversity values below 1.0 are associated with waters receiving heavy levels of organic wastes, values between 1.0 and 3.0 are associated with waters receiving moderate levels of organic wastes, values

between 3.0 and 5.0 are associated with waters receiving little or no organic wastes (Wilhm and Dorris, 1968; Wilhm, 1970). Brillouin's diversity measures the effect of community stress and not pollution directly. Community stress may be the result of many factors including organic or toxic pollution, physical stress, or lack of habitat. Other information can be obtained from the number of taxa present in a community and their relative abundances. EPT taxa and percent EPT are measures of the number of organisms in the groups Ephemeroptera (Mayflies), Plecoptera (Stoneflies), and Trichoptera (Caddisflies). These groups tend to be sensitive to poor water quality. High values of EPT taxa and percent EPT is an indication of good water quality. Percent dominate taxa measures the dominance of the single most abundant taxon. Low values of percent dominate taxa indicate a diverse invertebrate community, which is an indication of good water quality.

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Table 1: Sampling sites, station numbers, names, drainage areas, and period of record for sites in the Christina River Basin

Site number	Station number	Name	Drainage area	Period of record	
				Biological	Chemical
26	01479800	East Branch Red Clay Creek near Five Point	10.2	1970-96	1970-96
27	01479680	West Branch Red Clay Creek at Kennett Square	9.79	1970-96	1970-96
28	01478120	East Branch White Clay Creek near Avondale	11.3	1970-95	1970-95
29	01478190	Middle Branch White Clay Creek near Wickerton	9.94	1970-95	1970-95
30	01478220	West Branch White Clay Creek near Chesterville	9.92	1970-95	1970-95
36	01480700	East Branch Brandywine Creek near Downingtown	60.6	1970-96	1970-96
37	01480434	West Branch Brandywine Creek at Rock Run	37.3	1970-96	1970-96
38	01480640	West Branch Brandywine Creek at Wawaset	134	1970-96	1970-96
39	01480950	East Branch Brandywine Creek at Wawaset	123	1979-96	1970-96
40	01481030	Brandywine Creek near Chadds Ford	291.	1972-95	1970-95
42	01480653	East Branch Brandywine Creek at Glenmoore	16.5	1973-95	1971-95
44	01480903	Valley Creek at Mullstiens Meadows near Downingtown	16.1	1973-95	1971-95
45	01480632	Doe Run at Springdell	11.8	1973-95	1971-95
46	01480629	Buck Run at Doe Run	22.6	1973-95	1971-95
47	01480656	Indian Run near Springton	4.26	1974-95	1971-95
48	01480648	East Branch Brandywine Creek near Cupola	5.98	1973-95	1971-95

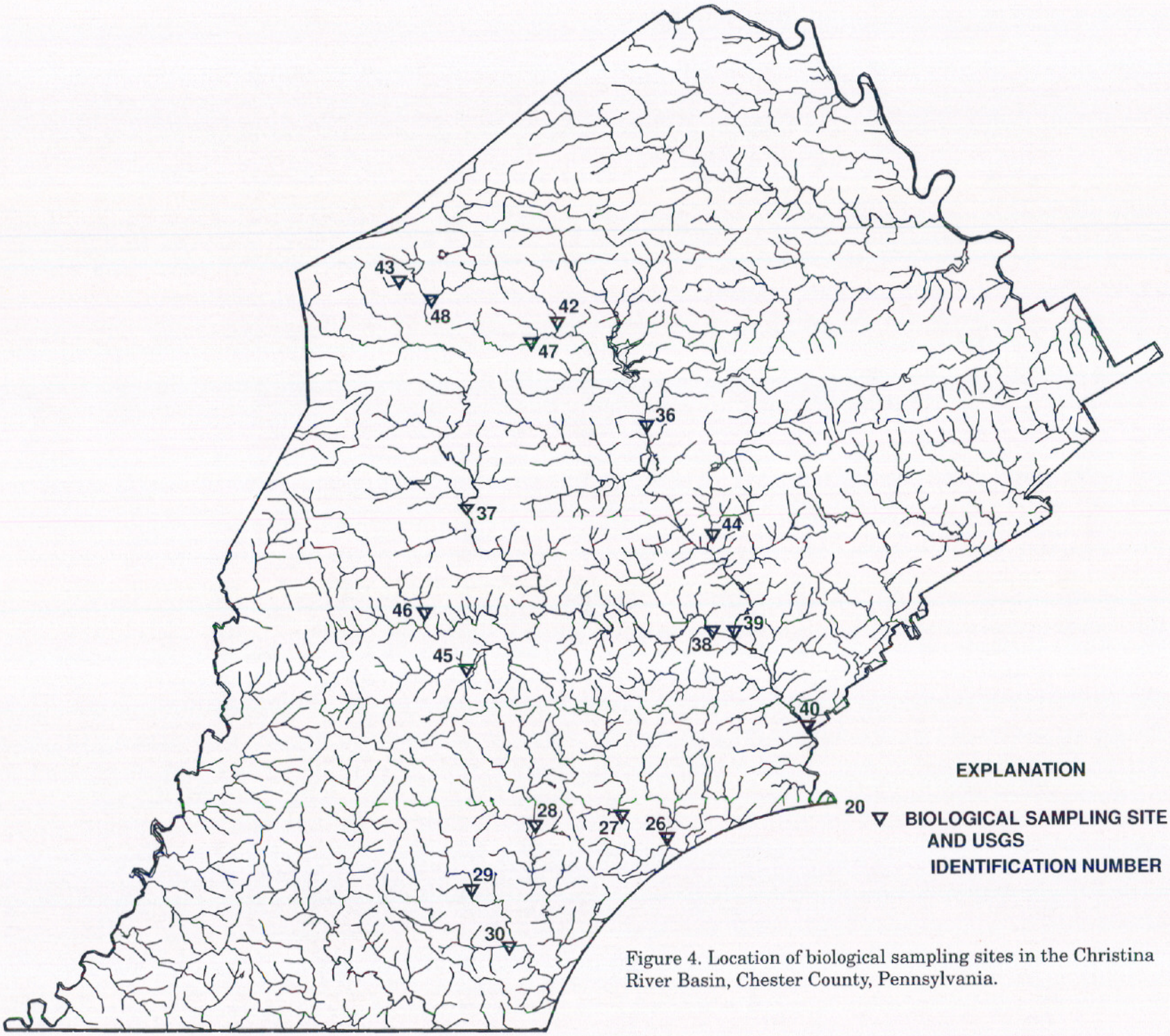
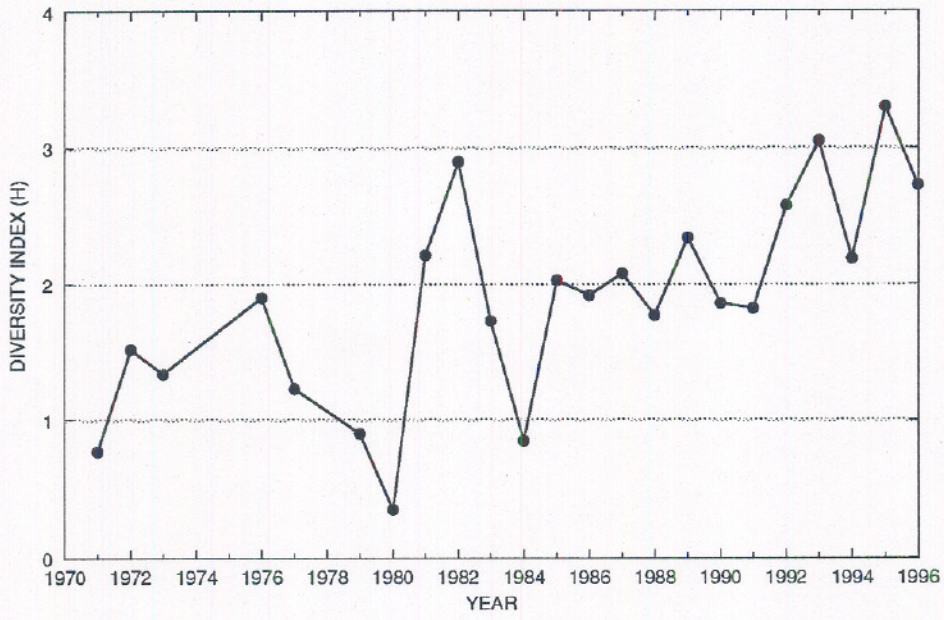


Figure 4. Location of biological sampling sites in the Christina River Basin, Chester County, Pennsylvania.

Table 1: Sampling sites, station numbers, names, drainage areas, and period of record for sites in the Chester County Biological Monitoring Network.

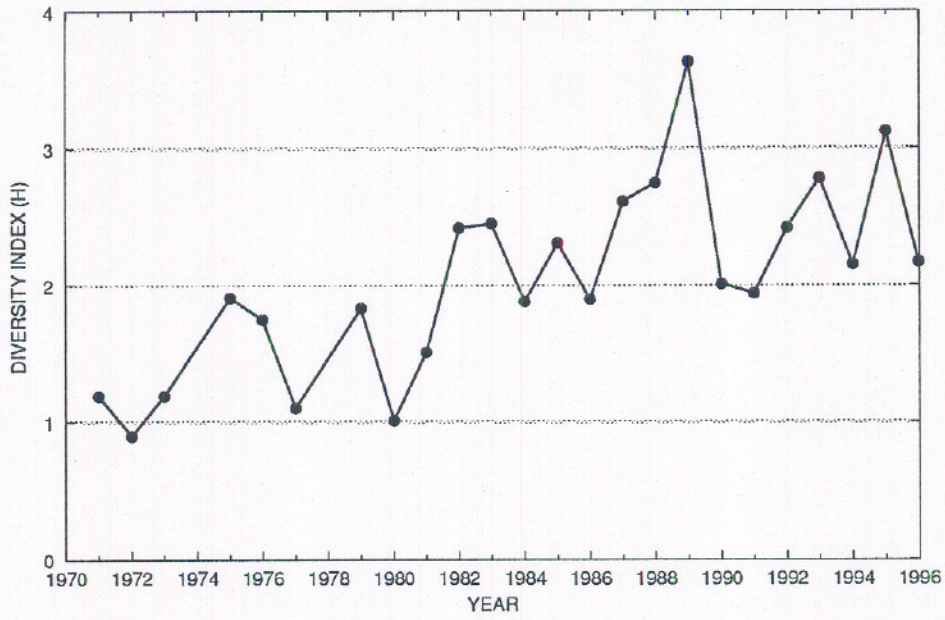
Site number	Station number	Name	Drainage area	Period of record	
				Biological	Chemical
1	01472170	Pickering Creek near Eagle	3.09	1970-96	1969-96
2	01472174	Pickering Creek near Chester Springs	5.98	1970-95	1969-95
3	014721854	Pickering Creek at Merlin	21.2	1970-95	1969-95
4	014721884	Pickering Creek at Charlestown Road at Charlestown	27.5	1972-96	1969-96
5	01472190	Pickering Creek near Phoenixville	31.4	1970-96	1969-96
6	01472109	Stony Run near Spring City	2.00	1970-96	1969-96
7	01472110	Stony Run at Spring City	4.07	1970-82	1969-82
8	01472054	Pidgon Creek near Bucktown	4.20	1970-82	1969-82
9	01472065	Pidgon Creek at Porters Mill	6.97	1970-82	1969-82
10	01472080	Pidgon Creek near Parker Ford	12.0	1970-96	1969-96
11	01472129	French Creek near Knauertown	11.7	1972-82	1969-82
12	01472140	South Branch French Creek at Coventryville	12.4	1970-95	1969-95
13	01472138	French Creek near Coventryville	19.9	1970-95	1969-95
14	01472154	French Creek near Pughtown	46.1	1970-95	1969-95
15	01472157	French Creek near Phoenixville	59.1	1970-96	1969-96
16	014721612	French Creek at Railroad Bridge at Phoenixville	70.7	1980-95	1970-95
17	01475300	Darby Creek at Waterloo Mills near Devon	5.15	1970-96	1969-96
18	01475830	Crum Creek near Paoli	6.16	1970-82	1969-82
19	01475840	Crum Creek at Whitehorse	10.1	1970-96	1969-96
20	01476430	Ridley Creek at Goshenville	4.22	1970-96	1969-96
21	01476435	Ridley Creek at Dutton Mill near West Chester	9.71	1970-96	1969-96
22	01476790	East Branch Chester Creek at Green Hill	0.63	1970-95	1969-95
23	01476830	East Branch Chester Creek at Milltown	5.77	1970-96	1969-96
24	01476835	East Branch Chester Creek at Westtown	10.4	1970-96	1969-96
25	01476840	Goose Creek Tributary to East Branch Chester Creek near West Chester	4.28	1975-82 1988-96	1970-82 1988-96
26	01479800	East Branch Red Clay Creek near Five Point	10.2	1970-96	1970-96
27	01479680	West Branch Red Clay Creek at Kennett Square	9.79	1970-96	1970-96
28	01478120	East Branch White Clay Creek near Avondale	11.3	1970-95	1970-95
29	01478190	Middle Branch White Clay Creek near Wickerton	9.94	1970-95	1970-95
30	01478220	West Branch White Clay Creek near Chesterville	9.92	1970-95	1970-95
31	01494900	East Branch Big Elk Creek at Elkview	11.1	1970-96	1970-96
32	01494950	West Branch Big Elk Creek near Oxford	10.0	1970-96	1970-96
33	01578340	East Branch Octoraro Creek at Christiana	11.8	1970-96	1970-96
34	01578343	Valley Creek at Atglen	10.5	1970-96	1970-96
35	01578345	East Branch Octoraro Creek at Steelville	32.9	1970-82	1970-82
36	01480700	East Branch Brandywine Creek near Downingtown	60.6	1970-96	1970-96
37	01480434	West Branch Brandywine Creek at Rock Run	37.3	1970-96	1970-96
38	01480640	West Branch Brandywine Creek at Wawaset	134	1970-96	1970-96
39	01480950	East Branch Brandywine Creek at Wawaset	123	1979-96	1970-96
40	01481030	Brandywine Creek near Chadds Ford	291.	1972-95	1970-95
41	01472126	French Creek at Trythall	5.06	1982	1970-82
42	01480653	East Branch Brandywine Creek at Glenmoore	16.5	1973-95	1971-95
43	01480647	East Branch Brandywine Creek near Struble Dam	4.36	1973-82	1971-82
44	01480903	Valley Creek at Mullstiens Meadows near Downingtown	16.1	1973-95	1971-95
45	01480632	Doe Run at Springdell	11.8	1973-95	1971-95
46	01480629	Buck Run at Doe Run	22.6	1973-95	1971-95
47	01480656	Indian Run near Springton	4.26	1974-95	1971-95
48	01480648	East Branch Brandywine Creek near Cupola	5.98	1973-95	1971-95
49	01473167	Little Valley Creek at Howellville	6.45	1973-96	1970-96
50	01473168	Valley Creek near Valley Forge	12.7	1973-96	1970-96
51	01476848	East Branch Chester Creek below Goose Creek near West Chester	19.2	1983-95	1970-95

SITE 26 EAST BRANCH RED CLAY CREEK NEAR FIVE POINT



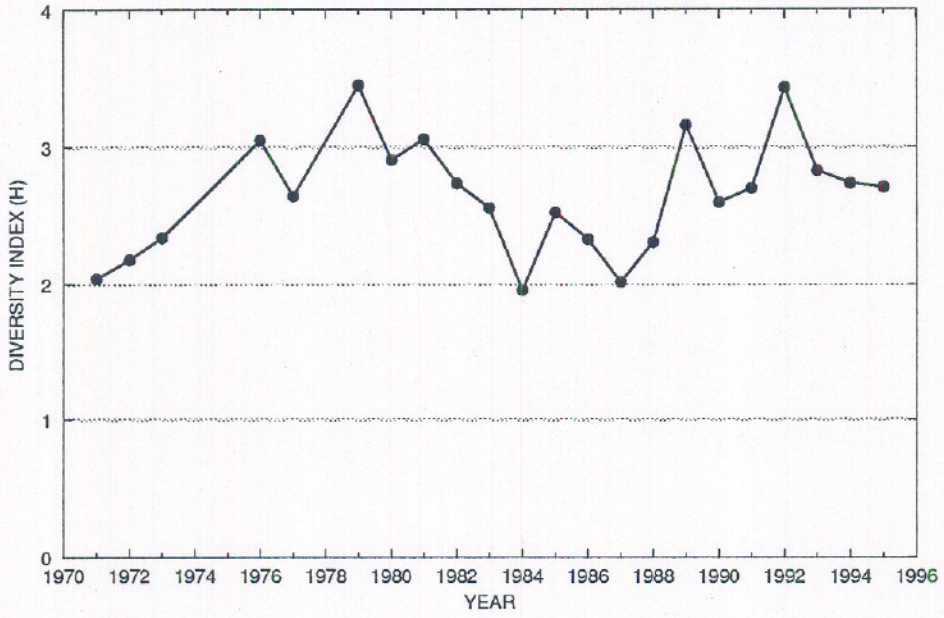
Year	# of Individuals	Taxa Richness	Brillouin's DI (H)	EPT Taxa	% EPT	% Dominate Taxa
1987	575	17	2.08	3	2.96	40.52
1988	919	11	1.77	0	0.00	60.39
1989	545	17	2.34	3	0.92	49.54
1990	2667	19	1.86	4	0.22	60.40
1991	696	15	1.82	2	0.43	62.64
1992	1053	26	2.58	7	1.33	49.86
1993	763	23	3.05	5	10.09	36.70
1994	998	21	2.19	6	4.51	51.20
1995	514	22	3.30	8	48.64	16.34
1996	1240	22	2.73	7	29.11	33.23

SITE 27 WEST BRANCH RED CLAY CREEK AT KENNETT SQUARE



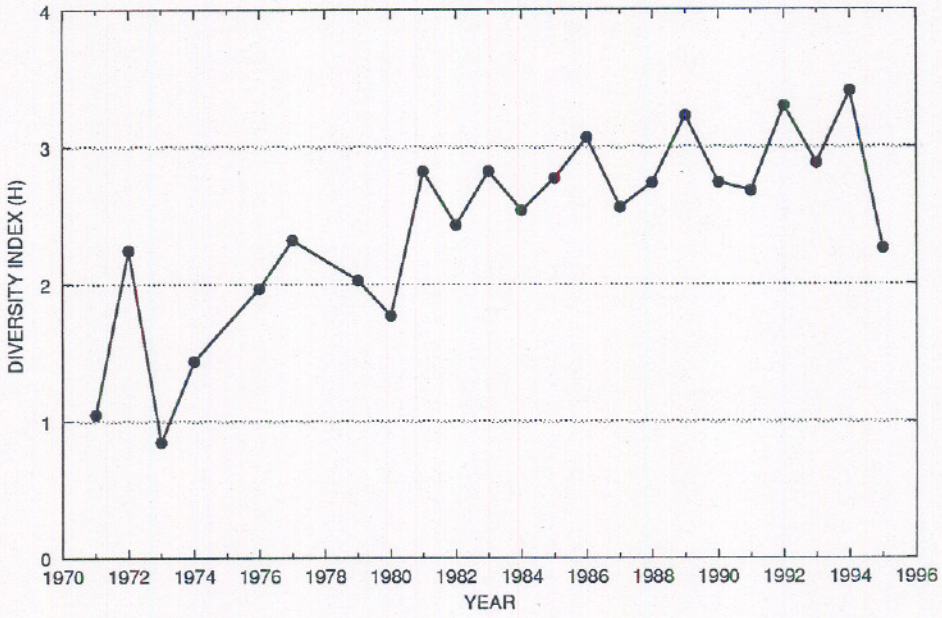
Year	# of Individuals	Taxa Richness	Brillouin's DI (H)	EPT Taxa	% EPT	% Dominate Taxa
1987	267	15	2.61	1	0.37	29.21
1988	543	17	2.75	3	1.10	39.96
1989	759	33	3.63	15	40.32	16.47
1990	1821	26	2.01	6	3.51	64.63
1991	420	14	1.94	3	6.43	55.95
1992	413	14	2.42	3	42.86	41.89
1993	838	28	2.78	7	8.59	35.80
1994	918	24	2.15	7	2.94	57.30
1995	323	22	3.12	6	14.24	31.89
1996	178	15	2.17	6	15.17	51.12

SITE 28 EAST BRANCH WHITE CLAY CREEK NEAR AVONDALE



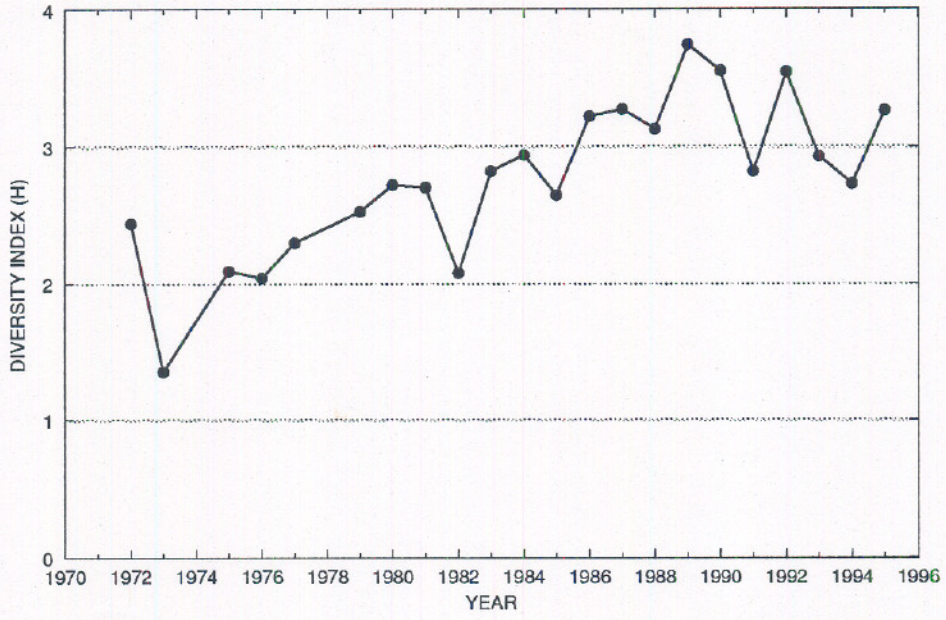
Year	# of Individuals	Taxa Richness	Brillouin's DI (H)	EPT Taxa	% EPT	% Dominate Taxa
1987	4216	19	2.02	7	8.44	45.59
1988	2599	19	2.31	9	28.43	49.33
1989	1798	29	3.16	14	48.22	24.25
1990	1486	20	2.60	8	30.35	37.42
1991	2009	19	2.70	11	28.87	38.43
1992	2504	29	3.43	13	33.11	25.76
1993	2084	27	2.83	14	23.03	39.16
1994	1779	28	2.74	14	23.89	37.21
1995	1543	28	2.71	11	20.93	41.02
1996	--	--	--	--	--	--

SITE 29 MIDDLE BRANCH WHITE CLAY CREEK NEAR WICKERTON



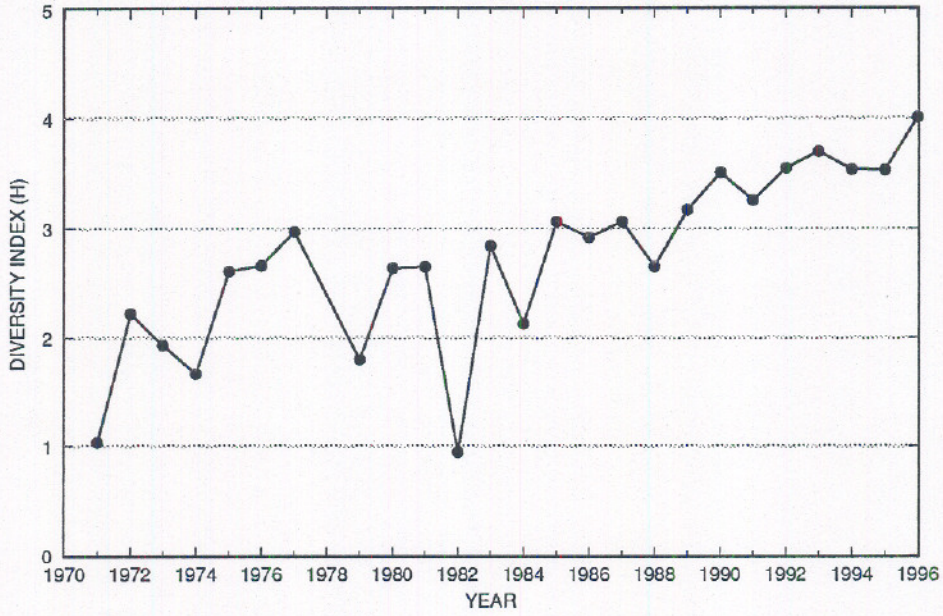
Year	# of Individuals	Taxa Richness	Brillouin's DI (H)	EPT Taxa	% EPT	% Dominate Taxa
1987	1317	23	2.56	9	32.27	39.71
1988	3469	21	2.74	9	58.86	30.04
1989	1438	26	3.23	12	41.72	22.81
1990	2010	29	2.74	13	44.13	37.71
1991	2458	24	2.68	12	51.75	36.21
1992	1456	32	3.30	13	55.77	26.79
1993	821	19	2.88	10	72.59	27.53
1994	1909	24	3.41	12	51.81	20.38
1995	1841	28	2.26	14	38.35	33.68
1996	--	--	--	--	--	--

SITE 30 WEST BRANCH WHITE CLAY CREEK NEAR CHESTERVILLE



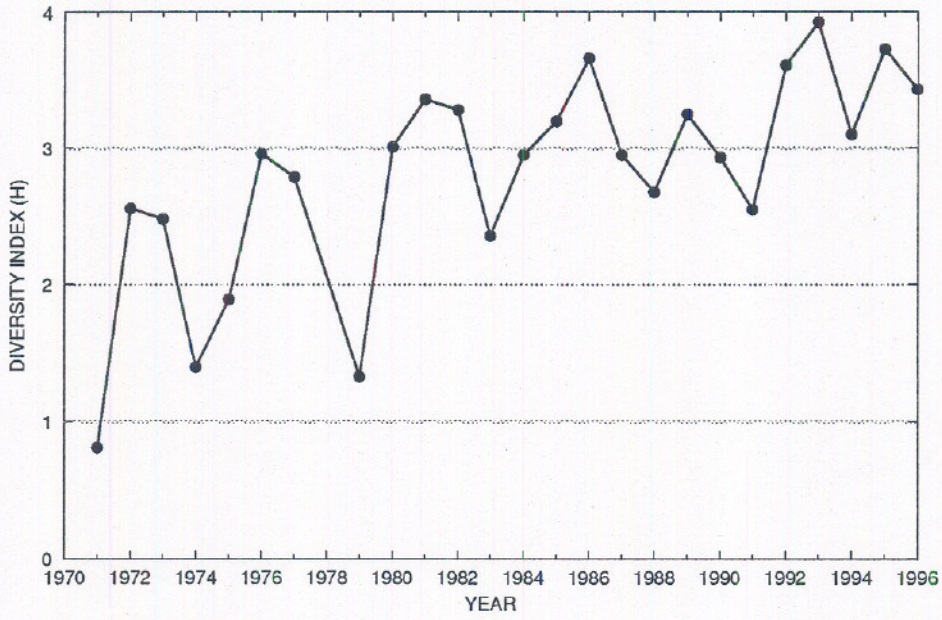
Year	# of Individuals	Taxa Richness	Brillouin's DI (H)	EPT Taxa	% EPT	% Dominate Taxa
1987	1647	24	3.27	14	64.54	17.36
1988	2071	23	3.13	14	80.64	27.81
1989	1110	34	3.74	17	56.58	21.53
1990	1789	29	3.55	16	64.06	24.93
1991	1423	27	2.82	17	59.24	32.75
1992	1480	34	3.54	17	58.58	23.92
1993	1262	33	2.93	18	37.64	45.64
1994	1024	25	2.73	16	50.00	28.52
1995	637	30	3.26	18	38.78	36.11
1996	--	--	--	--	--	--

SITE 36 EAST BRANCH BRANDYWINE CREEK NEAR DOWNINGTOWN



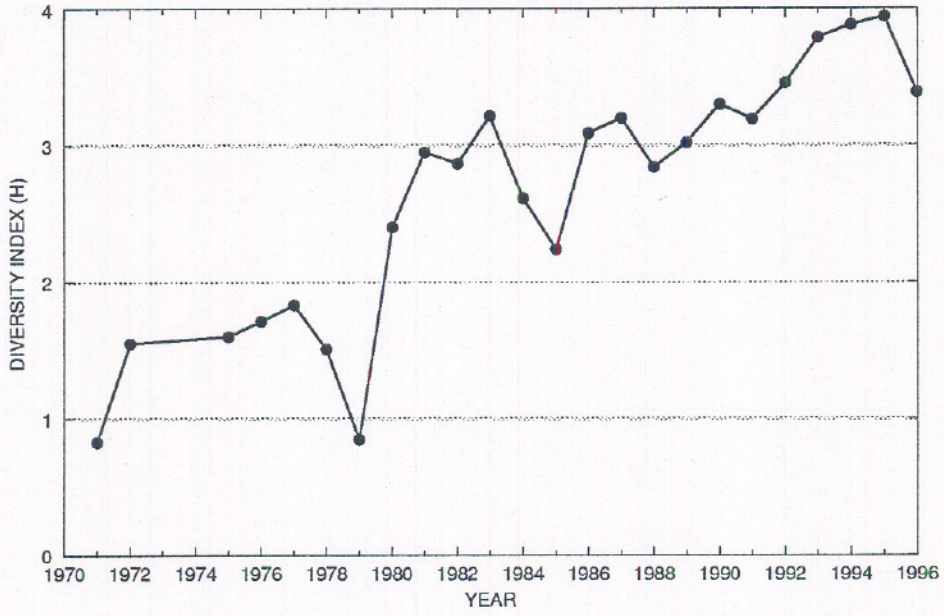
Year	# of Individuals	Taxa Richness	Brillouin's DI (H)	EPT Taxa	% EPT	% Dominate Taxa
1987	2184	31	3.06	18	50.18	38.23
1988	1498	24	2.65	16	64.55	40.05
1989	2202	41	3.17	23	37.33	44.41
1990	2491	46	3.51	26	65.56	24.93
1991	1401	41	3.26	26	59.60	30.05
1992	2416	46	3.55	28	46.11	36.22
1993	1895	49	3.70	29	76.68	27.39
1994	1021	38	3.54	23	80.22	28.60
1995	1508	41	3.53	26	65.78	31.56
1996	1347	49	4.01	27	49.07	19.38

SITE 37 WEST BRANCH BRANDYWINE CREEK AT ROCK RUN



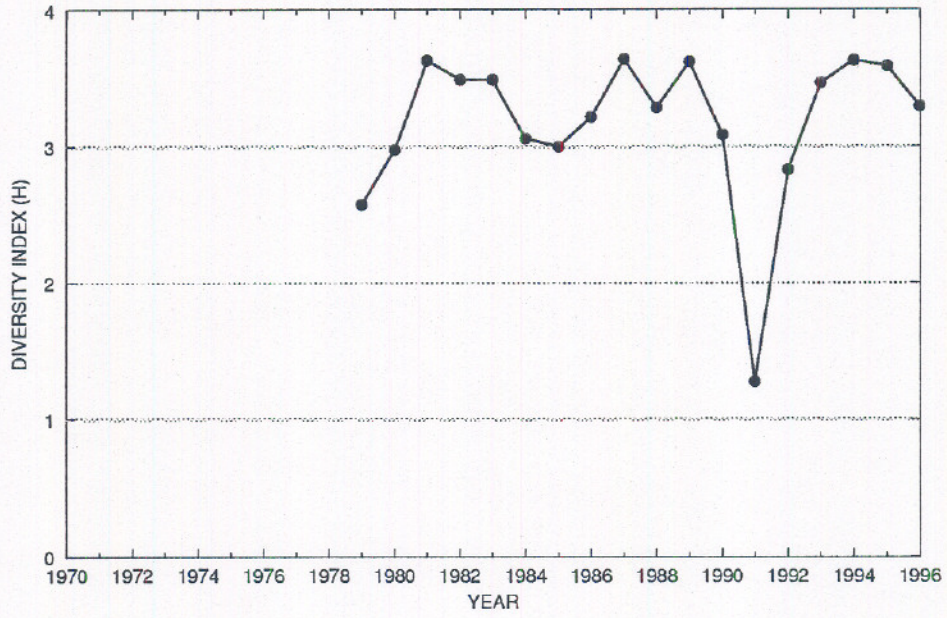
Year	# of Individuals	Taxa Richness	Brillouin's DI (H)	EPT Taxa	% EPT	% Dominate Taxa
1987	1278	36	2.95	21	52.90	41.24
1988	1190	28	2.68	16	84.96	51.60
1989	1404	37	3.25	19	58.48	33.62
1990	1020	29	2.93	21	73.14	40.29
1991	1836	38	2.55	23	33.44	57.08
1992	1370	38	3.61	22	57.52	28.18
1993	662	31	3.27	18	52.72	31.27
1994	1471	32	3.10	18	52.75	33.51
1995	440	36	3.73	18	46.36	28.41
1996	511	27	3.43	17	73.78	25.44

SITE 38 WEST BRANCH BRANDYWINE CREEK AT WAWASET



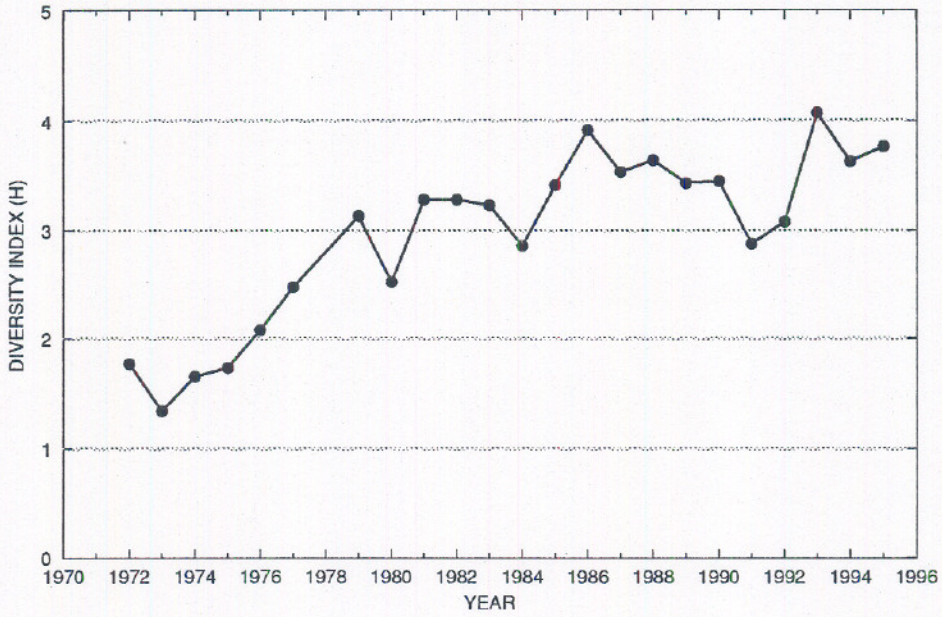
Year	# of Individuals	Taxa Richness	Brillouin's DI (H)	EPT Taxa	% EPT	% Dominate Taxa
1987	402	23	3.20	13	54.73	23.63
1988	1941	22	2.84	13	83.62	37.66
1989	1633	31	3.02	15	46.42	37.29
1990	1533	39	3.30	22	69.08	31.31
1991	1412	31	3.19	17	70.18	33.43
1992	1041	34	3.46	18	40.63	32.56
1993	770	39	3.79	20	52.47	22.47
1994	1005	37	3.88	23	81.99	13.53
1995	547	43	3.94	22	62.71	25.05
1996	861	30	3.39	14	53.77	29.04

SITE 39 EAST BRANCH BRANDYWINE CREEK AT WAWASET



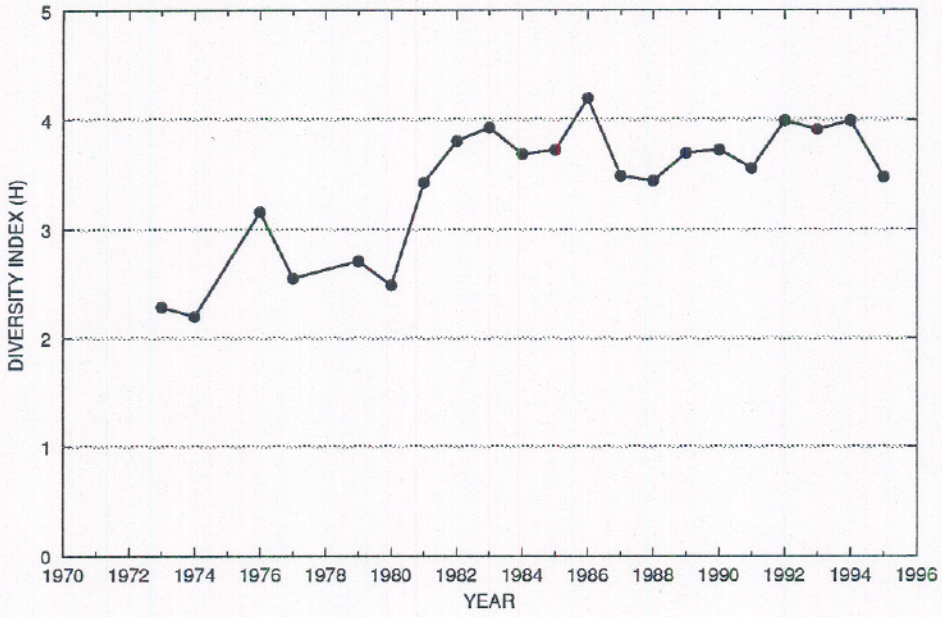
Year	# of Individuals	Taxa Richness	Brillouin's DI (H)	EPT Taxa	% EPT	% Dominate Taxa
1987	1110	40	3.64	17	60.09	28.65
1988	1354	28	3.29	16	76.37	23.63
1989	2690	40	3.62	19	56.51	22.53
1990	3773	44	3.09	21	63.40	34.08
1991	11753	50	1.28	21	89.44	82.40
1992	1358	19	2.83	10	49.34	35.35
1993	1694	33	3.47	13	61.16	17.00
1994	787	41	3.63	18	35.96	31.77
1995	307	33	3.59	14	58.63	23.13
1996	880	32	3.30	15	33.86	34.89

SITE 40 BRANDYWINE CREEK NEAR CHADDS FORD



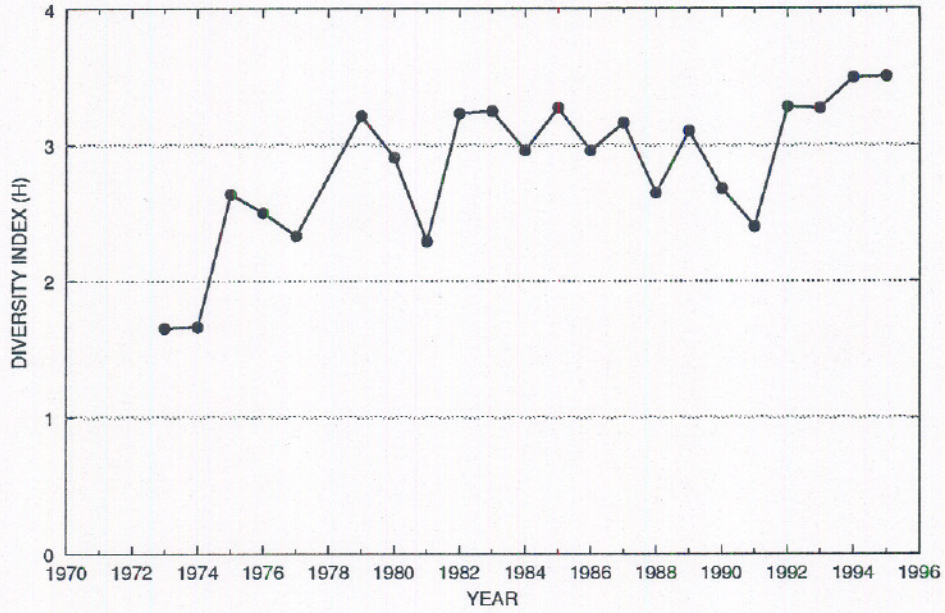
Year	# of Individuals	Taxa Richness	Brillouin's DI (H)	EPT Taxa	% EPT	% Dominate Taxa
1987	1049	37	3.53	21	36.42	36.51
1988	1819	25	3.64	16	65.64	19.19
1989	2153	37	3.43	19	55.83	30.75
1990	1696	31	3.45	19	46.29	31.66
1991	2360	31	2.88	18	39.49	49.58
1992	1839	29	3.08	17	63.38	28.40
1993	1141	36	4.02	21	57.67	15.34
1994	1412	32	3.63	21	78.54	16.71
1995	1208	33	3.77	16	67.22	22.68
1996	--	--	--	--	--	--

SITE 42 EAST BRANCH BRANDYWINE CREEK AT GLENMOORE



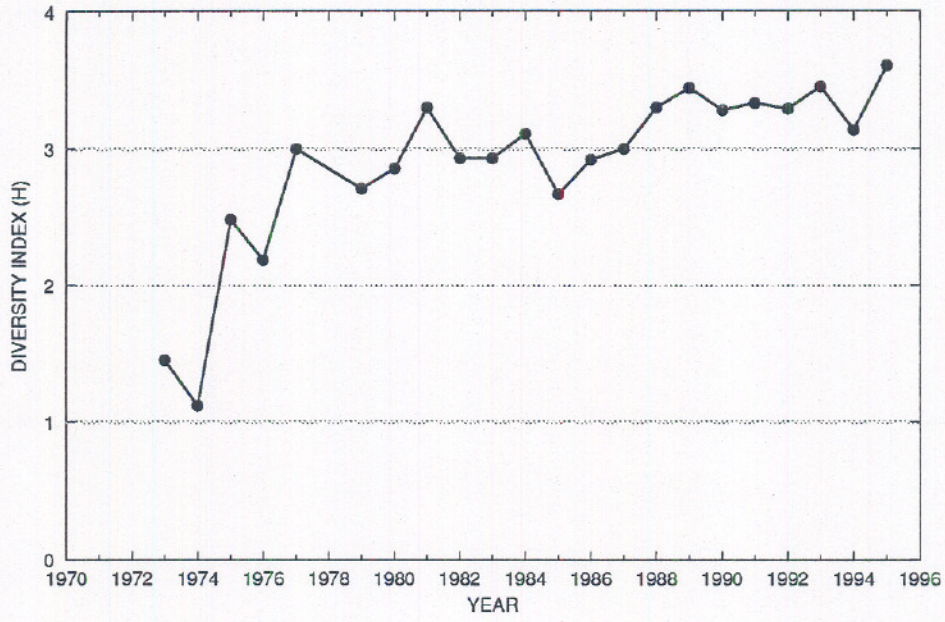
Year	# of Individuals	Taxa Richness	Brillouin's DI (H)	EPT Taxa	% EPT	% Dominate Taxa
1987	1438	36	3.49	22	67.18	27.12
1988	1662	33	3.45	19	59.81	27.44
1989	2619	46	3.70	22	45.13	25.47
1990	946	41	3.73	22	46.16	20.95
1991	1824	42	3.56	20	48.96	30.21
1992	1326	50	3.99	29	38.84	20.74
1993	1552	48	3.91	25	53.41	17.07
1994	1373	47	3.99	27	57.83	18.43
1995	625	34	3.48	18	30.40	22.40
1996	--	--	--	--	--	--

SITE 44 VALLEY CREEK AT MULLSTEINS MEADOW NEAR DOWNINGTOWN



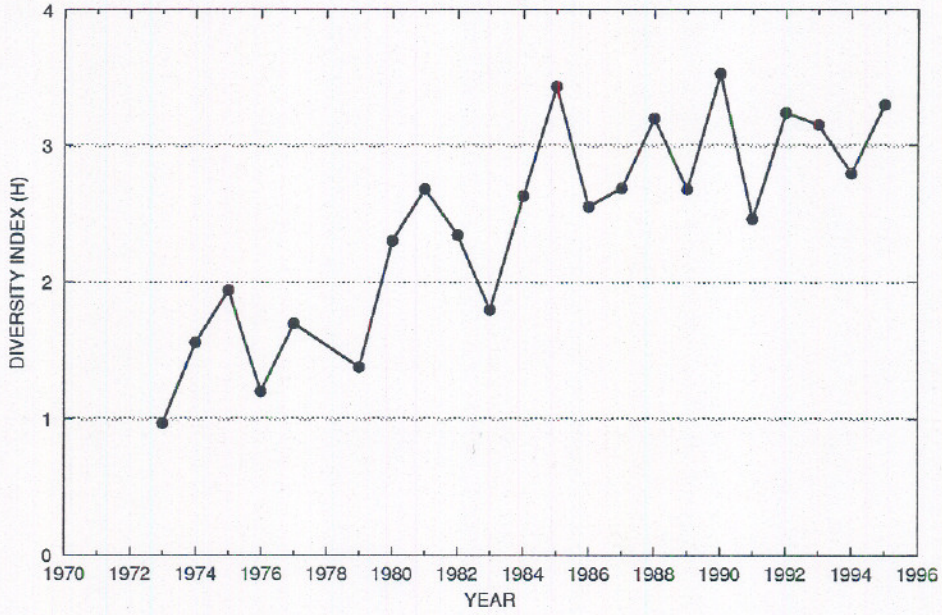
Year	# of Individuals	Taxa Richness	Brillouin's DI (H)	EPT Taxa	% EPT	% Dominate Taxa
1987	2352	33	3.16	19	64.07	26.87
1988	2631	22	2.65	15	74.84	45.80
1989	1106	30	3.10	16	76.31	32.64
1990	1091	28	2.68	14	81.03	50.96
1991	1492	21	2.40	13	50.67	38.87
1992	1381	28	3.28	18	52.35	22.45
1993	1172	36	3.27	20	59.64	23.55
1994	1164	27	3.49	14	55.33	22.51
1995	1327	34	3.50	19	46.80	18.39
1996	--	--	--	--	--	--

SITE 45 DOE RUN AT SPRINGDELL



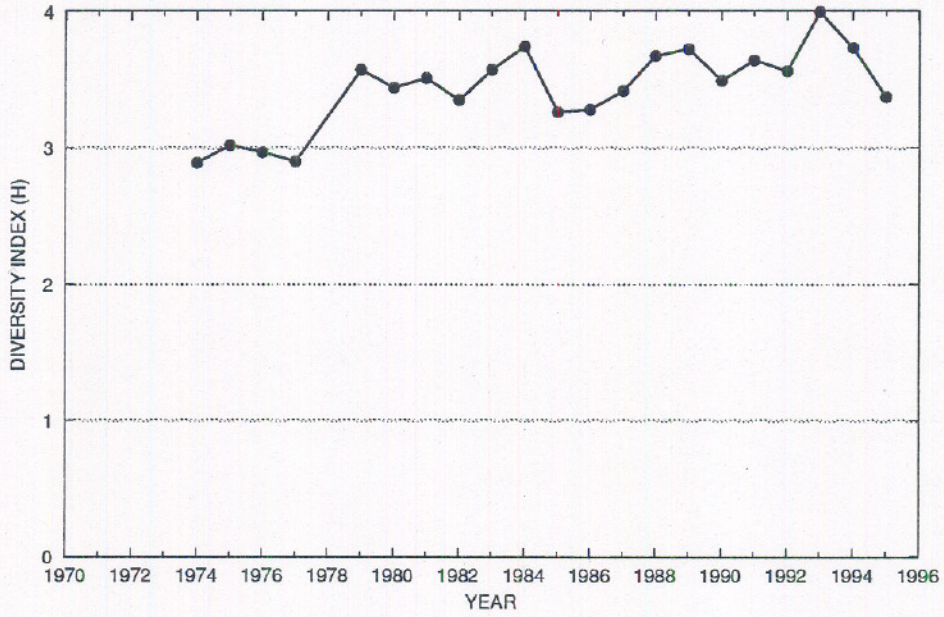
Year	# of Individuals	Taxa Richness	Brillouin's DI (H)	EPT Taxa	% EPT	% Dominate Taxa
1987	1619	26	3.00	13	61.52	43.65
1988	1808	22	3.30	15	71.96	25.11
1989	1427	34	3.44	18	79.47	24.53
1990	1755	25	3.28	15	61.94	29.63
1991	1389	29	3.33	15	49.32	21.74
1992	1189	23	3.29	14	54.42	20.86
1993	1220	32	3.45	16	75.90	24.26
1994	1300	23	3.14	11	67.38	20.69
1995	820	32	3.60	20	48.90	25.24
1996	--	--	--	--	--	--

SITE 46 BUCK RUN AT DOE RUN



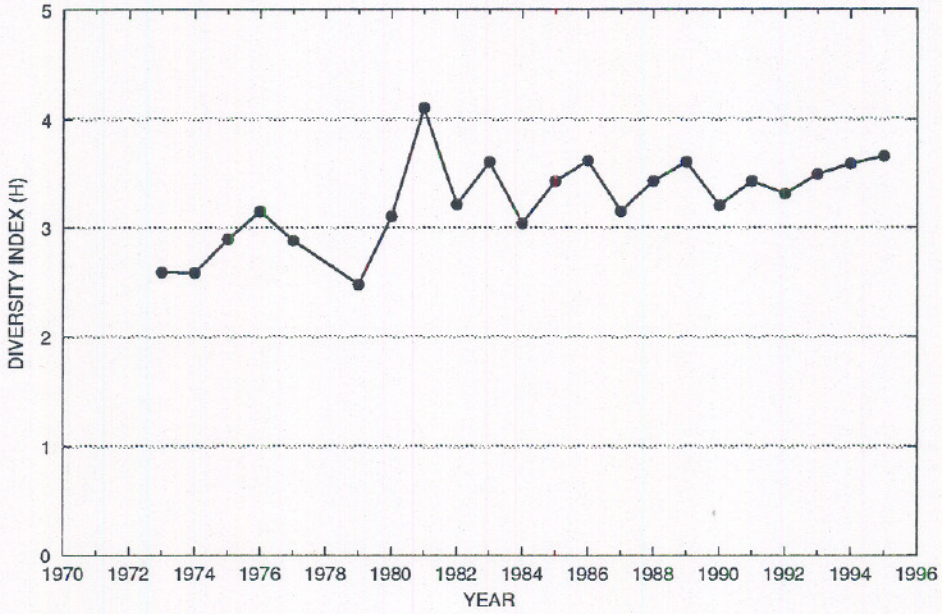
Year	# of Individuals	Taxa Richness	Brillouin's DI (H)	EPT Taxa	% EPT	% Dominate Taxa
1987	1645	25	2.69	11	60.91	43.16
1988	2065	24	3.20	15	68.47	35.64
1989	1361	32	2.68	13	82.51	49.52
1990	1808	39	3.53	19	57.74	23.45
1991	1752	26	2.46	13	83.05	55.76
1992	1431	34	3.24	16	77.36	33.75
1993	1396	31	3.15	16	69.48	36.32
1994	2608	24	2.80	13	73.39	34.24
1995	674	27	3.38	10	44.81	24.04
1996	--	--	--	--	--	--

SITE 47 INDIAN RUN NEAR SPRINGTON



Year	# of Individuals	Taxa Richness	Brillouin's DI (H)	EPT Taxa	% EPT	% Dominate Taxa
1987	641	35	3.42	19	46.18	39.16
1988	789	29	3.67	21	74.78	21.93
1989	1281	32	3.72	18	53.86	30.05
1990	837	32	3.49	20	41.82	32.14
1991	593	31	3.64	21	54.97	29.34
1992	440	25	3.56	17	63.41	17.05
1993	773	34	3.99	22	52.91	19.79
1994	1232	34	3.73	20	53.08	31.17
1995	647	33	3.37	19	44.82	28.59
1996	--	--	--	--	--	--

SITE 48 EAST BRANCH BRANDYWINE CREEK NEAR CUPOLA



Year	# of Individuals	Taxa Richness	Brillouin's DI (H)	EPT Taxa	% EPT	% Dominate Taxa
1987	1139	31	3.15	14	30.90	40.91
1988	1985	32	3.43	15	33.40	29.82
1989	3842	46	3.61	24	42.43	24.75
1990	537	25	3.20	14	26.26	20.86
1991	928	37	3.43	21	29.74	35.78
1992	610	25	3.31	11	50.98	26.23
1993	2019	49	3.49	24	13.17	28.97
1994	968	31	3.59	14	32.85	24.48
1995	648	35	3.66	20	28.86	17.59
1996	--	--	--	--	--	--

APPENDIX C

NONPOINT-SOURCE WATER-QUALITY-MONITORING PLAN FOR THE CHRISTINA RIVER BASIN

NONPOINT-SOURCE WATER-QUALITY-MONITORING PLAN FOR THE CHRISTINA RIVER BASIN

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October 25, 1996
revised May 27, 1997; August 31, 1997; March 31, 1998;
and May 13, 1998

NONPOINT-SOURCE WATER-QUALITY-MONITORING PLAN FOR THE CHRISTINA RIVER BASIN

1.0 INTRODUCTION

1.1 Background

The Christina River Basin drains 565 square miles in southeastern Pennsylvania and northern Delaware. The basin encompasses the watersheds of four main streams, the Red Clay, White Clay, and Brandywine Creeks and the Christina River (fig. 1). Streams in the Christina River are used for drinking water supplies, for recreation, and as receiving waters for discharges of municipal and industrial effluent. Water-quality problems in the basin identified by previous studies include elevated levels of bacteria, nutrients, suspended solids (sediment), and toxic compounds.

Cooperative efforts by the Pennsylvania Department of Environmental Protection (PaDEP) and the Delaware Department of Natural Resources and Environmental Control (DNREC) to assess the effects of point-source pollution resulted in a monthly surface-water sampling plan begun in 1994. However, the effects of nonpoint pollution on stream quality are not well known. The states, in conjunction with the U.S. Environmental Protection Agency (USEPA) and the Delaware River Basin Commission (DRBC), determined that a watershed model of the basin may be needed. The model could be used to (1) evaluate stream water quality, (2) evaluate options for managing contaminants from both nonpoint and point sources, and (3) provide a more comprehensive method of calculating loads to meet total maximum daily load requirements. Data required for a watershed model include concentrations of contaminants of interest over a range of hydrologic conditions, including stormflow and baseflow, in land-use areas that are expected to differ in contribution of nonpoint-source contaminants and hydrologic response. The existing monthly monitoring plan does not provide the stormflow data or data on nonpoint-source contamination from specific land uses, therefore, additional sampling is needed. The monitoring program proposed in this document would fill these gaps.

1.2 Purpose and scope

This document describes a nonpoint-source water-quality monitoring plan for the Christina River Basin, Pennsylvania and Delaware. The sampling plan is designed to provide data on the concentrations and loads of nutrients and suspended solids seasonally over a range of hydrologic conditions, including both high flow associated with storms and base flow, for the whole basin and for selected small areas predominantly covered by one land use. The plan also provides for data collection at various critical seasons (see section 2.2) during the proposed one-year monitoring period beginning in late summer or early fall 1997.

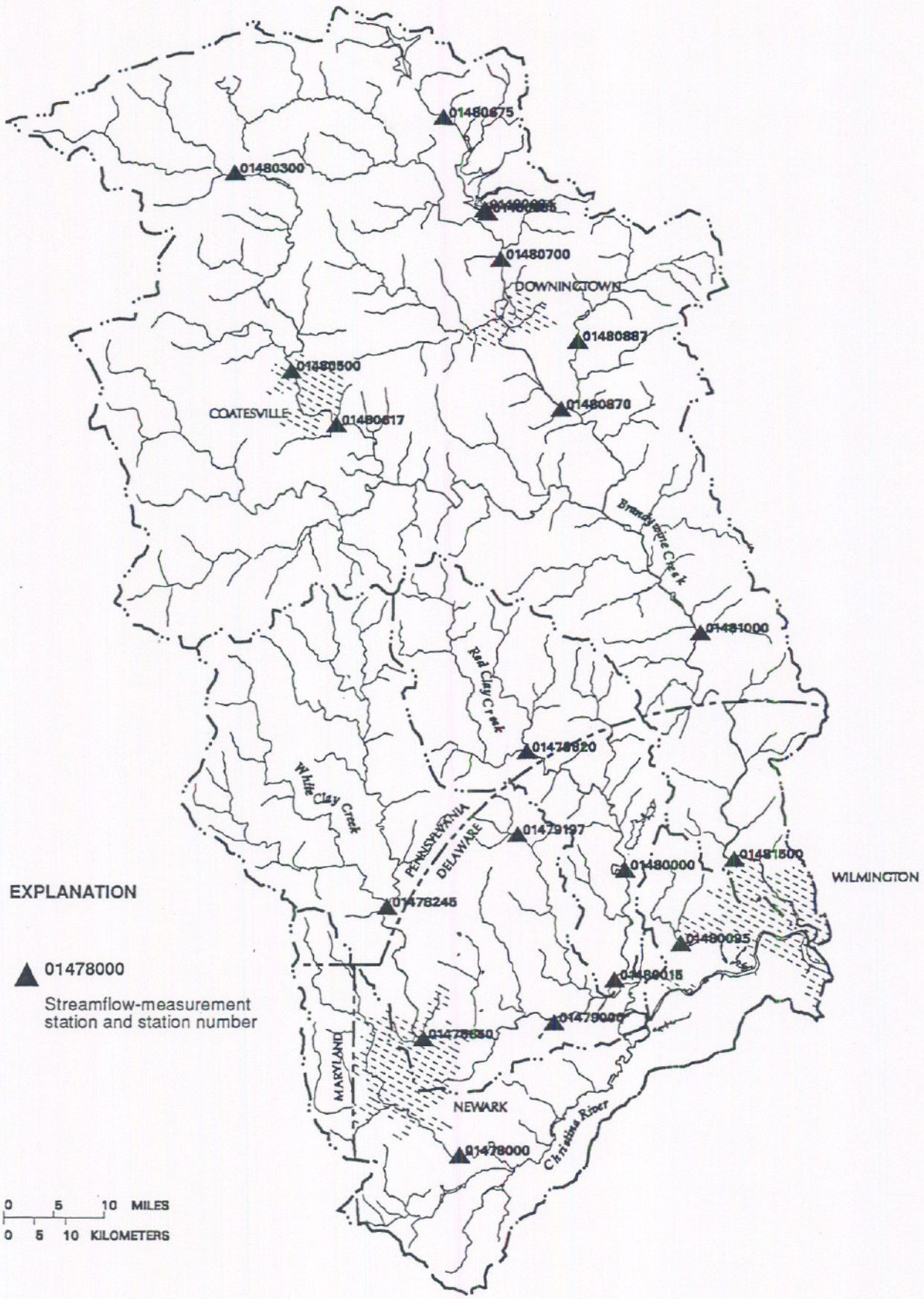

Figure 1.--The Christina River Basin and four subbasins -White Clay, Red Clay, and Brandywine Creeks and Christina River - and locations of active or recently active streamflow-measurement stations, fall 1996.

Data collected using this plan can be used to estimate total annual loads of nutrients and suspended solids (sediment) to the Christina River estuary and at other locations within the Christina River Basin. The data can also be used to target nutrient- and sediment-control measures for small scale water-quality improvement projects. Finally, execution of the plan will provide data for calibration of a watershed model (HSPF) that will be used to simulate nonpoint-source loading and transport of nutrients and sediment to streams in the basin.

The plan describes the methods, frequency, timing, duration, and locations for stream sampling. In addition, the plan also estimates the personnel required to execute the sampling protocol, calculates the number of environmental and quality-assurance samples required, and provides guidelines for data reporting and quality assurance. Cost estimates for work to be done by USGS are included.

1.3 Objectives

The principal objective of the nonpoint-source water-quality sampling plan is to provide streamflow, nutrient, and suspended solids data that can be used to: (1) estimate total loads to the Christina River Basin from point and nonpoint sources for selected constituents -- nitrate, phosphorous, and suspended sediment; (2) estimate concentrations and loads of the selected constituents from various land uses; and (3) calibrate a watershed model of the basin for these selected constituents. The proposed watershed model for the Christina River Basin is the Hydrologic Simulation Program--Fortran (HSPF) that can simulate the hydrodynamics, chemical reactions, and sediment transport in the stream and the delivery of nonpoint-source contaminants to the stream.

1.4 Previous and ongoing investigations

The Brandywine River, the largest of the four streams in the Christina River Basin, has been studied more extensively than the other streams. Wolman (1955) studied channel geometry and its relation to fluvial processes. Miller and others (1971) describe the hydrology of the East Branch Brandywine Creek, including drainage area-discharge relations, suspended-sediment transport, chemical quality of streamflow, ground-water discharge and quality, and stream fauna. Suspended-sediment data were collected daily at two streamflow measurements stations -- 01481000 Brandywine Creek at Chadds Ford, Pa. (1963-70) and 01481500 Brandywine Creek at Wilmington, Delaware (1947-70) (Ott and Cummings, 1972). For these two stations, data on particle size were collected, and transport curves were calculated. Guy (1957) examined the relation between rainfall, runoff, and suspended-sediment transport for data collected at Brandywine Creek at Wilmington, Delaware. Sloto (1982) developed rainfall-runoff models for three subbasins in the West Branch Brandywine Creek. Murphy and others (1982) evaluated data on dissolved oxygen, pH, temperature and specific conductance for three continuous monitoring locations on the Brandywine Creek. Moore (1987) described trends in water quality based on benthic invertebrate indices at selected sites on the Red Clay, White Clay and Brandywine Creeks in Chester County.

Hardy and others (1995) discussed the relation between land use and benthic invertebrates indices for selected streams in Chester County, including sites in the Red Clay and Brandywine Creeks. A compilation and assessment of existing water-quality data, and identification of problem areas was done for the Brandywine Creek in 1993 (Science Applications International Corporation, 1993).

The Red Clay Creek has been studied largely because of the presence of toxic substances including pesticides, metals, and PCB's present in the sediments. Reports were prepared by Roy F. Weston, Inc. (1988), Green and others (1992), and Rice (1993). A recent draft watershed plan and environmental assessment stated that the Red-White Clay Creek watershed has high potential for nonpoint-source agricultural pollution (United States Department of Agriculture, 1996, p. 2-1). Benthic invertebrate data (Moore, 1987; Hardy and others, 1995) indicate impaired water quality in the Red Clay Creek.

Ongoing investigations by PaDEP and DNREC summarize stream chemistry data at the long-term water-quality monitoring stations in the Christina River Basin in periodic water-quality (305(b)) reports. In Pennsylvania, 20.9 miles in the White Clay Creek subbasin are reported to be degraded by nutrients and suspended solids from agricultural (nonpoint) sources (Pennsylvania Department of Environmental Resources, 1994, p. 29). In addition, fish consumption advisories are in place on reaches of the Brandywine and Red Clay Creeks due to the presence of contaminants in the fish. These reports do not include data from water-quality stations established in the past two years for the point-source study of the Christina River Basin.

In Delaware, pathogens (as indicated by elevated bacteria counts), nutrients, physical habitat, and water supply are identified as water-quality problems in the Christina River Basin (Delaware Department of Natural Resources and Environmental Control, 1996a). Historical and current water-quality data at the monitoring stations in Delaware were reviewed by DNREC in 1996 to evaluate trends, current conditions, and compliance with water-quality criteria (Delaware Department of Natural Resources and Environmental Control, 1996b). This assessment determined that concentrations of enterococcus bacteria, total zinc, total iron, and total phosphorous exceeded water-quality criteria at some to many of the stations. In addition, trends in decreasing concentrations of dissolved oxygen and increasing concentrations of nitrate-nitrogen were observed throughout the basin in the last 20 to 25 years. However, problems in the data set included missing data, censored values for metals, and lack of streamflow measurements at the time of sampling.

Current data-collection activities include continuous monitoring and monthly, seasonal, and yearly sampling of streams in the Christina River Basin by several government agencies. Three water-quality monitors that provide continuous measurement of pH, dissolved-oxygen concentration, specific conductance, and temperature are maintained by USGS on the Brandywine Creek in Pennsylvania.

The USGS also collects samples weekly at these three sites for fecal coliform bacteria analysis. Samples at selected sites in the Christina River Basin are collected monthly by PaDEP and DNREC as part of long-term and short-term monitoring for metals, nutrients, and other water-quality parameters. Seasonal stream samples are collected by the Chester County Health Department for metals, nutrient, biological oxygen demand, bacteria, and other analyses. Annual sampling for benthic invertebrates is done by the USGS throughout the basin each fall and by PaDEP at their WQN stations. In addition, PaDEP and DNREC collect invertebrates semi-annually for the Red Clay Creek Monitoring Program. The USGS also collects sediment for analysis of metals and organic compounds, as well as some water column samples for a limited chemical analysis including nutrients.

1.5 Evaluation of existing monitoring programs in Pennsylvania and Delaware

The PaDEP operates four long-term Water Quality Network (WQN) (Pennsylvania Department of Environmental Protection, 1996) stations and DNREC operates 18 stations in the non-tidal portion of the Christina River basin (table 1). Ten additional short-term stations were established in Pennsylvania (table 1) specifically as part of a point-source monitoring plan. Water samples are collected monthly (at fixed time intervals) at the WQN and other stations without regard to streamflow conditions, such that some may be baseflow and others stormflow samples. Station locations are shown in figure 2.

The WQN stations and the special stations for the Christina River point-source monitoring were established to evaluate ambient water quality and to specifically target impacts of point-source discharges. Water-quality data from these stations will likely have limited usefulness for the nonpoint-source water-quality-monitoring plan. The loads and concentrations of many constituents from non-point sources change in relation to discharge during storms, and thus a single sample per month cannot be used to characterize water-quality during storm events. However, these data can be used to supplement the data collected under the proposed nonpoint-source water-quality monitoring plan and will be invaluable for model calibration, identifying problem areas, and overall water-quality assessments.

In addition, the constituent analysis schedule for the stations sampled monthly under the point-source monitoring program in Pennsylvania does not include dissolved nitrogen species or dissolved phosphorus. Generally, much of the nitrogen present and transported in streams is in dissolved forms and dissolved phosphorous can be a significant part of the total phosphorous in the stream. By measuring the dissolved and total forms of nitrogen and phosphorous, it is possible to quantify the amount of these nutrients transported in the dissolved and suspended phases.

The mixture of land uses in the drainage areas above the existing point-source monitoring sites is another limitation of this program for characterizing contributions from nonpoint sources. Samples collected at these sites represent a

composite of runoff and baseflow from various land uses, and thus can not be used to represent water quality from any single land use.

Thus, while the existing water-quality monitoring programs are extensive and useful, they are not adequate for calculations of annual loads of nutrients and suspended sediment, for estimating loads from various land uses, or for providing necessary input to the HSPF water-quality model. Stormflows throughout the basin are not adequately sampled. Spatial distribution of the existing monitoring stations focuses on larger, multiple-land-use watersheds. The constituents targeted for analysis do not include the full range of nutrient species. A supplemental monitoring plan, focused on stormwater sampling, is indicated.

Table 1. PaDEP and DNREC water-quality monitoring stations in non-tidal reaches of the Christina River Basin, Pennsylvania and Delaware

PA WQN # or DE station #	Stream and station	Nearest USGS gage	Drainage area (mi^2)
PaDEP sites - Brandywine Creek			
	E. Br. Brandywine Creek above Downingtown, Pa.	01480700	60.6
	E. Br. Brandywine Creek below Downingtown, Pa.	01480870	89.9
	Mouth of E. Br. Brandywine Creek, Pa. near Wawaset, Pa.		
	W. Br. Brandywine Creek above Coatesville, Pa.	01480500	45.8
	W. Br. Brandywine Creek below Coatesville, Pa.	01480617	55.0
	Mouth of W. Br. Brandywine Creek near Wawaset, Pa.		
105	Brandywine Creek, Pa. near Chadds Ford, Pa.	01481000	287
PaDEP sites - Red Clay Creek			
	W.Br. Red Clay Creek, Toughkenamon Trib.		
	W.Br. Red Clay Creek, NVF Trib.		
	W.Br. Red Clay Creek - invertebrate sampling only		
	E. Br. Red Clay Creek		
150	Red Clay Creek, Pa.	01479820	28.3
PaDEP sites - White Clay Creek			
179	E. Br., White Clay Creek, Pa.		
149	White Clay Creek, Pa.	01478245	59.2

Table 1. PaDEP and DNREC water-quality monitoring stations in non-tidal reaches of the Christina River Basin, Pennsylvania and Delaware—Continued

PA WQN # or DE station #	Stream and station	Nearest USGS gage	Drainage area (mi^2)
DNREC sites - Brandywine Creek			
104011	Foot bridge in Brandywine Pike, Del.		
104021	Road 279 Bridge, DuPont Experimental Station, Del.	01481500	314
104051	Smith Bridge (state line), Del.		
DNREC sites - Red Clay Creek			
103011	DE Rt. 4 at Stanton Bridge, Del.	01480015	52.4
103031	DE Rt. 48 in Woodale, Del.	01480000	47
103041	Road 258A in Ashland, Del.		
103061	Confluence of Burroughs Run with Red Clay Creek at Rt. 241 bridge, Del.		
DNREC sites - White Clay Creek			
105011	DE Rt. 7 bridge, Stanton, Del.		
105031	Road 329 near Thompson, Del.		
105071	Above confluence with Mill Creek, Del.		
105101	Pike Creek at Road 322, Del.		
105131	Middle Run at Possum Park Rd., Del		
105151	Near Delaware Racing Association road	01479000	89.1
DNREC sites - Christina River			
106031	At Smalley's Dam, Del.		
106141	Rt. 26 at Old Baltimore Pike, Del.	01478000	20.5
106191	DE Rt. 273 above Newark, Del.		
106281	Little Mill Creek, Del.	014800095	5.24

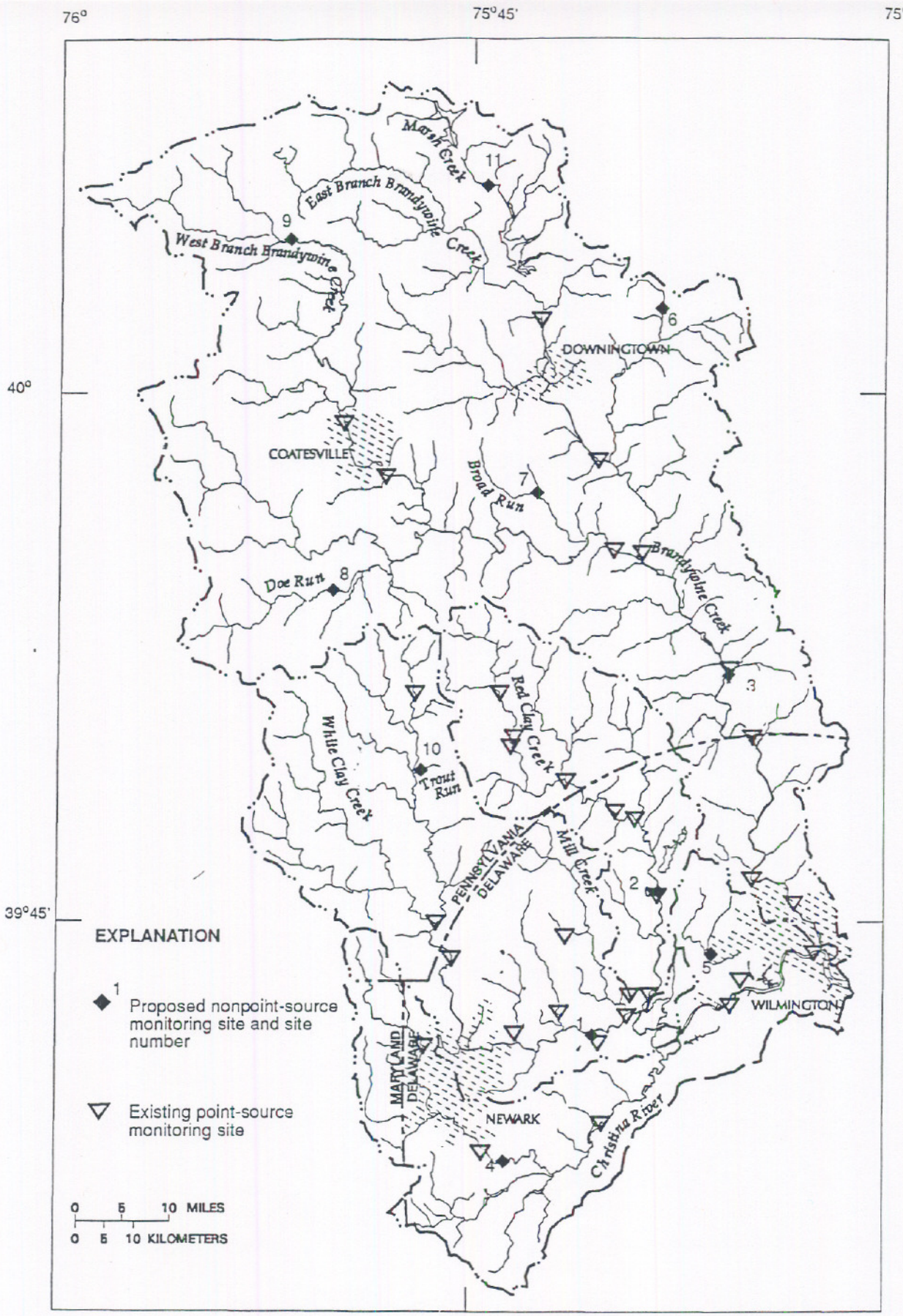

Figure 2.-- Location of existing point-source and proposed nonpoint-source (storm-water) water-quality monitoring sites in the Christina River Basin, Pennsylvania and Delaware

2.0 DATA COLLECTION

2.1 Description of data needed

The objective for data collection is to collect water-quality data best representing the range of streamflow and water-quality expected during stormflow and base flow conditions over a one-year monitoring period. Data to be collected include continuous streamflow, water temperature, water chemistry consisting primarily of dissolved and total nitrogen and phosphorus species and suspended solids concentrations.

Other constituents, such as dissolved organic carbon (DOC) and chlorophyll *a*, and properties, such as chemical oxygen demand (COD) and biological oxygen demand (BOD), will be monitored to better understand and simulate the chemical processes involving the fate and transport of nutrients. Chloride will also be monitored to provide data on the concentrations of a conservative solute.More detailed discussion of sample analyses is given in the section on Methods of Analysis.

Additional data to be collected includes particle-size analysis of bed sediments at selected sites. The bed sediment data can be used in simulation of sediment transport in the stream.

2.2 Criteria for collection

Water chemistry and suspended solids data will be collected during 6 seasonally selected stormflow events, 4 times during seasonally selected base flow, and twice during high flow. The stormflow, base-flow and high-flow events will be selected to be representative of seasonal variation due to climate and land use. Timing for the 6 stormflow events is as follows: two storms in early spring after pre-planting tillage, one storm in late spring/early summer after planting of crops, one storm in midsummer, one in fall after harvest, and one storm during late winter (targeting frozen ground runoff and snow melt events). Storms targeted for sampling should result from precipitation events no less than 1.0 inch to secure a representative range of instantaneous discharges. Timing for the base-flow sampling is as follows: one sample each in the periods January-February, April-May, July-August, and October-November. Timing for the high-flow sampling is as follows: one sample each in the periods March-May and September-November.

2.3 Methods for collecting and processing hydrologic and water-quality data

Streamflow and precipitation

A stream-gaging station operated by the USGS will be located at each of 11 proposed stormwater sampling sites. The gage will house stage-recording and water-sampling equipment. Stream stage will be recorded every 15 minutes and stored in an electronic data logger. Where possible, the data logger will be linked to the automatic sampler and collection times for/of water-quality samples will also be stored in the data logger. Streamflow will be derived from stage data by use of a stage-discharge rating developed for each site using techniques described by Rantz and others (1982). Due to the difficulty of obtaining discharge measurements

during transient high-flow conditions, especially in small drainage areas, rating development, where necessary and possible, will be assisted by correlation with streamflow records at existing USGS gaging stations.

A modem and telephone line will be installed at each of the proposed 11 nonpoint-source monitoring sites, where not currently available, to provide real-time access to stage and sampler data.

Rain gages will be operated at or near the seven small basin monitoring sites, Chadds Ford, Pa. and Ashland, Del. to provide precipitation data throughout the basin. In addition, DNREC's contractor, Carmine Balascio operates a recording rain gage in the White Clay Basin. Where rain gages can be linked to USGS data loggers, USGS will collect precipitation data. Where rain gages are not linked to USGS loggers, USGS will retrieve the data; if DNREC or its contractor retrieves precipitation data at one or more of these sites they will provide the data to USGS in a digital format.

Storm water-quality samples

Collection

Stream samples during storms will be collected by an automatic sampler installed at each site. Automatic water-sampling equipment will consist of a portable self-contained unit (ISCO 6700, or equivalent) capable of collecting a minimum of 24 discrete samples. The proposed model with necessary additional equipment, as specified by DNREC, is described below.

Required equipment - all sites

Isco model 6700 - portable full-size 24-bottle sampler

Suction line and strainer

Isco model 720 submergeable electronic transducer

Bottle configuration with 24 bottles and extra set of 24 bottles

Modem for telephone data transfer

Other equipment

Isco 674L logging rain gage (3 sites)

Isco 674 non-logging rain gage (5 sites)

Portable data transfer unit

The sampler will be equipped with a pressure transducer to measure stage and a data logger to record stage continuously. USGS, in collaboration with contractor Carmine Balascio of the University of Delaware, will program the sampler to collect samples automatically. Sample collection will be initiated by a rise in stream stage of a specified number of feet above the current base stage and will proceed at intervals based on flow increments at sites where stage ratings are available or

otherwise on the absolute stage and rate of change in stage until stream stage returns to the begin-sampling stage.

The USGS will select likely storms to be sampled based on weather forecasts and contact DNREC, DNREC's contractor, and USGS field personnel to prepare for collection of storm samples. Clean bottles must be placed in the sampler and the intake lines checked. Because some samples require chilling for preservation, samplers must be loaded with ice before the storm. The temperature of sampler chamber will be monitored with a thermometer. In addition, if the flow increment for sampling needs to be adjusted based on estimates of projected storm duration and volume, USGS will advise DNREC, DNREC's contractor, and USGS field personnel of changes in sampler programming.

At each station, up to 24 one-liter samples can be collected by the automatic sampler during each storm. A minimum of 2 liters (2 bottles) is required for a complete analysis. Sample volumes needed for each analysis as specified by the DNREC laboratory are listed in table 3.

Samples submitted for analysis will be selected to cover the hydrograph for the storm. Discrete samples will be selected to characterize concentrations of constituents at the rise, peak and recession of stormflow, and the remainder of the samples will be composited to determine total loads for the storm. USGS in consultation with DNREC's contractor will program the automatic samplers to collect two concurrent series of samples. Discrete samples will be collected in a time-paced series, with each sample consisting of 2 liters. The composite samples will be collected in a flow-weighted series, with each sample consisting of a 250 milliliter aliquot. From the series of time-paced samples, USGS will select the discrete samples to be analyzed based on the hydrograph in coordination with the analyzing laboratory (DNREC laboratory in Dover, Del.) and DNREC's contractor. The flow-weighted samples will be composited at the analyzing laboratory using standard methods. Because the flow-volumes are equal between flow-weighted samples, equal volumes from full 1-liter bottles can be used; if a bottles is less than full, then only a representative fraction of that bottle is added to the composite. It is anticipated that 3 discrete samples and 1 composite sample (a total of 4 samples) will be analyzed for each storm at each of the 11 sites. No more than 6 samples per storm (per station) will be submitted for laboratory analysis. Should USGS fail to provide guidance on sample selection before the 24-hour deadline for sample processing, the DNREC laboratory personnel will analyze the first time-paced sample as a discrete sample (first flush) and then combine all of the flow-weighted samples for a composite sample.

The sampler intake will be positioned using methods described by Edwards and Glysson (1988) to maximize intake efficiency. The point sampling required for an automatic sampler is known to be biased for streams that are not well mixed. The degree of mixing is not known and may be greater in the small subbasins where streams are shallow with appreciable turbulence than in the larger streams at the

four mainstem sites. Therefore, at each of the 4 mainstem sampling sites, measurements of pH, temperature and conductivity will be made across the stream under various flows by USGS to assess the degree of mixing. These measurements can be used to verify that representative samples of dissolved constituents are being collected by the automatic sampler (Ward and Harr, 1990; Edwards and Glysson, 1988) but do not address suspended material.

Processing

Sample processing will be as follows: after a storm event, all stormwater samples will be retrieved from the samplers, labelled, and stored in a cooler chilled to 4 °C (degrees Celsius) by field personnel. Sample temperature at the time of collection will be determined by measuring the temperature of a water-filled vial kept with the samples. If sample temperature at the time of collection or delivery to the laboratory exceeds 6 °C, samples will be flagged and sample temperature recorded for reporting with results of chemical analysis. USGS and DNREC will provide field personnel for sample retrieval. Concurrently, USGS personnel will retrieve stream-stage and sample-collection time data through modem connections to data loggers at each site for the event and select samples to be analyzed. Stormwater samples will be stored at 4 °C and delivered by field personnel to the DNREC laboratory for processing within 24 hours of the end of the sampling event. USGS will collect the samples in Pennsylvania. DNREC's contractor will collect the samples in Delaware. Sample transport to the DNREC laboratory in Dover, Del. will be done under arrangements determined by participating agencies. DNREC laboratory personnel will be notified by USGS of which samples to submit for analysis as discrete samples and which to combine for a composite sample.

Baseflow and high-flow grab samples -

The USGS will select the dates for baseflow and high-flow grab samples, contacting PaDEP and DNREC personnel, who will collect the samples, to ensure coordination. Baseflow samples will be collected quarterly at the same sites as the stormflow samples at least five days after the last storm and on the same date or within two days of that date at all sites in the basin.

In addition to the baseflow samples, up to two sets of grab samples will be collected - one set during high-flow in late winter/early spring, and the other during high-flow in late summer/early autumn.

These samples will be collected manually at sites, unless otherwise specified. The samples will be shipped within 24 hours in the same manner as storm samples and processed in the laboratory using standard methods (filtration and addition of preservatives, if necessary). Measurements of pH, dissolved oxygen, temperature, and specific conductance will be made in the field at the time of sample collection of both baseflow and high-flow grab samples. Alkalinity will be determined in the laboratory. Discharge will be determined from the gage reading.

2.4 Summary of required environmental samples

A summary of environmental samples required to complete the nonpoint-source water-quality monitoring plan is presented in table 2. Although the expected number of samples to be analyzed for stormflow events is four (three discrete, one composite) on average, it is projected that up to six samples per event will be analyzed to represent long storms or storms with multiple peaks and to account for any additional QA samples that may be needed.

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Table 2. --Environmental samples to be collected over one year of nonpoint-source water-quality monitoring

Type of sample	Sampling event	Samples per event	Sampling sites	Total samples
Stormflow	6 storms	6	11	396
Base flow	4 seasons	1	11	44
High flow (grab)	2 seasons	1	11	22
Total				462

3.0 METHODS OF ANALYSIS

All stream samples will be analyzed in the laboratory for the following constituents (table 3): dissolved and total ammonia, dissolved and total ammonia plus organic nitrogen, dissolved nitrite plus nitrate, dissolved orthophosphorous, dissolved and total phosphorous, chloride, biological oxygen demand (BOD), dissolved organic carbon (DOC), suspended solids, chlorophyll *a* and phaeophytin. Because of the expense of the chlorophyll *a* analysis and necessary field filtration, the analyses for chlorophyll *a* will be done only on one storm-sampling and the two to four baseflow- sampling events. Samples from the five sites in Delaware also will be analyzed in the laboratory for selected metals (table 3) and samples from four downstream-most sites also will be analyzed for chemical oxygen demand (COD) and total organic carbon (TOC) (table 3). Field measurements (table 4) using standard methods will be made at the time of collection of all baseflow and high-flow grab samples. Alkalinity of grab samples will be determined in the laboratory (table 4).

3.1 Chemical constituents, laboratory analysis

All analytical methods for chemical constituents will be completed using approved methods referenced to U. S. Environmental Protection Agency (USEPA) STORET parameter codes. Chemical constituents, STORET codes, method codes, sample volume, sample holding time and sample preservation are presented in table 3. Method references include U.S. Environmental Protection Agency (1983); and Patton and Truit (1992) and Fishman (1993) for the USGS National Water Quality Laboratory (NWQL).

3.2 Field measurements of chemical constituents and properties

Calibrated meters will be used to measure pH, specific conductance, and dissolved oxygen with a reporting limit or precision shown in table 4. Records of instrument calibration will be kept for quality assurance. Air and stream temperature $\pm$ 0.5°C will be measured with a thermometer

3.3 Suspended solids

The analytical method for suspended solids will be an approved method referenced to USEPA STORET code 00530. Suspended solids concentration is assumed to approximate suspended sediment concentration. The analytical method for suspended sediment following Guy (1969) is referenced to USEPA STORET code 80154. If necessary, a correction coefficient for suspended solids (sediment) as described by Porterfield (1972) will be applied to suspended solids data collected from automatic samples.

3.4 Bed sediment

A single survey for particle size distributions of bed sediments is planned. The survey will be done by DNREC or its contractor using standard methods.

Table 3. --Constituents in nonpoint-source monitoring samples to be determined by laboratory chemical analysis[1], Christina River Basin, Pennsylvania and Delaware

[mg/L, milligrams per liter; mL, milliliters. Sample preservation - C, chill to 4°C; F, filter; A, acidify to pH <2 with 2 mL concentrated sulfuric acid per liter; An, acidify to pH < 2 with 2 mL concentrated 1:1 nitric acid]

Constituent	STORET code	Method	Reporting limit (mg/L)	Holding time	Sample volume (mL)	Sample preserv-ation
Required constituents or properties for all samples -						
Ammonia nitrogen, dissolved Ammonia nitrogen, total	00608 00610	EPA 350.1	0.002	28 days	5 5	C,F,A C,A
Kjehldahl nitrogen, dissolved Kjehldahl nitrogen, total	00623 00625	EPA 351.2	.05	28 days	40 40	C,F,A C,A
Nitrite plus nitrate nitrogen, dissolved	00631	EPA 353.2	.05	28 days	5	C,F,A
Orthophosphorus, dissolved	00671	EPA 365.1	.005	28 days	5	C,F
Phosphorus, dissolved Phosphorous, total	00666 00665	EPA 365.1	.005	28 days	40 40	C.F.A C,A
Chloride	00940	EPA 325.2	1	28 days	5	none
Specific conductance	90095	EPA 120.1	1 µS/cm	none	10	none
Total suspended solids - concentration	00530	EPA 160.2	1	7 days	125	C
Biological oxygen demand (BOD_{20})	00308	EPA 405.1	2.4	48 hours	600	C
Dissolved organic carbon	00681	EPA 415.1	1	28 days	25	C,F,A
Chlorophyll-a[2] Pheophytin	70953	92 STDMTD 10200H	.001	48 hours	100	C,F
Additional metals - 5 sites in Delaware[3]						
Copper, dissolved Copper, total	01040 01042	EPA 220.2	.005	6 months	100	C,F,An C,An
Lead, dissolved Lead, total	01049 01052	EPA 239.2	.003	6 months	100	C,F,An C,An
Zinc, dissolved Zinc, total	01090 01092	EPA 200.7	.010	6 months	200	C,F,An C,An
Additional constituents - 4 downstream-most sites						
Chemical oxygen demand	00340	EPA 410.1, 410.2, 410.3	5.0	28 days	50	C,A
Total organic carbon	00680	EPA 415.1	1	28 days	25	C.A

[1] Specifications for analytical method, reporting limit, holding time, sample volume and preservation provided by the DNREC laboratory.
[2] First storm sampling event, all grab sampling events
[3] Hardness will be determined in samples from 5 sites that are being analyzed for metals

Table 4. -- Chemical constituents and properties to be measured for baseflow and high-flow grab samples, Christina River Basin, Pennsylvania and Delaware. [mg/l, milligrams per liter, µS/cm, microsiemens per centimeter, °C, degrees Celsius]

Constituent or property	STORET code	Reporting limit or precision
Additional required constituents for baseflow and grab samples - all sites		
Field measurements --		
Dissolved oxygen	00300	0.1 mg/L
pH	00400	.1 standard unit
Specific Conductance	00095	1 µS/cm
Water temperature	00010	.5 °C
Air temperature	00020	.5 °C
Laboratory analysis		
Alkalinity	00419	1 mg/L

4.0 QUALITY ASSURANCE AND CONTROL

4.1 Sample collection

The primary quality-assurance objectives will be to control bias due to equipment contamination and poor sampler-intake efficiency and as an evaluation of sample collection techniques and potential problems with laboratory performance. Due to a limited total number of samples being collected, meaningful quality assurance through statistical process control is not possible. Quality-assurance procedures for sample collection will consist of using appropriate equipment cleaning and sample-collection techniques prescribed by Ward and Harr (1990) and Edwards and Glysson (1988) and submitting quality-control samples.

The quality-control samples for storm samples will consist of equipment blanks, trip blanks, blind reference samples, and replicates for field and laboratory processing (table 5). Quality-control samples for baseflow and high-flow grab samples will include replicates for field and laboratory processing and field-split duplicates. Equipment blanks will provide data on sample contamination. Trip blanks will provide data on contamination due to sample handling. Blank samples will consist of deionized water provided by DNREC's laboratory and will be collected with automatic samplers in situ and after at least one stormwater sample has been collected. Blind reference samples will consist of known standards submitted blind to the laboratory to test analytical accuracy. Replicates processed in the field and laboratory will provide data on sample integrity and preservation. Sample processing includes filtration and addition of preservatives if necessary. Field-split duplicate grab samples will provide a measure of analytical precision on environmental samples. Duplicates will be split in the field from one baseflow or high-flow grab sample.

The schedule for submission of quality-control samples (table 5) is as follows:

-- Two equipment blanks will be collected from each of two randomly selected automatic samplers. One sample will be collected following the first storm event and one after the fourth storm event.

-- One trip blank will be submitted concurrent with each equipment blank.

-- One blind reference sample for nutrients will be submitted for 3 storm sampling events.

-- Replicates for field and laboratory sample processing would be collected from selected sites (6) during the regular bimonthly sampling round conducted by PaDEP and DNREC at their established monitoring locations (table 1). Additional replicates would be collected at 11 monitoring stations during a stormflow event. Should results indicate problems, replicates may be collected at later events and at one or more of the eleven nonpoint-source monitoring sites.

-- Field-split duplicate samples will be collected from four baseflow and two high-flow sampling events. One duplicate sample from 5 of the 11 sites at each of the six grab-sampling events will be submitted.

The quality-control samples, except for the field-processed replicates, will be processed in the same manner as environmental water samples.

Table 5. -- Required quality-control samples

Type of sample	Number of samples	Sampling event	Sampling sites	Total samples
Equipment blank	1	2 (storm or baseflow)	2	4
Trip blank	1	2 (storm or baseflow)	1	2
Replicates for field and laboratory processing	1 1	1 baseflow grab 1 storm	6 11	6 11
Blind reference sample	1	first three grab	1	3
Field-split duplicate	1	4 baseflow grab 2 high-flow grab	5	30
Total				57

Corrective-action criteria for the quality-control data define when remedial action is needed in the sample-collection process to improve the integrity of water-quality data. Corrective-action criteria for blank and replicate quality-control samples is as follows:

Blanks (equipment and trip) - Analytes reported above the method reporting limit.

Blind reference samples - Reported values differing by more than 2 standard deviations from reference value.

Duplicates and replicates - reported values differing by more than 20 percent or by more than the determined level of precision determined by the laboratory for that analysis.

4.2 Sample analysis

Quality assurance and control procedures will be in place for chemical and suspended-solids analyses and are the responsibility of the analytical laboratory. As a guideline, the minimum analytical performance standard for all constituents except suspended solids will be defined as being within "acceptable" limits for analytical results as established by USEPA Water Supply evaluation studies for analytical laboratories (typically the 95-percent confidence interval calculated from available performance data of USEPA and state laboratories). The minimum analytical performance standards and QA goals for suspended solids are defined under goals for laboratory operations as set forth in Knott and others (1993).

5.0 SAMPLING LOCATIONS

Sampling locations were selected to represent the overall Brandywine Creek, Red Clay Creek, White Clay Creek, and Christina River (non-tidal) drainage basins and within those basins, subbasins delimited by four primary land-use categories - agricultural (subdivided into 3 categories), urban (commercial and industrial), residential (subdivided into 2 categories), and forested - for a total of eleven sites. Sites are located at existing USGS streamflow measurement stations where possible. Proposed sites represent dominant land uses in the basin (table 5). The sites are listed below and shown in figure 2.

Table 6. Land use in the Christina River Basin for 1990 in Pennsylvania and 1993 in Delaware and Maryland [Source of data: Water Resources Agency for New Castle County, 1996]

Land use	Area (in square miles)			
	Pennsylvania	Maryland and Delaware	Total for Christina Basin	Total as percent of basin area
Agriculture	175	19.3	194	35.0
Commercial	4.0	10.4	14.4	2.6
Industrial	2.0	5.0	7.0	1.3
Institutional	2.4	4.2	6.6	1.2
Mining	0.6		0.6	.1
Multiple Family	3.2	8.6	11.8	2.1
Public/Private Open	3.4	22.1	25.5	4.6
Single Family	65.0	48.7	114	20.5
Transportation/Utility	6.2	2.5	8.7	1.6
Vacant	6.1		6.1	1.1
Water	3.2	0.5	3.7	.7
Wooded	122	38.0	160	28.8
Office		2.4	2.4	.4
Total	393	162	555	100

5.1 Large basin sites

One water-quality site will be established at a downstream location in each of the four major drainages to represent cumulative loads to the Christina River estuary. These sites are at the gage furthest downstream on the free-flowing or non-tidal reaches of the streams. Data collected at these sites can be used to calculate both total loads and concentrations of selected constituents for the one-year study period in each of the streams.

Overall basin nonpoint-source water-quality sampling sites:

1. White Clay Creek near Newark, DE
   USGS station 01479000 DA = 89.1 mi^2.

2. Red Clay Creek near Woodale, DE
   USGS station 01480000 DA = 47.0 mi^2.

3. Brandywine Creek at Chadds Ford, PA
   USGS station 01481000 DA = 287 mi^2.

4. Christina River at Cooch's Bridge, DE
   USGS station 01478000. DA = 20.5 mi^2.

5.2 Subbasins sites having a single, dominant land use

One water-quality site will be established for each land-use category. The four primary land-use categories are: urban, residential, agricultural, and forested. Residential and agricultural land uses are further subdivided for a total of 7 categories. Residential is subdivided into sewered and non-sewered uses. Agricultural is subdivided into row crop, livestock, and mushroom uses. Some proposed sites are at existing USGS streamflow-measurement stations. At the other proposed sites, temporary gages will need to be installed to measure streamflow.

Urban nonpoint-source water-quality sampling site

5. Little Mill Creek near Newport, Del. (USGS station 01480095). DA=5.24 mi^2. *and*

   Use stormwater data for commercial and industrial sites from NPDES study for New Castle County, Delaware.

Residential, nonpoint-source water-quality sampling site

6. Sewered - Unnamed tributary to Valley Creek at U.S. Rt. 30/Fairview Road near East Caln/West Whiteland township line. DA = 1.47 mi^2. (need to install gage) *and*

   Use stormwater data from New Castle County study.

7. Non-sewered - Unnamed tributary to Broad Run north of Rt. 162 and 1.5 mile west of Marshallton. DA = 1.37 mi^2. (need to install gage)

Agricultural nonpoint-source water-quality sampling site

8. Row crop - Doe Run at Rt. 841 near Springdell. DA = 11.7 mi^2. (need to install gage)
9. Livestock - West Branch Brandywine Creek near Honeybrook, Pa. (USGS station 01480300). DA = 18.7 mi^2.
10. Mushroom - Trout Run at Rt. 41 at Toughkenamon. DA. = 1.31mi^2.

Forested nonpoint-source water-quality sampling site

11. Marsh Creek near Glenmoore, Pa. (USGS station 01480675). DA = 8.57 mi^2.

6.0 DATA REPORTING

6.1 Distribution

All data will be distributed in both paper and digital format to cooperating agencies. This includes streamflow, water-quality, and GIS data. Water-quality data and associated streamflow data will also be distributed to the USEPA STORET database by the respective state environmental agencies.

6.2 Format

Water-quality data will be supplied to USGS in digital format suitable for entry into the USGS WATSTORE database and in paper format. All finalized data will be stored in digital form. Formats must be acceptable for input to HSPF either through ANNIE (Lumb and others, 1990) or BASINS software (for GIS data). Acceptable formats for ANNIE include USGS WATSTORE database format and a more generic ASCII-type flat file format. All streamflow data will be entered into the WATSTORE database by the U.S. Geological Survey.

7.0 PERSONNEL REQUIREMENTS

The work elements of the nonpoint-source water-quality monitoring plan can be divided into multiple tasks with separate personnel requirements for each task. The tasks and associated personnel requirements are listed in table 7.

Table 7. Time lines for work to be done by USGS, PADEP, and DNREC for nonpoint-source monitoring of Christina River Basin. [1]

Task	Date			Responsible agency
	1997	1998	1999	
	J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D	
	Phase II	Phase III	Phase IV	
Install 4 new gages	<---->			USGS
Install samplers at 11 sites	? <---->			USGS
Operation & maintenance of gage sites, collect streamflow data and develop rating at 5 gages	<---------->	<---------->	<---------->	USGS
Train PADEP, DNREC in sampling protocol - stormflow and baseflow samples	<-->			USGS, PADEP, DNREC
Operation & maintenance of rain gages, collect precipitation data	? <---------->	<---------->	<---------->	USGS (PADEP, DNREC)
Provide oversight for water-quality sample collection	<---------->	<---------->	<---------->	USGS
Water-quality sample collection	<---------->	<---------->	<---------->	PADEP, DNREC, USGS
Water-quality sample analysis	<---------->	<---------->	<---------->	DNREC
Provide oversight for QA/QC of water-quality sample collection	<---------->	<---------->	<---------->	USGS
QA/QC for water-quality sample collection	<---------->	<---------->	<---------->	PADEP, DNREC
	J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D	

[1] Start and end dates are estimates and subject to change based on equipment and personnel availability, property access, and other factors.

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7.1 COSTS OF PROGRAM

Costs of non-point source monitoring program include installation of 4 new gages, restart of one existing gage, operation and maintenance of gages for streamflow measurements, telephone and power service to 11 monitoring sites, oversight of QA and sampling program, training of PaDEP and DNREC personnel, labor to collect samples, and laboratory analyses.

For the USGS component of work detailed in a separate document, each agency will contribute to the project according to the following plan.

Agency contribution	FY 1997	FY 1998	Total
DRBC	$86,357	$48,503	$134,860
USGS	49,235	8,115	57,350
TOTAL	$135,592	$56,618	192,210

APPENDIX D

MAP 1 - GEOLOGY
MAP 2 - SOILS

MAP 1 - GEOLOGY
Christina Basin Water Quality Management Strategy

Geological Formation	Depth to Bedrock	Depth to Groundwater Table
DELAWARE		
Potomac Formation		
Bryn Mawr Formation		
Cockeysville Formation		
Gabbro		
Serpentinite		
Granitic gneiss		
Felsic & mafic gneiss		
Hornblende - plagioclase		
gneiss		
Amphibolite (Granofeis)		
Metagraywacke facies		
Peltic facies		
Biotite - quartz feldspar		
Biotite - almandine schist		
Noritic Anorthosite		
Norite		
Hypersthene - quartz gneiss		
Magothy Formation		
Amphibolite (Gneiss)		
MARYLAND		
Peltic Gneiss		
Metagraywacke		
Alluvium		
Gabbroic rocks		
Gilpins Falls		
Frenchtown Member		
Principio Furnace member		
Gneiss at Rolling Mill		
Potomac Group		
Gabbro & Serpentine		
Big Elk Creek member		
Pensauken formation		
PENNSYLVANIA		
Lancaster County		
Antietam/Harpers Formation		
Chickies Formation		
Graphitic gneiss		
Gabbroic gneiss		
Granodiorite/Granodiorite Gneiss Pegamite		
Delaware County		
Felsic gneiss with hornblende		
Malfic gneiss with hornblende		
Bryn Mawr formation		
Cockeysville formation		
Mafic gneiss with hornblende		
Mafic gneiss with pyroxene		
Pegamite		
Wissahickon formation		
Chester County		
Dikes		
Faults		
diabase		
mafic gneiss, amphibolite facies		
Chickies Quartzite		
felsic gneiss, amphibolite facies		
graphitic felsic gneiss, granulite facies		
felsic and intermediate gneiss, granulite facies		
marble		
Vintage Dolomite		
Antietam and Harpers Formations, undivided		
ultramafite		
metadiabase		
anorthosite suite		
pegmatite		
felsic and intermediate gneiss, amphibolite facies		
graphitic felsic gneiss, amphibolite facies		
banded mafic gneiss, amphibolite gneiss		
Ledger Dolomite		
Elbrook Limestone		
Bryn Mawr Formation		
Conestoga Limestone		
Octoraro Phylite		
Kinzers Limestone		
Wissahickon Schist		
felsic gneiss, granulite facies		
felsic gneiss, amphibolite facies		
felsic and mafic gneiss		
Peters Creek Schist		
metagabbro		
Cockeysville Marble		
mafic gneiss, amphibolite facies		
Setters Quartzite		

MAP 2 - SOILS
Christina Basin Water Quality Management Strategy

Map ID	Designation	Soil Association	Description	Depth to Bedrock (ft)	Depth to Groundwater Table (ft)	SCS Hydrologic Soil Group (A, B, C, or D)	Permeability (in./hr.)	Soil Type (sand, loam, clay)
1	GMC	Glenelg - Manor - Chester	Nearly level to steep, well-drained, medium-textured soils formed over micaceous crystalline rocks; on uplands	2-7	5+	B	0.63-2.0	loam, silt loam
2	E	Edgemont	Moderately deep, channery soils on grayish quartzite and phyllite	2-6	5+	B	0.63-2.0	channery loam
3	HCG	Hagerstown - Conestoga - Guthrie	Deep, silty soils on limestone	3-6	B/C/D	C, B, D	<0.2	silt loam
4	NG	Neshaminy - Glenelg	Moderately deep and deep, well-drained, silty, channery, and gravelly soils on gabbro and granodiorite	3-6	5+	B	0.63-2.0	gravelly silt loam
5	NCC	Neshaminy - Chrome - Conowingo	Moderately deep and deep, silty soils on serpentine	1-6	2-5	B/C	0.63-2.0	gravelly silt loam gravelly silty clay loam
6	NAW	Neshaminy - Aldino - Watchung	Level to steep, well drained, moderately well drained, and poorly drained, medium-textured soils formed over dark-colored gabbroic rocks; on uplands	4-10	0-4	B/C/D	<0.2	silt loam
7	NTU	Neshaminy - Talleyville - Urban	Level to moderately sloping, well-drained, medium-texture soils, relatively undisturbed to severely disturbed; formed over dark-colored gabbroic rocks; on uplands	6-10	4-6	B	0.2-0.63	silt loam
8	EDU	Elsinboro - Delanco - Urban	Level to gently sloping, well drained and moderately well drained, medium-textured soils, relatively undisturbed to severly disturbed; formed in old alluvium on stream terraces	6-20	2-5	B/C	0.2-0.63	silt loam
9	SFM	Sassafras - Fallsington - Matapeake	Level to gently rolling, well-drained and poorly drained, moderately coarse textured and medium-textured soils on uplands	10+	5+	B/D	0.2-0.63	sandy loam loam / silt loam
10	MS	Matapeake - Sassafras	Nearly level to steep, well-drained, medium-textured and moderately coarse textured soils on uplands	10+	5+	B	0.2-0.63	silt loam sandy loam
11	MSU	Matapeake - Sassafras - Urban	Level to gently sloping, well-drained, medium-textured and moderately coarse textured soils, relatively undisturbed to severely disturbed; on uplands	10+	5+	B	0.2-0.63	silt loam sandy loam
12	AKMU	Aldino - Keyport - Mattapex - Urban	Level to gently sloping, moderately well drained, medium-textured soils, relatively undisturbed to severely disturbed; on uplands	4-6	2	C	<0.2	silt loam
13	TM	Tidal Marsh	Marshy areas bordering the Delaware River and short tidal streams					
14	U	Urban	Areas used for streets, sidewalks, and buildings and other areas where cutting and filling have been extensive					
15	CGG	Chester - Glenelg - Glenville	Deep well drained and moderately well drained, nearly level to sloping, loamy soils derived from micaceous rock material	4-10	1-4	B/C	0.20-0.63	silt loam
16	GMG	Glenelg - Manor - Glenville	Deep, somewhat excessively drained to moderately well drained, gently sloping to steep, loamy soils derived from micaceous rock material	4-10	4-10	B/C	0.20-0.63	loam / silt loam
17	KLB	Keyport - Loam/Clay - Beltsville	Deep well drained to moderately well drained, nearly level to steep soils that developed in old coastal plain deposits ranging from gravelly loamy sand to clay	10+	1-4	C	<0.20	silty loamy clay
18	MB	Matapeake - Butlertown	Deep, nearly level to gently sloping, well drained and moderately well drained, loamy soils on the coastal plain	10+	2-5	B/C	0.20-0.63	silt loam
19	MEO	Mattapex - Elsinboro - Othello	Deep, well-drained to poorly drained, nearly level to sloping, loamy soils on the coastal plain and over course water-transported material on stream terraces	6-20	0-4	B/C/D	0.20-0.63	silt loam

* Water table perched.
** Bedrock is at great, but unknown, depth.

APPENDIX E

MAP 3 - OUTFALLS/INTAKES

MAP 3 - STREAM GAGES
Christina Basin Water Quality Management Strategy
May 21, 1998

USGS Gage	Description	Watershed	Subwatershed	State	County	Latitude	Longitude	D A (sq mi)	Period of Record	Streamflow/Water Quality	Contact for Data
1480400	Birch Run near Wagontown, PA	Brandywine Creek	Birch Run	PA	Chester	400138	755043	4.55	2/95-Present	SF	
1480300	WB Brandywine Creek near Honeybrook, PA	Brandywine Creek	WB Brandywine Creek	PA	Chester	400422	755140	18.7	6/60 - Present	SF	
1480685	Marsh Creek near Downingtown	Brandywine Creek	Marsh Creek	PA	Chester	400319	754300	20.3	6/73-Present	SF	
1480684	Marsh Creek Reservoir near Downingtown	Brandywine Creek	Marsh Creek	PA	Chester	400324	754306	20.1	11/73 - Present	SF	
1480675	Marsh Creek near Glenmoore, PA	Brandywine Creek	Marsh Creek	PA	Chester	400552	754431	8.57	7/66-Present	SF	
1480700	EB Brandywine Creek near Downingtown, PA	Brandywine Creek	EB Brandywine Creek	PA	Chester	400205	754232	60.6	10/65 - Present	SF/WQ	
1480500	WB Brandywine Creek at Coatesville, PA	Brandywine Creek	WB Brandywine Creek	PA	Chester	395908	754940	45.8	10/43 - 12/51, 1/70 - Present	SF/WQ	
1480887	Valley Creek at Ravine Rd near Downingtown, PA	Brandywine Creek	Valley Creek	PA	Chester	395955	753952	14.5	10/89 - Present	SF	
1480617	WB Brandywine Creek at Modena, PA	Brandywine Creek	WB Brandywine Creek	PA	Chester	395742	754806	55	1/70 - Present	SF/WQ	
1480870	EB Brandywine Creek below Downingtown, PA	Brandywine Creek	EB Brandywine Creek	PA	Chester	395807	754025	89.9	2/72 - Present	SF/WQ	
1481000	Brandywine Creek at Chadds Ford, PA	Brandywine Creek	MS Brandywine Creek	PA	Delaware	395211	753537	287	8/11 - 9/53, 10/62 - Present	SF/WQ	
1479820	Red Clay Creek near Kennett Square, PA	Red Clay Creek	MS Red Clay Creek	PA	Chester	394900	754131	28.3	1/88 - Present	SF	
1478245	White Clay Creek near Strickesville, PA	White Clay Creek	MS White Clay Creek	PA	Chester	394452	754614	50	7/96 - Present	SF	
1479197	Mill Creek at Mill Creek Road at Hockessin, DE	White Clay Creek	Mill Creek	DE	New Castle	394648	754149	3.66	10/89 - 1/95	SF	
1480000	Red Clay Creek at Wooddale, DE	Red Clay Creek	MS Red Clay Creek	DE	New Castle	394552	753808	47	4/43 - Present	SF	
1481500	Brandywine Creek at Wilmington, DE	Brandywine Creek	MS Brandywine Creek	DE	New Castle	394609	753425	314	10/46 - Present	SF	
1480095	Little Mill Creek near Newport, DE	Christina River	Little Mill Creek	DE	New Castle	394354	753614	5.24	10/90 - 9/95; 8/97 - Present	SF	
1480015	Red Clay Creek near Stanton, DE	Red Clay Creek	MS Red Clay Creek	DE	New Casle	394255	753828	52.4	10/88 - Present	SF	
1478650	White Clay Creek at Newark, DE	White Clay Creek	MS White Clay Creek	DE	New Castle	394120	754458	69	3/94 - Present	SF	
1479000	White Clay Creek near Newark, DE	White Clay Creek	MS White Clay Creek	DE	New Castle	394147	754031	89.1	0/31-9/36, 6/43-9/57, 10/59-Presen	SF	
1478000	Christina River at Cooches Bridge, DE	Christina River	Christina River above Smalley's Pond	DE	New Castle	391814	754342	20.5	4/43 - Present	SF	
1481602	Delaware River below Christina River at Wilmington, DE	Christina River	Tidal Christina River	DE	New Castle	394300	753103	565	1983 - 1991, 1995 - 1996	SF	
1480065	Christina River at Newport, DE	Christina River	Tidal Christina River	DE	New Castle	394238	753633	234	1995 - Present	SF	

Data Sources: U.S. Geological Survey Water Data Reports, PA-94-1, MD-DE-95-1

MAP 3 - OBSERVATION WELLS
Christina Basin Water Quality Management Strategy
May 21, 1998

Well ID No.	Location	Watershed	Subwatershed	State	County	Latitude	Longitude	Record	Formation	Dia (in)	Depth (ft)	Contact for Data
CH - 2	Honeybrook	Brandywine Creek	EB Brandywine Creek	PA	Chester	400650	755140	1973 - Present	Gneiss	6	15	USGS
CH - 10	West Marlborough	Brandywine Creek	Doe Run	PA	Chester	395450	754854	1951 - Present	Carbonate Rock	6	34	USGS
CH - 12	West Bradford	Brandywine Creek	EB Brandywine Creek	PA	Chester	395717	753923	1973 - Present	Gneiss		38	USGS
CH - 28	East Marlborough	Red Clay Creek	EB Red Clay Creek	PA	Chester	395222	754232	1974 - Present	Carbonate Rock		25	USGS
CH - 38	New Garden	Red Clay Creek	WB Red Clay Creek	PA	Chester	394846	754449	1974 - Present	Schist		18	USGS
CH - 249	West Whiteland	Brandywine Creek	West Valley Creek	PA	Chester	400103	753901	1987 - Present	Carbonate Rock		600	USGS
CH - 1229	Upper Uwchlan	Schuykill River	Valley Creek	PA	Chester	400412	754043	1974 - Present	Gneiss		165	USGS
CH - 1247	West Vincent	Schuykill River	Valley Creek	PA	Chester	400645	754115	1974 - Present	Gneiss		75	USGS
CH - 1921	New Garden	White Clay Creek	EB White Clay Creek	PA	Chester	394757	754321	1974 - Present	Schist		65	USGS
CH - 2273	West Brandywine	Brandywine Creek	WB Brandywine Creek	PA	Chester	400242	754843	1975 - Present	Gneiss		298	USGS
CH - 2456	East Brandywine	Brandywine Creek	EB Brandywine Creek	PA	Chester	400133	754500	1982 - Present	Gneiss		225	USGS
CH - 2456	East Brandywine	Brandywine Creek	Beaver Creek	PA	Chester	400133	754500	1982 - Present				
CH - 2663	New Garden	White Clay Creek	EB White Clay Creek	PA	Chester	394624	754440	1984 - Present	Carbonate Rock		150	USGS
DE - 3	Birmingham	Brandywine Creek	MS Brandywine Creek	PA	Delaware	395040	753418	1951 - Present	Wissahickon	42	18	USGS
Bc - 43 - 01	Hoopes Reservoir	Red Clay Creek	MS Red Clay Creek	DE	New Castle							DGS
Db - 15 - 05	Smalley's Dam	Christina River	MS Christina River	DE	New Castle	393917	754016	1979 - Present	Potomac	12	306	DGS
Db - 24 - 10	Ogletown	Christina River	MS Christina River	DE	New Castle							DGS
Db - 24 - 17	So. of Ogletown	Christina River	MS Christina River	DE	New Castle	393856	754154	1986 - Present	Columbia	2	22	DGS

MAP 3 - PRECIPITATION GAGES
Christina Basin Water Quality Management Strategy
May 21, 1998

ID No	Location	Watershed	Subwatershed	Latitude	Longitude	State	County	Period of Record	Avg. Annual Precip. (in.)	Operated By
P - 21	Avondale	Red Clay Creek	WB Red Clay Creek			PA	Chester			CCWRA
P - 29	West Grove	White Clay Creek	MB White Clay Creek			PA	Chester			CCWRA
P - 41	Coatesville	Brandywine Creek	WB Brandywine Creek			PA	Chester			CCWRA
P - 50	West Chester WTP	Brandywine Creek	EB Brandywine Creek			PA	Chester			CCWRA
P - 57	Honeybrook	Brandywine Creek	EB Brandywine Creek			PA	Chester			CCWRA
P - 58	Chadds Ford	Brandywine Creek	MS Brandywine Creek			PA	Chester			CCWRA
P - 75	Glenmoore	Brandywine Creek	EB Brandywine Creek			PA	Chester			CCWRA
P - 76	Uwchlan	Brandywine Creek	EB Brandywine Creek			PA	Chester			CCWRA
P - 83	London Britain	White Clay Creek	MS White Clay Creek			PA	Chester			CCWRA
P - 84	West Chester University	Brandywine Creek	MS Brandywine Creek			PA	Chester			CCWRA
P - 079605	Wilmington Porter Reservoir	Brandywine Creek	MS Brandywine Creek	3940	7536	DE	New Castle	8/48 - Present		City of Wilmington
P - 076410	Newark University Farm	White Clay Creek	MS White Clay Creek	3940	7544	DE	New Castle	8/48 - Present		University of Delaware
P - 079595	Wilmington Airport	Christina River	Tidal Christina River	3940	7536	DE	New Castle	8/48 - Present		US Natl Weather Service
P - 000000	Covered Bridge Farms	Christina River	EB Christina River			DE	New Castle	1995 - Present		C. Bolascio

MAP 3 - PUBLIC SURFACE WATER WITHDRAWALS

Christina Basin Water Quality Management Strategy

May 21, 1998

ID No 1	Purveyor	Location	Watershed	Stream	State	County	Latitude	Longitude	Pump Capacity (mgd)	Safe Yield (mgd)	Contact for Data
PA - 1	City of Coatesville Authority	Hibernia Reservoir	Brandywine Creek	Birch Run	PA	Chester	400137	755042	1.0	1.5	PADEP
PA - 2	City of Coatesville Authority	Rock Run Reservoir	Brandywine Creek	Rock Run	PA	Chester	400016	755016	5.0	3.0	PADEP
PA - 3	Downingtown MUA	Downingtown	Brandywine Creek	EB Brandywine Creek	PA	Chester	400047	754224	2.5	0.0	PADEP
PA - 4	West Chester MUA	West Chester	Brandywine Creek	EB Brandywine Creek	PA	Chester	395754	753946	6.0	6.0	PADEP
PA - 5	Embreeville State Hospital	Embreeville	Brandywine Creek	EB Brandywine Creek	PA	Chester	395613	754348	0.2	0.2	PADEP
DE - 1	City of Wilmington	Brandywine WTP	Brandywine Creek	MS Brandywine Creek	DE	New Castle			20.0	16.0	DNREC
DE - 2	City of Wilmington	Porter WTP	Brandywine Creek	MS Brandywine Creek	DE	New Castle			24.0	20.0	DNREC
DE - 3	City of Newark	Papermill WTP	White Clay Creek	MS White Clay Creek	DE	New Castle			3.0	0.0	DNREC
DE - 4	United Water Delaware	Stanton WTP	White Clay Creek	MS White Clay Creek	DE	New Castle			30.0	12.0	DNREC
DE - 5	United Water Delaware	Smalley's Pond WTP	Christina River	MS Christina River	DE	New Castle			6.0	4.0	DNREC

MAP 3 - COMMUNITY PUBLIC WATER SUPPLY WELLS
Christina Basin Water Quality Management Strategy
May 21, 1998

Well ID No	Owner	Location	Local ID	Watershed	Subwatershed	State	County	Latitude	Longitude	Depth (ft)	Diameter (in)	Capacity (mgd)	Date Drilled	Aquifer Source	Contact
1150005	Avondale Borough Water Dept.	Avondale Boro.	1	White Clay Creek	EB White Clay Creek	PA	Chester	394920	754706	101		0.124			
1150005	Avondale Borough Water Dept.	Avondale Boro.	2	White Clay Creek	EB White Clay Creek	PA	Chester	394922	754708	101		0.108			
1150004	Avonwheel Estates MHP	London Grove	1	White Clay Creek	EB White Clay Creek	PA	Chester	394952	754731	85		0.005			
1150007	Chatham Acres Nursing Home	London Grove	1	White Clay Creek	EB White Clay Creek	PA	Chester	395128	754903	150		0.010			
1150126	PSW Franklin Water Co.	Franklin	1	White Clay Creek	WB White Clay Creek	PA	Chester	394518	754939	300		0.019			
1150108	Kennett Square Water Company	Kennett Square Boro.	1	Red Clay Creek	EB Red Clay Creek	PA	Chester	395216	754209	267		0.373			
1150003	London Grove MHP	London Grove	1	White Clay Creek	EB White Clay Creek	PA	Chester	395004	754743	20		0.004			
1150130	Landenburg Water Company	New Garden	1	White Clay Creek	EB White Clay Creek	PA	Chester	394718	754603	165		0.008			
1150131	Longwood Gardens	East Marlborough	1	Red Clay Creek	EB Red Clay Creek	PA	Chester	395226	754100	450		0.078			
1150131	Longwood Gardens	East Marlborough	2	Red Clay Creek	EB Red Clay Creek	PA	Chester	395222	754126	112		0			
1150188	Shangri La Water Company	New Garden	1	White Clay Creek	EB White Clay Creek	PA	Chester	394701	754428	100		0.017			
1150105	West Grove Borough Water Co.	West Grove	1	White Clay Creek	MB White Clay Creek	PA	Chester	394913	755010	65		0			
1150105	West Grove Borough Water Co.	West Grove	2	White Clay Creek	MB White Clay Creek	PA	Chester	394921	755003	92		0.127			
1150105	West Grove Borough Water Co.	West Grove	3	White Clay Creek	MB White Clay Creek	PA	Chester	394923	754917	185		0.149			
1150105	West Grove Borough Water Co.	West Grove	4	White Clay Creek	MB White Clay Creek	PA	Chester	394913	755013						
1150105	West Grove Borough Water Co.	West Grove	5	White Clay Creek	MB White Clay Creek	PA	Chester	394923	755000						
1150094	Appleville MHP	Jonathan	1	Brandywine Creek	EB Brandywine Creek	PA	Chester	395735	754209						
1150094	Appleville MHP	Melba 14	2	Brandywine Creek	EB Brandywine Creek	PA	Chester	395741	754200	115		0.005			
1150094	Appleville MHP	Melba 14	3	Brandywine Creek	EB Brandywine Creek	PA	Chester	395741	754200						
1150094	Appleville MHP	Melba 17	4	Brandywine Creek	EB Brandywine Creek	PA	Chester	395741	754200						
1150094	Appleville MHP	Melba 17	5	Brandywine Creek	EB Brandywine Creek	PA	Chester	395741	754200	182					
1150094	Appleville MHP	Melba 17	6	Brandywine Creek	EB Brandywine Creek	PA	Chester	395741	754200						
1150094	Appleville MHP	Melba 17	7	Brandywine Creek	EB Brandywine Creek	PA	Chester	395741	754200						
1150094	Appleville MHP	Stayman 3	8	Brandywine Creek	EB Brandywine Creek	PA	Chester	395738	754133						
1150094	Appleville MHP	Stayman 3	9	Brandywine Creek	EB Brandywine Creek	PA	Chester	395738	754133	168		0.005			
1150094	Appleville MHP	Stayman 3	10	Brandywine Creek	EB Brandywine Creek	PA	Chester	395738	754133	202					
1150094	Appleville MHP	Stayman 6	11	Brandywine Creek	EB Brandywine Creek	PA	Chester	395740	754127						
1150094	Appleville MHP	Stayman 7	12	Brandywine Creek	EB Brandywine Creek	PA	Chester	395740	754127						
1150094	Appleville MHP	Locust 1	13	Brandywine Creek	EB Brandywine Creek	PA	Chester	395733	754149						
1150094	Appleville MHP	Locust 2	14	Brandywine Creek	EB Brandywine Creek	PA	Chester	395733	754149						
1150155	PSW Beversrede	E. Marlborough	1	Brandywine Creek	Pocopson Creek	PA	Chester	395310	754037	350		0.032			
1150155	PSW Beversrede	E. Marlborough	2	Brandywine Creek	Pocopson Creek	PA	Chester	395309	754037	67					
1150155	PSW Beversrede	E. Marlborough	3	Brandywine Creek	Pocopson Creek	PA	Chester	395312	754031	400					
1150146	PSW B & E Water System	West Bradford	1	Brandywine Creek	WB Brandywine Creek	PA	Chester	395704	754522	305		0.017			
1150146	PSW B & E Water System	West Bradford	2	Brandywine Creek	WB Brandywine Creek	PA	Chester	395706	754524	307		0.017			
1150045	Brandywine Terrace MHP	Honeybrook	1	Brandywine Creek	WB Brandywine Creek	PA	Chester	400434	755104	120		0.02			
1150150	Caln MHP	Caln	1	Brandywine Creek	Beaver Creek	PA	Chester	395930	754650	200		0.002			
1150154	Carriage Crest System	Coatesville	1	Brandywine Creek	WB Brandywine Creek	PA	Chester	395729	755011	310		0.003			
1150032	Church Farm School	West Whiteland	1	Brandywine Creek	Valley Creek	PA	Chester	400153	753541	150		0.013			
1150134	Chester County Prison	Pocopson	1	Brandywine Creek	Pocopson Creek	PA	Chester	395421	753948	200		0.018			
1150134	Chester County Prison	Pocopson	2	Brandywine Creek	Pocopson Creek	PA	Chester	395421	753948	280		0.075			
1150134	Chester County Prison	Pocopson	3	Brandywine Creek	Pocopson Creek	PA	Chester	395420	753940	264		0.065			
1150134	Chester County Prison	Pocopson	4	Brandywine Creek	Pocopson Creek	PA	Chester	395420	753948						
1150133	Chester County Pocopson Home	Pocopson	1	Brandywine Creek	Pocopson Creek	PA	Chester	395418	753933	246		0.021			
1150037	Devereaux School	Wallace	1	Brandywine Creek	EB Brandywine Creek	PA	Chester	400458	754542	120		0.017			
1150037	Devereaux School	Wallace	2	Brandywine Creek	EB Brandywine Creek	PA	Chester	400504	754540	120					
1150149	Downingtown I & A School	East Brandywine	1	Brandywine Creek	Beaver Creek	PA	Chester			550		0.003			
1150149	Downingtown I & A School	East Brandywine	2	Brandywine Creek	Beaver Creek	PA	Chester			250		0.003			
1150149	Downingtown I & A School	East Brandywine	3	Brandywine Creek	Beaver Creek	PA	Chester			300		0.003			
1150149	Downingtown I & A School	East Brandywine	4	Brandywine Creek	Beaver Creek	PA	Chester			135		0.003			
1150132	Embreeville State Hospital	Newlin	1	Brandywine Creek	WB Brandywine Creek	PA	Chester			75		0.157			
1150137	PSW Friendship Water Co.	West Brandywine	1	Brandywine Creek	Beaver Creek	PA	Chester	400117	754734	340		0.017			
1150137	PSW Friendship Water Co.	West Brandywine	2	Brandywine Creek	Beaver Creek	PA	Chester	400117	754734	200		0.017			
1150087	Glenview MHP	Upper Uwchlan	1	Brandywine Creek	Marsh Creek	PA	Chester			245		0.002			
1150046	Gregory Courts MHP	Honeybrook	1	Brandywine Creek	WB Brandywine Creek	PA	Chester	400431	755030	50		0.04			
1150046	Gregory Courts MHP	Honeybrook	2	Brandywine Creek	WB Brandywine Creek	PA	Chester	400431	755030	70		0.05			
1150050	Hickory House	Honeybrook	1	Brandywine Creek	WB Brandywine Creek	PA	Chester	400440	755147	200		0.006			
1150050	Hickory House	Honeybrook	2	Brandywine Creek	WB Brandywine Creek	PA	Chester	400441	755149	160		0.001			
1150070	Highland MHP	Highland	1	Brandywine Creek	Buck Run	PA	Chester	395637	755351	120		0.002			
1150070	Highland MHP	Highland	2	Brandywine Creek	Buck Run	PA	Chester	395637	755351	117		0.002			
1150010	Hilltop MHP	East Fallowfield	1	Brandywine Creek	WB	PA	Chester			140		0.004			
1150010	Hilltop MHP	East Fallowfield	2	Brandywine Creek	WB	PA	Chester			165		0.007			
1150010	Hilltop MHP	East Fallowfield	3	Brandywine Creek	WB	PA	Chester			120		0.006			
1150127	Honeybrook Borough Authority	Honeybrook	1	Brandywine Creek	WB Brandywine Creek	PA	Chester	400611	755409	235		0.05			
1150127	Honeybrook Borough Authority	Honeybrook	2	Brandywine Creek	WB Brandywine Creek	PA	Chester	400609	755413	295		0.04			
1150127	Honeybrook Borough Authority	Honeybrook	3	Brandywine Creek	WB Brandywine Creek	PA	Chester	400610	755418	112		0.099			
1150042	Icedale MHP	Honeybrook	1	Brandywine Creek	WB Brandywine Creek	PA	Chester	400440	755136	87		0.012			

1150042	Icedale MHP	Honeybrook	2	Brandywine Creek	WB Brandywine Creek	PA	Chester	400441	755137	152		0.012			
1150013	Imperial MHP	West Caln	1	Brandywine Creek	EB Brandywine Creek	PA	Chester	400022	755016	200		0.004			
1150013	Imperial MHP	West Caln	2	Brandywine Creek	EB Brandywine Creek	PA	Chester	400021	755022	200		0.002			
1150013	Imperial MHP	West Caln	3	Brandywine Creek	EB Brandywine Creek	PA	Chester	400018	755019	150		0.002			
1150051	Indian Run Village MHP	West Brandywine	1	Brandywine Creek	EB Brandywine Creek	PA	Chester	400352	754849	150		0.042			
1150051	Indian Run Village MHP	West Brandywine	2	Brandywine Creek	EB Brandywine Creek	PA	Chester	400353	754849	300					
1150047	Keystone MHP	Honeybrook	1	Brandywine Creek	WB Brandywine Creek	PA	Chester	400434	755042	240		0.011			
1150174	Kimberwick Community	East Brandywine	1	Brandywine Creek	Beaver Creek	PA	Chester			400		0.011			
1150048	Lazy Acres MHP	Honeybrook	1	Brandywine Creek	WB Brandywine Creek	PA	Chester	400432	755026	75		0.004			
1150048	Lazy Acres MHP	Honeybrook	2	Brandywine Creek	WB Brandywine Creek	PA	Chester	400432	755026	300		0.005			
1150048	Lazy Acres MHP	Honeybrook	3	Brandywine Creek	WB Brandywine Creek	PA	Chester	400439	755026	480					
1150019	Londonderry Court	Londonderry	1	Brandywine Creek	Doe Run	PA	Chester	395130	755241						
1150019	Londonderry Court	Londonderry	2	Brandywine Creek	Doe Run	PA	Chester	395136	755243						
1150082	Lincoln Crest MHP	Sadsbury	1	Brandywine Creek	Buck Run	PA	Chester	395758	755308	45		0.008			
1150082	Lincoln Crest MHP	Sadsbury	2	Brandywine Creek	Buck Run	PA	Chester	395759	755308	45		0.008			
1150082	Lincoln Crest MHP	Sadsbury	3	Brandywine Creek	Buck Run	PA	Chester	395801	755308	250		0.008			
1150028	Little Washington System	East Brandywine	1	Brandywine Creek	EB Brandywine Creek	PA	Chester			280		0.022			
1150028	Little Washington System	East Brandywine	2	Brandywine Creek	EB Brandywine Creek	PA	Chester			326		0.031			
1150028	Little Washington System	East Brandywine	3	Brandywine Creek	EB Brandywine Creek	PA	Chester			200		0.011			
1150030	Loags Corner MHP	West Nantmeal	1	Brandywine Creek	EB Brandywine Creek	PA	Chester	400743	754851	160		0.004			
1150030	Loags Corner MHP	West Nantmeal	2	Brandywine Creek	EB Brandywine Creek	PA	Chester	400740	754853	120		0.004			
1150148	PSW Locust Knoll	East Brandywine	1	Brandywine Creek	EB Brandywine Creek	PA	Chester	400130	754505	320		0.022			
1150017	Maplewood MHP	West Brandywine	1	Brandywine Creek		PA	Chester	400033	754833	150		0.002			
1150017	Maplewood MHP	West Brandywine	2	Brandywine Creek		PA	Chester	400034	754833	150		0.002			
1150100	Marshallton Manor System		1	Brandywine Creek	WB Brandywine Creek	PA	Chester			125		0.005			
1150100	Marshallton Manor System		2	Brandywine Creek	WB Brandywine Creek	PA	Chester			124		0.005			
1150020	Mount Idy MHP	East Brandywine	1	Brandywine Creek	EB Brandywine Creek	PA	Chester	400227	754309			0.005			
1150020	Mount Idy MHP	East Brandywine	2	Brandywine Creek	EB Brandywine Creek	PA	Chester	400222	754317						
1150020	Mount Idy MHP	East Brandywine	3	Brandywine Creek	EB Brandywine Creek	PA	Chester	400228	754306						
1150147	PSW Pocopson	Pocopson	1	Brandywine Creek	EB Brandywine Creek	PA	Chester	395406	753907			0.057			
1150040	Springton MHP	West Brandywine	1	Brandywine Creek	WB Brandywine Creek	PA	Chester	400331	754717	130		0.003			
1150089	PSW Spring Run	Brandywine Green	1	Brandywine Creek	EB Brandywine Creek	PA	Chester	395821	754146	320					
1150089	PSW Spring Run	Brandywine Green	2	Brandywine Creek	EB Brandywine Creek	PA	Chester	395821	754146	440					
1150089	PSW Spring Run	Brandywine Green	3	Brandywine Creek	EB Brandywine Creek	PA	Chester	395821	754146	250					
1150089	PSW Spring Run	Brandywine Green	4	Brandywine Creek	EB Brandywine Creek	PA	Chester	395821	754138	260					
1150089	PSW Spring Run	Brandywine Green	5	Brandywine Creek	EB Brandywine Creek	PA	Chester	395821	754138	185					
1150089	PSW Spring Run	Brandywine Green	6	Brandywine Creek	EB Brandywine Creek	PA	Chester	395821	754138	305					
1150089	PSW Spring Run	Brandywine Green	7	Brandywine Creek	EB Brandywine Creek	PA	Chester	395821	754138	360					
1150089	PSW Spring Run	Spring Run	8	Brandywine Creek	EB Brandywine Creek	PA	Chester	395832	754321	440					
1150089	PSW Spring Run	Spring Run	9	Brandywine Creek	EB Brandywine Creek	PA	Chester	395832	754321	320					
1150089	PSW Spring Run	Spring Run	10	Brandywine Creek	EB Brandywine Creek	PA	Chester	395832	754321	360					
1150089	PSW Spring Run	Spring Run	11	Brandywine Creek	EB Brandywine Creek	PA	Chester	395844	754341	400					
1150089	PSW Spring Run	Colonial Wood	12	Brandywine Creek	EB Brandywine Creek	PA	Chester	395904	754352	105					
1150089	PSW Spring Run	Colonial Wood	13	Brandywine Creek	EB Brandywine Creek	PA	Chester	395904	754352	132					
1150089	PSW Spring Run	Colonial Wood	14	Brandywine Creek	EB Brandywine Creek	PA	Chester	395904	754352	126					
1150089	PSW Spring Run	Colonial Wood	15	Brandywine Creek	EB Brandywine Creek	PA	Chester	395904	754352	124					
1150089	PSW Spring Run	Colonial Wood	16	Brandywine Creek	EB Brandywine Creek	PA	Chester	395904	754352	315					
1150089	PSW Spring Run	Colonial Wood	17	Brandywine Creek	EB Brandywine Creek	PA	Chester	395904	754352						
1150089	PSW Spring Run	Bradford Glen	18	Brandywine Creek	EB Brandywine Creek	PA	Chester	395823	754406	305					
1150089	PSW Spring Run	Bradford Glen	19	Brandywine Creek	EB Brandywine Creek	PA	Chester	395825	754410	305					
1150089	PSW Spring Run	Bradford Glen	20	Brandywine Creek	EB Brandywine Creek	PA	Chester	395817	754413	260					
1150089	PSW Spring Run	Chestnut Lane	21	Brandywine Creek	EB Brandywine Creek	PA	Chester	395804	754457	303		0.072			
1150089	PSW Spring Run	Marshallton Wood	22	Brandywine Creek	EB Brandywine Creek	PA	Chester	395800	754107	207					
1150089	PSW Spring Run	Marshallton Wood	23	Brandywine Creek	EB Brandywine Creek	PA	Chester	395800	754107	93					
1150089	PSW Spring Run	Marshallton Wood	24	Brandywine Creek	EB Brandywine Creek	PA	Chester	395800	754107	93					
1150089	PSW Spring Run	Embreeville Well #1	25	Brandywine Creek	EB Brandywine Creek	PA	Chester	395614	754330	171					
1150029	St. Mary of Providence Home	West Nantmeal	1	Brandywine Creek	EB Brandywine Creek	PA	Chester	400642	755017			0.006			
1150029	St. Mary of Providence Home	West Nantmeal	2	Brandywine Creek	EB Brandywine Creek	PA	Chester	400642	755017						
1150029	St. Mary of Providence Home	West Nantmeal	3	Brandywine Creek	EB Brandywine Creek	PA	Chester	400639	755019						
1150029	St. Mary of Providence Home	West Nantmeal	4	Brandywine Creek	EB Brandywine Creek	PA	Chester	400639	755019						
1150088	Stonehedge System	Upper Uwchlan	1	Brandywine Creek	Marsh Creek	PA	Chester			200		0.022			
1150015	Taylor's MHP	Valley	1	Brandywine Creek	WB Brandywine Creek	PA	Chester	395852	755119	40		0.003			
1150015	Taylor's MHP	Valley	2	Brandywine Creek	WB Brandywine Creek	PA	Chester	395847	755117	60		0.004			
1150044	Tel Hai Retirement Community	Honeybrook	1	Brandywine Creek	WB Brandywine Creek	PA	Chester	400351	755324	274		0.03			
1150044	Tel Hai Retirement Community	Honeybrook	2	Brandywine Creek	WB Brandywine Creek	PA	Chester	400341	755328	109		0.006			
	Theo-zel MHP														
1150035	PSW Uwchlan Twp.	Bell Tavern	1	Brandywine Creek	Marsh Creek	PA	Chester	400116	754043	200		0.423			
1150035	PSW Uwchlan Twp.	Bell Tavern	2	Brandywine Creek	Marsh Creek	PA	Chester	400112	754042	186		0.074			
1150035	PSW Uwchlan Twp.	Shoen Road	3	Brandywine Creek	Marsh Creek	PA	Chester	400211	753827	410		0.378			
1150035	PSW Uwchlan Twp.	Shoen Road	4	Brandywine Creek	Marsh Creek	PA	Chester	400214	753822	300		0.042			
1150035	PSW Uwchlan Twp.	Robert Dean	5	Brandywine Creek	Marsh Creek	PA	Chester	400141	753906	158		0.421			
1150035	PSW Uwchlan Twp.	Robert Dean	6	Brandywine Creek	Marsh Creek	PA	Chester	400144	753906	600		0.278			
1150035	PSW Uwchlan Twp.	Milford	7	Brandywine Creek	Marsh Creek	PA	Chester	400430	754243	300		0.068			

1150035	PSW Uwchlan Twp.	Stonehedge	8	Brandywine Creek	Marsh Creek	PA	Chester	400605	754304	200					
1150035	PSW Uwchlan Twp.	Saybrooke	9	Brandywine Creek	Marsh Creek	PA	Chester	400553	754230	390					
1150035	PSW Uwchlan Twp.	Saybrooke	10	Brandywine Creek	Marsh Creek	PA	Chester	400553	754230	400					
	Upland Country Day School														
1150185	Valley Springs Water Company	Valley	1	Brandywine Creek	Rock Run	PA	Chester	395948	755041	220		0.024			
1150185	Valley Springs Water Company	Valley	2	Brandywine Creek	Rock Run	PA	Chester	395948	755043	310		0.009			
1150185	Valley Springs Water Company	Valley	3	Brandywine Creek	Rock Run	PA	Chester	395910	755100	285		0			
1150052	Valley View MHP	Honeybrook	1	Brandywine Creek	WB Brandywine Creek	PA	Chester	400432	755039	243					
1150052	Valley View MHP	Honeybrook	2	Brandywine Creek	WB Brandywine Creek	PA	Chester	400423	755041	95					
1150052	Valley View MHP	Honeybrook	3	Brandywine Creek	WB Brandywine Creek	PA	Chester	400423	755041	220					
1150052	Valley View MHP	Honeybrook	4	Brandywine Creek	WB Brandywine Creek	PA	Chester	400423	755030	408					
1150052	Valley View MHP	Honeybrook	5	Brandywine Creek	WB Brandywine Creek	PA	Chester	400421	755030	312					
1150186	Veterans Admin. Medical Center	Valley TWP	1	Brandywine Creek	WB	PA	Chester								
1150198	West Chester Area Authority	West Chester	1	Brandywine Creek	Taylor Run	PA	Chester	395754	753703	300					
1150198	West Chester Area Authority	West Chester	2	Brandywine Creek	Taylor Run	PA	Chester	395754	753703	400					
1150198	West Chester Area Authority	West Chester	3	Brandywine Creek	Taylor Run	PA	Chester	395754	753703	300		0.065			
1150198	West Chester Area Authority	West Chester	4	Brandywine Creek	Taylor Run	PA	Chester	395754	753703	270					
1150139	West Whiteland System	West Whiteland	1	Brandywine Creek	Valley Creek	PA	Chester			108		0.156			
1150139	West Whiteland System	West Whiteland	2	Brandywine Creek	Valley Creek	PA	Chester			85		0.179			
1150164	Woodbrooke Water Authority	West Brandywine	1	Brandywine Creek	WB Brandywine Creek	PA	Chester	400110	754936	225		0.006			
1150028	PSW Culbertson Run	East Brandywine	1	Brandywine Creek		PA	Chester	400252	754648	300					
1150028	PSW Culbertson Run	East Brandywine	2	Brandywine Creek		PA	Chester	400301	754604	300					
1150043	Cupola Court MHP	Honeybrook	1	Brandywine Creek		PA	Chester	400535	755115	80					
1150100	PSW Manorwood	West Bradford	1	Brandywine Creek		PA	Chester	395646	754103	132					
1150100	PSW Manorwood	West Bradford	2	Brandywine Creek		PA	Chester	395446	759103	124					
1150145	Shady Grove MHP	West Fallowfield	1	Brandywine Creek		PA	Chester	395506	755352	200					
1150145	Shady Grove MHP	West Fallowfield	2	Brandywine Creek		PA	Chester	395506	755352	0					
1150145	Shady Grove MHP	West Fallowfield	3	Brandywine Creek		PA	Chester	395506	755354	0					
1150174	PSW Kimberwick	West Brandywine	1	Brandywine Creek		PA	Chester	400320	754730	400					
1150174	PSW Kimberwick	West Brandywine	2	Brandywine Creek		PA	Chester	400320	754228	0					
1150174	PSW Kimberwick	West Brandywine	3	Brandywine Creek		PA	Chester	400254	754731	300					
1150174	PSW Kimberwick	West Brandywine	4	Brandywine Creek		PA	Chester	400256	754731	300					
1150179	Kendal Crosslands	Pocopson	1	Brandywine Creek		PA	Chester	395329	754013	120					
1150179	Kendal Crosslands	Pocopson	2	Brandywine Creek		PA	Chester	395329	754014	150					
1150180	PSW LaReserve	East Marlborough	1	Brandywine Creek		PA	Chester	395319	754334	0					
1150186	Coatesville Vet. Mem. Hospital	Caln	1	Brandywine Creek		PA	Chester	395931	754757						
1150189	Perry Phillips MHP	West Caln	1	Brandywine Creek		PA	Chester	395944	755420	175					
1150189	Perry Phillips MHP	West Caln	2	Brandywine Creek		PA	Chester	395946	755410	175					
1150195	PSW Honeybrook	Honeybrook	1	Brandywine Creek		PA	Chester	400419	755214	288					
1150195	PSW Honeybrook	Honeybrook	2	Brandywine Creek		PA	Chester	400419	755214	200					
1150198	Heatherwood Retirement Home		1	Brandywine Creek		PA	Chester	400442	755155	200					
1150198	Heatherwood Retirement Home		2	Brandywine Creek		PA	Chester	400442	755155	160					
1150204	Stone Barn	West Marlborough	1	Brandywine Creek		PA	Chester	395326	754654	120					
1150204	Stone Barn	West Marlborough	2	Brandywine Creek		PA	Chester	395322	754657	80					
1150205	Willowdale Water Co.	East Marlborough	1	Brandywine Creek		PA	Chester	395227	754333	500					
1150205	Willowdale Water Co.	East Marlborough	2	Brandywine Creek		PA	Chester	395245	754329	350					
1150205	Willowdale Water Co.	East Marlborough	3	Brandywine Creek		PA	Chester	395226	754334	0					
1150208	Lake Road MHP	London Grove	1	White Clay Creek		PA	Chester	394947	754843	0					
1150211	Modern Mushroom Farms	New Garden	1	White Clay Creek		PA	Chester	395038	754528	320					
DE 3	Winterthur	Winterthur	9	Brandywine Creek	MS below Chadds Ford	DE	New Castle							Wissahickon	
DE 4	Winterthur	Winterthur	8	Brandywine Creek	MS below Chadds Ford	DE	New Castle							Wissahickon	
DE 5	Winterthur	Winterthur	5	Brandywine Creek	MS below Chadds Ford	DE	New Castle							Wissahickon	
DE 6	Winterthur	Winterthur	6	Brandywine Creek	MS below Chadds Ford	DE	New Castle							Wissahickon	
DE 7	Methodist Country Home	Rte. 82 & 52	5	Red Clay Creek	MS above Wooddale	DE	New Castle	394656	754150					Wissahickon	
DE 8	Methodist Country Home	Rte. 82 & 52	4	Red Clay Creek	MS above Wooddale	DE	New Castle	394744	753642		6		1969	Wissahickon	
DE 9	Methodist Country Home	Rte. 82 & 52		Red Clay Creek	MS above Wooddale	DE	New Castle	394744	753642		8		1959	Wissahickon	
DE 10	Artesian Water Co.	Hockessin	4	White Clay Creek	Mill Creek	DE	New Castle	394720	754145	250	16	0.72	1974	Cockeysville	
DE 11	Artesian Water Co.	Hockessin	3	White Clay Creek	Mill Creek	DE	New Castle	394704	754211	312	6	0.612	1967	Cockeysville	
DE 12	Artesian Water Co.	Hockessin	1	White Clay Creek	Mill Creek	DE	New Castle	394708	754202	325	17	0.468	1964	Cockeysville	
DE 13	Artesian Water Co.	Hockessin	2	White Clay Creek	Mill Creek	DE	New Castle	394706	754207	330	17	0.576	1968	Cockeysville	
DE 14	Artesian Water Co.	Hockessin	G3	White Clay Creek	Mill Creek	DE	New Castle	394704	754150	300	8	0.288	1974	Cockeysville	
DE 15	Artesian Water Co.	Hockessin	G1	White Clay Creek	Mill Creek	DE	New Castle	394653	754129	199	14	0.576	1972	Cockeysville	
DE 16	Newark Water Dept.	North Wellfield	23	White Clay Creek	MS above Newark	DE	New Castle	394146	754450	400	8	0.504	1973	Wissahickon	
DE 17	Newark Water Dept.	North Wellfield	25	White Clay Creek	MS above Newark	DE	New Castle	394135	754513	450	8	0.216	1973	Wissahickon	
DE 18	Newark Water Dept.	North Wellfield	20	White Clay Creek	MS above Newark	DE	New Castle	394133	754508	102	10	0.792	1971	Wissahickon	
DE 19	Newark Water Dept.	North Wellfield	21	White Clay Creek	MS above Newark	DE	New Castle	394131	754456	55	10	0.288	1971	Wissahickon	
DE 20	Artesian Water Co.	Collins Park	1	Christina River	MS Lower Tidal	DE	New Castle	394129	753517	124	17	0.432	1960	Potomac	
DE 21	Artesian Water Co.	Wilmington Airport	3	Christina River	MS Lower Tidal	DE	New Castle	394123	753551	159	8	0.288	1944	Lower Potomac	
DE 22	Artesian Water Co.	Wilmington Airport	1	Christina River	MS Lower Tidal	DE	New Castle	394116	753522	198	8	0.288	1944	Lower Potomac	
DE 23	Artesian Water Co.	Wilmington Airport	2	Christina River	MS Lower Tidal	DE	New Castle	394115	753521	222	8	0.288	1944	Lower Potomac	
DE 38	Newark Water Dept.	Academy St.	8	White Clay Creek	MS above DE Park	DE	New Castle	394019	754501	63	16	0.202	1940	Colombia	
DE 39	Newark Water Dept.	South Well Field	12	Christina River	EB/WB above Coochs Bridge	DE	New Castle	393927	754329	175	10	0.108	1956	Potomac	

DE 40	Newark Water Dept.	South Well Field	13	Christina River	EB/WB above Coochs Bridge	DE	New Castle	393925	754335	64	10	0.259	1969	Colombia	
DE 41	Newark Water Dept.	South Well Field	10	Christina River	EB/WB above Coochs Bridge	DE	New Castle			153	4	0.086	1969	Colombia	
DE 42	Newark Water Dept.	South Well Field	14	Christina River	EB/WB above Coochs Bridge	DE	New Castle	393852	754309	128	10	0.468	1964	Lower Potomac	
DE 43	Newark Water Dept.	South Well Field	11	Christina River	EB/WB above Coochs Bridge	DE	New Castle	393852	754309	63	10	0.216	1969	Colombia	
DE 44	Newark Water Dept.	South Well Field	15	Christina River	EB/WB above Coochs Bridge	DE	New Castle	393852	754309	69	10	0.612	1969	Colombia	
DE 45	Newark Water Dept.	South Well Field	16	Christina River	MS above Smalley's Pond	DE	New Castle	393852	754309	167	10	0.684	1969	Lower Potomac	
DE 46	Newark Water Dept.	South Well Field	17	Christina River	Muddy Run	DE	New Castle	393739	754419	79	8	0.216	1971	Colombia	
DE 60	Artesian Water Co.	Glendale	7	Christina River	MS above Smalley's Pond	DE	New Castle	393751	753853	138_153	10	0.576	1976	Colombia	
DE 61	Artesian Water Co.	South Well Field	19	Christina River	Muddy Run	DE	New Castle	393753	754343	133	6	0.086	1974	Lower Potomac	
DE 62	Artesian Water Co.	Glendale	5	Christina River	MS above Smalley's Pond	DE	New Castle	393743	753916	138	12	0.432	1973	Colombia	
DE 63	Artesian Water Co.	Glendale	2	Christina River	MS above Smalley's Pond	DE	New Castle	393735	753920	80	17	0.36	1960	Colombia	
DE 65	Artesian Water Co.	Glendale	4R	Christina River	MS above Smalley's Pond	DE	New Castle	393735	753921	138_153	10	0.144	1961	Colombia	
DE 66	Artesian Water Co.	Glendale	6	Christina River	MS above Smalley's Pond	DE	New Castle	393735	753935	138_153	12	0.396	1974	Colombia	
DE 69	Artesian Water Co.	Eastern States	2	Christina River	Muddy Run	DE	New Castle	393603	753635	263	10	0.72	1981	Potomac	
DE 70	Artesian Water Co.	Eastern States	1	Christina River	Muddy Run	DE	New Castle	393612	754647	263	10	0.576	1981	Potomac	
DE 71	Artesian Water Co.	Caravel Farms	1	Christina River	Belltown Run	DE	New Castle	393536	754316	100	10	0.36	1976	Potomac	

MAP 3 - NPDES DISCHARGES
Christina Basin Water Quality Management Strategy
May 21, 1998

Permit No	Owner	Watershed	Stream	State	County	Latitude	Longitude	Reissue Date	Ind/Com/Mun	Flow Limit (mgd)	Description	Parameters	Contact for Data
DE 50962	AMTRAK	Brandywine Creek	TB-Brandywine Creek	DE	New Castle	394416	753125	1997	Industrial		Stormwater		
DE 51004	Boeing	Christina River	Nonesuch Creek	DE	New Castle	394105	753621	2001	Industrial		Stormwater		
DE 00400	Ciba-Geigy Corp.	Christina River	Christina River	DE	New Castle	394238	753638	2001	Industrial		Cooling Water		
DE 00566	DuPont Chestnut Run	Christina River	Little Mill Creek	DE	New Castle	394458	753622	1997	Industrial		Stormwater/Cooling Water		
DE 00191	FMC Corp.	White Clay Creek	Cool Run	DE	New Castle	394056	754310	1997	Industrial	0.0300	Stormwater/Cooling Water		
DE 00523	General Motors Assembly	Christina River	Little Mill Creek	DE	New Castle	394341	753639	1997	Industrial	2.8000	Stormwater		
DE 21709	Greenville Country Club	Red Clay Creek	TB-Red Clay Creek	DE	New Castle	394854	753710	2001	Municipal	0.0150	Small STP		
DE 00230	Hercules, Inc.	Red Clay Creek	Red Clay Creek	DE	New Castle	394522	753804	2001	Industrial	0.3500	Cooling Water		
DE 00451	NVF, Yorklyn	Red Clay Creek	Red Clay Creek	DE	New Castle	394824	754025	1997	Industrial	2.1700	Stormwater/Cooling Water		
DE 21768	Winterthur	Brandywine Creek	Clenney Run	DE	New Castle	394824	753605	1997	Municipal	0.0250	Small STP		
PA 53783	Avon Grove School Dist	White Clay Creek	TB-WB White Clay Creek	PA	Chester	394753	755251	2000	Commercial	0.0200	Small STP		
PA 52019	Avon GroveTrailer Court	White Clay Creek	EB White Clay Creek	PA	Chester	394925	754903	2001	Municipal	0.0075	Small STP		
PA 25488	Avondale Borough Sewer Authority	White Clay Creek	Indian Run	PA	Chester	394918	754706		Municipal	0.3000	Large STP		
PA 43982	Broad Run Sew Co.	Brandywine Creek	EB Brandywine Creek	PA	Chester	395840	754100		Municipal	0.4000	Large STP		
PA 29343	Chatham Acres	White Clay Creek	TB-EB White Clay Creek	PA	Chester	395222	754903		Municipal	0.0270	Small STP		
PA 53821	Chester County Aviation Inc.	Brandywine Creek	Sucker Run	PA	Chester	395851	755204		Commercial		Stormwater		
PA 26859	Coatesville City Authority	Brandywine Creek	WB Brandywine Creek	PA	Chester	395823	754927		Municipal	3.8500	Large STP		
PA 31097	Radley Run C.C.	Brandywine Creek	Radley Run	PA	Chester	395448	753703		Municipal	0.0170	Small STP		
PA 55425	D'Ambro Anthony, Jr. - Lot #22	Red Clay Creek	TB-EB Red Clay Creek	PA	Chester	394957	753901		Municipal	0.0005	Single Residence STP		
PA 26531	Downingtown Area Regional Authority	Brandywine Creek	EB Brandywine Creek	PA	Chester	395403	754641	2001	Municipal	7.0000	Large STP		
PA 36374	Eaglepoint Dev. Assoc.	Brandywine Creek	TB Marsh Creek	PA	Chester	400421	754126	2001	Municipal	0.0150	Small STP		
PA 53554	Earthgro, Inc.	Red Clay Creek	WB Red Clay Creek	PA	Chester	394938	754519		Industrial		Stormwater		
PA 55107	East Marlborough Township STP	Red Clay Creek	TB-EB Red Clay Creek	PA	Chester	395141	754052	1998	Municipal	0.1500	Large STP		
PA 29912	Embreeville Hospital	Brandywine Creek	WB Brandywine Creek	PA	Chester	395559	754329		Municipal	0.2000	Large STP		
PA 54356	Getty Petroleum Corporation	White Clay Creek	TB-EB White Clay Creek	PA	Chester	395004	754941		Industrial	no discharge since 1992	Small STP		
PA 53228	Gramm, Jeffery	Brandywine Creek	WB Brandywine Creek	PA	Chester	395651	754033		Municipal	0.0005	Single Residence STP		
PA 50458	Little Washington Drainage Co.	Brandywine Creek	Culbertson Run	PA	Chester	400248	754633	2002	Municipal	0.0531	Small STP		
PA 57126	Hess Oil - SS #38291	Brandywine Creek	Valley Run	PA	Chester	395946	754450		Commercial		DP		
PA 44776	NW Chester Co. Municipal Authority	Brandywine Creek	WB Brandywine Creek	PA	Chester	400420	755150	2002	Municipal	0.6000	Large STP		
PA 50547	Indian Run Village MHP	Brandywine Creek	Indian Run	PA	Chester	400414	754832	1998	Municipal	0.0375	Small STP		
PA 51365	West Chester Area Municipal Authority	Brandywine Creek	EB Brandywine Creek	PA	Chester	395149	753906	2001	Municipal	0.3690	Ingram's Mill - Filter Backwash		
PA 53937	Johnson, Ralph & Gayla	Brandywine Creek	Broad Creek	PA	Chester	395900	753830		Municipal	0.0005	Single Residence STP		
PA 24058	Kennett Square Boro. WWTP	Red Clay Creek	WB Red Clay Creek	PA	Chester	395010	754330		Municipal	1.1000	Large STP		
PA 55531	Khalife, Paul	Brandywine Creek	TB Valley Run	PA	Chester	395915	754505		Commercial	0.0007	Small STP		
PA 53678	Lambert, Earl R.	Brandywine Creek	EB Brandywine Creek	PA	Chester	400022	754220		Industrial		DP		
PA 36161	Lincoln Crest MHP STP	Brandywine Creek	Buck Run	PA	Chester	395857	755349	1999	Municipal	0.0360	Small STP		
PA 53660	Mobil Oil Company #016	Brandywine Creek	EB Brandywine Creek	PA	Chester	400022	754220		Commercial		Air stripper at Service Station		
PA 11568	Lukens Steel Co.	Brandywine Creek	Sucker Run	PA	Chester	395828	755008		Industrial	0.5000	Large STP		
PA 56324	Mobil SS#16-GPB	Brandywine Creek	TB-WB Valley Run	PA	Chester	400036	753625	2000	Commercial	0.0440	DP		
PA 50679	National Vulcanized Fiber (NVF)	Red Clay Creek	TB-WB Red Clay Creek	PA	Chester	395024	754255	2001	Industrial	0.2500	Cooling Water		
PA 56618	O'Cornwell, David & Jeanette	Brandywine Creek	Broad Run	PA	Chester	395928?	753838?		Municipal	0.0005	Single Residence STP		
PA 52949	Phila. Suburban Water Co.	Brandywine Creek	Marsh Creek	PA	Chester	400442	754250		Industrial		Uwchlan DP		
PA40436	Chadds Ford Investment Co./Red Fox GC	White Clay Creek	TB-EB White Clay Creek	PA	Chester	395052	754612		Municipal	0.0090	Small STP		
PA 27987	Pennsylvania Turnpike/Caruiel Service Plaza	Brandywine Creek	Marsh Creek	PA	Chester	400706	754617	1997	Commercial	0.0500	Small STP		
PA 55697	Spring Run Estates	Brandywine Creek	WB Brandywine Creek	PA	Chester	400229	754747		Commercial	0.0490	Small STP		
PA 40665	Stone Barn Restuarant and Apt. Cplx	White Clay Creek	EB White Clay Creek	PA	Chester	395304	754702		Commercial	0.0100	Small STP		
PA 54691	Stoltzfus, Ben Z.	Brandywine Creek	TB Brandywine Creek	PA	Chester	400559	755245		Municipal	0.0005	Single Residence STP		
PA 53996	Redmond, Michael	Brandywine Creek	TB-WB Brandywine Creek	PA	Chester	395630	754400		Municipal	0.0005	Single Residence STP		
PA 36897	South Coatesville Borough	Brandywine Creek	WB Brandywine Creek	PA	Chester	395819	754831	1999	Municipal	0.3900	Large STP		
PA 12815	Sunoco Products	Brandywine Creek	EB Brandywine Creek	PA	Chester	400000	754219	2001	Industrial	3.0000	Paper Company - Mill Raceway		
PA 54917	Uwchlan Twp. Municipal Authority	Brandywine Creek	Shamona Creek	PA	Chester	400345	754046	2001	Municipal	0.0030	Eagleview CC STP		
PA 56073	Vreeland, Russell Dr.	Brandywine Creek	TB Rock Run	PA	Chester	395926	755329		Municipal	0.0005	Single Residence STP		
PA 26018	West Chester Borough MUA/Taylor Run	Brandywine Creek	Taylor Run	PA	Chester	395802	753746	2000	Municipal	1.8000	Large STP		
PA 34612	Tel Hai Rest Home	Brandywine Creek	Two Log Run	PA	Chester	400338	755306		Commercial	0.0550	Small STP		
PA 55492	Topp, John & Jane	White Clay Creek	Indian Run	PA	Chester	400443	754859		Municipal	0.0005	Single Residence STP		
PA 52728	Farmland Industries, Inc./Turkey Hill	Brandywine Creek	WB Brandywine Creek	PA	Chester	400012	754838		Industrial		Small STP		
PA 30848	Unionville - Chadds Ford Elem. School	Brandywine Creek	Ring Run	PA	Chester	395224	753556		Municipal	0.0063	Small STP		
PA 53236	Woodward, Raymond Sr. STP	Brandywine Creek	WB Brandywine Creek	PA	Chester	395651	754033		Municipal	0.0005	Single Residence STP		
PA 24066	West Grove Borough Authority STP	White Clay Creek	MB White Clay Creek	PA	Chester	394901	755017	1999	Municipal	0.2500	Large STP		
PA 55484	Keating, Herbert & Elizabeth	Brandywine Creek	TB Brandywine Creek	PA	Chester	395158	753500		Municipal	0.0005	Single Residence STP		
PA 55476	Birmingham TSA/Ridings at Chadds Ford	Brandywine Creek	TB Harvey Creek	PA	Chester	395155	753312	2001	Municipal	0.0231	Small STP		
PA 52663	Knight's Bridge Corp./Villages at Painters	Brandywine Creek	Harvey Run	PA	Chester	395256	753310		Commercial	0.0450	Small STP		
PA 55085	Winslow, Nancy Ms.	Brandywine Creek	TB Brandywine Creek	PA	Chester	395200	753525		Municipal	0.0005	Single Residence STP		
PA 36200	Radley Run Mews	Brandywine Creek	Plum Run	PA	Chester	395501	753737		Municipal	0.0320	Small STP		
PA 50229	Perry Salisbury	Brandywine Creek	Indian Run Creek	PA	Chester				Municipal	0.0005	Single Residence STP		
PA 12416	Coatesville Water Plant	Brandywine Creek	Rock Run	PA	Chester	400022	755053		Industrial	0.0750	ater Filtration Plant (Filter Backwash)		
PA 53449	Birmingham Twp. STP	Brandywine Creek	Radley Run	PA	Chester	395437	753424	2001	Municipal	0.0230	Small STP		
PA 56171	McGlaughlin, Jeffrey	Brandywine Creek	Plum Run	PA	Chester	395538	753624		Municipal	0.0005	Single Residence STP		
PA 53082	Mendenhall Inn	Brandywine Creek	TB Brandywine Creek	PA	Chester	395115	753824		Commercial	0.0220	Small STP		
PA 52990	Mitchell, Rodney	Brandywine Creek	Rock Run	PA	Chester	395922	755332		Municipal	0.0005	Single Residence STP		
PA 52451	Frances L. Hamilton Oates STP	White Clay Creek	EB White Clay Creek	PA	Chester	394641	754622		Municipal	0.0012	Small STP		
PA 51918	Pepperidge Farms	Brandywine Creek	Parke Run Creek	PA	Chester	400015	754115		Industrial	0.1440	Cooling Water		
PA 56120	Schindler	Brandywine Creek	Pocopson Creek	PA	Chester	395410	753815		Municipal	0.0005	Single Residence STP		
MD 00000	Highlands WWTP	Christina River	WB Christina River	MD	Cecil				Municipal		Small STP		
MD 00000	Meadowview Utilities, Inc.	Christina River	WB Christina River	MD	Cecil				Municipal		Small STP		

MAP 3 - STREAM WATER QUALITY MONITORING STATIONS
Christina Basin Water Quality Management Strategy
May 21, 1998

Map Ref No	STORET No	Watershed	Subwatershed	Location	State	County	Latitude	Longitude	Period of Record	Freq of Sampling	Contact for Data
B1		Brandywine Creek	EB Brandywine Creek	Route 30 Bridge above Downingtown	PA	Chester	400205	754231			
B2		Brandywine Creek	EB Brandywine Creek	Route 322 Bridge below Downingtown	PA	Chester	395807	754025			
B3		Brandywine Creek	EB Brandywine Creek	Route 842 Bridge at Mouth of East Branch	PA	Chester	395530	753847			
B4		Brandywine Creek	WB Brandywine Creek	Route 30 Bridge above Coatesville	PA	Chester	395910	754940			
B5		Brandywine Creek	WB Brandywine Creek	Strasbrug Road Bridge below Coatesville	PA	Chester	395741	754808			
B6		Brandywine Creek	WB Brandywine Creek	Route 842 Bridge at Mouth of West Branch	PA	Chester	395534	753949			
B7		Brandywine Creek	MS Brandywine Creek	Chadds Ford Stream Gage WQ105	PA	Chester	395211	753536			
B8	104051	Brandywine Creek	MS Brandywine Creek	Smith Bridge	DE	New Castle					
B9	104021	Brandywine Creek	MS Brandywine Creek	t 279 Bridge DuPont Exper. Station (USGS Gage 01481500	DE	New Castle					
B10	104011	Brandywine Creek	MS Brandywine Creek	Foot Bridge Brandywine Park	DE	New Castle					
C1	106191	Christina River	EB Christina River	DE Route 273 above Newark	DE	New Castle					
C1.1	106181	Christina River	EB Christina River	DE Route 2 at Elkton Road	DE	New Castle					
C1.2	106171	Christina River	Persimmon Run	Sandy Brae Road	DE	New Castle					
C1.3	106161	Christina River	WB Christina River	DE Route 2	DE	New Castle					
C2	106141	Christina River	MS Christina River	Old Baltimore Pike below Newark (USGS Gage 0147800)	DE	New Castle					
C2.1	106131	Christina River	Muddy Run	Sunset Lake Road	DE	New Castle					
C2.2	106121	Christina River	Belltown Run	Becks Pond Salem Church Road	DE	New Castle					
C2.3	106111	Christina River	MS Christina River	Road 346	DE	New Castle					
C3	106031	Christina River	MS Christina River	Smalley's Dam Spillway	DE	New Castle					
C4	106021	Christina River	Tidal Christina River	Rt 141 Drawbridge Newport (USGS Tide Gage 01480065)	DE	New Castle					
C5	106011	Christina River	Tidal Christina River	US Route 13 at 3rd Street Bridge	DE	New Castle					
C6	091011	Christina River	Tidal Christina River	Port of Wilmington Cherry Island Flats	DE	New Castle					
C7	106281	Christina River	Little Mill Creek	Atlantic Avenue (USGS Gage 01480095)	DE	New Castle					
C7.1	106291	Christina River	Tidal Christina River	Conrail Bridge (USGS Tide Gage 10141602)	DE	New Castle					
R1		Red Clay Creek	EB Red Clay Creek	Old Kennett Road	PA	Chester	394936	754131			
R2		Red Clay Creek	WB Red Clay Creek	Hillendale Road	PA	Chester	395131	754357			
R3		Red Clay Creek	MS Red Clay Creek	Marshall Bridge Road (WQN 150)	PA	Chester	394900	754131			
R3.1	103051	Red Clay Creek	MS Red Clay Creek	Road 252 in Yorklyn	DE	New Castle					
R4	103041	Red Clay Creek	MS Red Clay Creek	Road 258A in Ashland	DE	New Castle					
R5	103031	Red Clay Creek	MS Red Clay Creek	DE Route 48 Wooddale (USGS Gage 01480000)	DE	New Castle					
R5.1	103021	Red Clay Creek	MS Red Clay Creek	Road 332 in Marshallton	DE	New Castle					
R6	103011	Red Clay Creek	MS Red Clay Creek	DE Route 4 at Stanton Bridge (USGS Gage 01480015)	DE	New Castle					
R7	103061	Red Clay Creek	Burroughs Run	Confluence with Red Clay Creek - Road 241 Bridge	DE	New Castle					
W1		White Clay Creek	EB White Clay Creek	London Tract Road Bridge	PA	Chester					
W2		White Clay Creek	WB White Clay Creek	London Tract Road (WQN 179)	PA	Chester	395130	754701			
W3		White Clay Creek	MS White Clay Creek	Creek Road (WQN 149)	PA	Chester	394459	754612			
W4	105031	White Clay Creek	MS White Clay Creek	Chambers Rock Road	DE	New Castle					
R4.1	105041	White Clay Creek	MS White Clay Creek	DE Route 72 Bridge	DE	New Castle					
R4.2	105021	White Clay Creek	MS White Clay Creek	DE Route 2 Bridge near Newark	DE	New Castle					
W5	105151	White Clay Creek	MS White Clay Creek	DE Park Race Track (USGS Gage 01479000)	DE	New Castle					
W6	105011	White Clay Creek	MS White Clay Creek	Stanton, Old Route 7 Bridge	DE	New Castle					
W7	105071	White Clay Creek	MS White Clay Creek	Above Mill Creek Confluence below Route 4	DE	New Castle					
W8	105101	White Clay Creek	Pike Creek	Upper Pike Creek Road	DE	New Castle					
W9	105131	White Clay Creek	MS White Clay Creek	Middle Run Confluence - Possum Park Road	DE	New Castle					

MAP 3 - INDUSTRIAL, RECREATIONAL, and IRRIGATION INTAKES
Christina Basin Water Quality Management Strategy
May 21, 1998

ID No.	Purveyor	Location	Watershed	Stream	State	County	Latitude	Longitude	Peak Withdrawal (mgd)	Contact for Data
DE-1	NVF	Yorklyn	Red Clay Creek	MS Red Clay Creek	DE	New Castle			3.500	
DE-2	Hercules Research Center	Woodale	Red Clay Creek	MS Red Clay Creek	DE	New Castle			0.900	
DE-3	Hercules C.C.	Woodale	Red Clay Creek	MS Red Clay Creek	DE	New Castle			0.500	
DE-4	Beard, Samuel	Wilmington	Red Clay Creek	MS Red Clay Creek	DE	New Castle			0.030	
DE-5	Hershberger, Marvin	Smalley's Pond Hdwtrs	Christina River	MS Christina River	DE	New Castle			0.020	
DE-6	Cavalier's C.C.	Newark, Pond #1, River	Christina River	MS Christina River	DE	New Castle			0.590	
DE-7	Ed Oliver C.C.	Wilmington, Pond #1	Christina River	Little Mill Creek	DE	New Castle			0.450	
DE-8	Wilmington Finishing	Wilmington	Brandywine Creek	MS Brandywine Creek	DE	New Castle			1.000	
DE-9	DuPont C.C.	Wilmington	Brandywine Creek	MS Brandywine Creek	DE	New Castle			0.360	
DE-10	DuPont C.C.	Wilmington	Brandywine Creek	MS Brandywine Creek	DE	New Castle			0.360	
DE-11	Wilmington C.C.	Kennett Pike	Brandywine Creek	MS Brandywine Creek	DE	New Castle			1.300	
DE-12	Wilmington C.C.	Kennett Pike	Brandywine Creek	MS Brandywine Creek	DE	New Castle			0.430	
DE-13	Wilmington C.C.	Kennett Pike	Brandywine Creek	MS Brandywine Creek	DE	New Castle			0.070	
DE-14	Brandywine C.C.	Shipley Rd., Pond #1	Brandywine Creek	MS Brandywine Creek	DE	New Castle			0.510	
DE-15	Curtis Paper	Newark	White Clay Creek	MS White Clay Creek	DE	New Castle			1.000	
DE-16	NVF	Newark	White Clay Creek	MS White Clay Creek	DE	New Castle			1.500	
DE-17	MBNA	Louviers	White Clay Creek	MS White Clay Creek	DE	New Castle			0.290	
DE-18	MBNA	Deerfield Golf Course	White Clay Creek	MS White Clay Creek	DE	New Castle			0.230	
DE-19	Delcastle Golf Course	McKennans Church Rd.	White Clay Creek	Mill Creek	DE	New Castle			0.260	
DE-20	Three Little Bakers C.C.	Wilmington	White Clay Creek	Pike Creek	DE	New Castle			0.240	
6971-004	Lukens Steel Co.	Coatesville	Brandywine Creek	WB Brandywine Creek	PA	Chester	395840	754936	4.760	
6971-005	Lukens Steel Co.	Coatesville	Brandywine Creek	Sucker Run	PA	Chester	395840	754936		
6987-004	Sonoco Prod. Co.	Downingtown	Brandywine Creek	EB Brandywine Creek	PA	Chester	400008	754215	1.320	
6990-004	Brandywine Paperboard	Downingtown	Brandywine Creek	EB Brandywine Creek	PA	Chester	400022	754216	0.024	
6996-006	General Crushed Stone		Brandywine Creek	Valley Creek	PA	Chester	400032	753951	0.620	
7045-004	Sealed Air Corp.		Brandywine Creek	Dennis Run	PA	Chester	395740	754804	0.278	
7227-005	Laurel Valley Farms	New Garden	White Clay Creek	EB White Clay Creek	PA	Chester	394807	754601	0.032	
7266-004	Shyrock Bros. Inc.	Uwchlan	Brandywine Creek	EB Brandywine Creek	PA	Chester	400220	754222	0.010	
250560-002	Radley Run C.C.	Birmingham	Brandywine Creek	Radley Run	PA	Chester	395446	753712	0.100	
250611-004	Lock Nairn G.C.	New Garden	White Clay Creek	EB White Clay Creek	PA	Chester	395054	754644	0.058	
250612-003	Whiteford C.C.	West Whitland	Brandywine Creek	Valley Creek	PA	Chester	400138	753959	0.643	
450088-002	Thompson Inc., J.H.	New Garden	Red Clay Creek	WB Red Clay Creek	PA	Chester	395002	754445		
450090-002	Hawthowne, Byran L.	West Brandywine	Brandywine Creek	WB Brandywine Creek	PA	Chester	400147	754906	0.088	
400475-003	Valley Forge Stone	Honeybrook	Brandywine Creek	WB Brandywine Creek	PA	Chester	400719	755422		
250156-022	Ingleside G.C.		Brandywine Creek		PA	Chester	395946	754508	0.013	
250445-004	Kennett Square Golf	Kennett Square	Red Clay Creek	EB Red Clay Creek	PA	Chester	395153	754231	0.084	
250611-002	Lock Nairn G.C.	New Garden	White Clay Creek	EB White Clay Creek	PA	Chester	395054	754644	0.017	
250611-003	Lock Nairn G.C.	New Garden	White Clay Creek	EB White Clay Creek	PA	Chester	395054	754644	0.017	
250615-003	West Chester Golf & C.C.	West Chester	Brandywine Creek	Taylor Run	PA	Chester	395809	753702	0.096	
450090-003	Hawthorne, Byron L.	West Brandywine	Brandywine Creek	WB Brandywine Creek	PA	Chester	400147	754906	0.015	
6996-013	Gen. Crushed Stone		Brandywine Creek	Valley Creek	PA	Chester	400035	754000	0.004	

MAP 3 - CHESTER COUNTY HEALTH DEPARTMENT SAMPLING STATIONS
Christina Basin Water Quality Management Strategy
May 21, 1998

ID No	Watershed	Subwatershed	Township	USGS Quad	Latitude	Longitude	State	County	Parameters	Frequency	Contact for Data
WS 620	Brandywine Creek	East Branch	Honeybrook	Wagontown	400541	755114	PA	Chester			
WS 621	Brandywine Creek	East Branch	Wallace	Wagontown	400547	754644	PA	Chester			
WS 622	Brandywine Creek	East Branch	Uwchlan	Downingtown	400206	754232	PA	Chester			
WS 623	Brandywine Creek	East Branch	Downingtown	Downingtown	400020	754218	PA	Chester			
WS 624	Brandywine Creek	East Branch	East Bradford	Unionville	395941	754143	PA	Chester			
WS 625	Brandywine Creek	East Branch	East Bradford	Unionville	395807	754026	PA	Chester			
WS 626	Brandywine Creek	East Branch	East Bradford	Unionville	395733	753920	PA	Chester			
WS 627	Brandywine Creek	East Branch	East Bradford	Unionville	395531	753857	PA	Chester			
WS 636	Brandywine Creek	West Branch	Honeybrook	Honeybrook	400451	755538	PA	Chester			
WS 628	Brandywine Creek	West Branch	Honeybrook	Wagontown	400421	755143	PA	Chester			
WS 629	Brandywine Creek	West Branch	Valley	Coatesville	395937	754936	PA	Chester			
WS 630	Brandywine Creek	West Branch	Modena	Coatesville	395743	754806	PA	Chester			
WS 745	Brandywine Creek	Doe Run	West Marlborough	Coatesville	395423	754941	PA	Chester			
WS 746	Brandywine Creek	Buck Run	West Marlborough	Coatesville	395546	754922	PA	Chester			
WS 631	Brandywine Creek	West Branch	Newlin	Coatesville	395603	754502	PA	Chester			
WS 632	Brandywine Creek	West Branch	Pocopson	Unionville	395534	753949	PA	Chester			
WS 633	Brandywine Creek	MS above Chadds Ford	Pocopson	Unionville	395450	753748	PA	Chester			
WS 634	Brandywine Creek	MS above Chadds Ford	Pocopson	West Chester	395403	753727	PA	Chester			
WS 635	Brandywine Creek	MS above Chadds Ford	Pennsbury	Wilmington-North	395217	753547	PA	Chester			
WS 460	Red Clay Creek	East Branch	East Marlborough	Kennett Square	395205	754219	PA	Chester			
WS 466	Red Clay Creek	West Branch	Kennett	Kennett Square	395059	754330	PA	Chester			
WS 469	Red Clay Creek	West Branch	Kennett	Kennett Square	394950	754319	PA	Chester			
WS 463	Red Clay Creek	MS above Wooddale	Kennett	Kennett Square	394859	754131	PA	Chester			
WS 472	Red Clay Creek	MS above Wooddale	Kennett	Kennett Square	394848	754054	PA	Chester			
WS 510	White Clay Creek	EB above Avondale	London Grove	West Grove	395124	754815	PA	Chester			
WS 515	White Clay Creek	EB above Avondale	Avondale	West Grove	394942	754653	PA	Chester			
WS 663	White Clay Creek	EB above Avondale	West Marlborough	West Grove	395203	755029	PA	Chester			
WS 659	White Clay Creek	EB above Avondale	London Grove	West Grove	395150	755009	PA	Chester			
WS 526	White Clay Creek	Middle Branch	London Grove	West Grove	394747	754929	PA	Chester			
WS 529	White Clay Creek	Middle Branch	London Britain	West Grove	394559	754744	PA	Chester			
WS 535	White Clay Creek	Middle Branch	London Britain	West Grove	394556	754747	PA	Chester			
WS 520	White Clay Creek	EB below Avondale	London Britain	West Grove	394609	754554	PA	Chester			
WS 538	White Clay Creek	MS above Newark	New Castle County	Newark-West	394358	754537	DE	New Castle			
WS 700	Brandywine Creek	Hibernia Creek	West Caln	Wagontown	400139	755046	PA	Chester			
WS 701	Brandywine Creek	Hibernia Creek	West Caln	Wagontown	400151	755220	PA	Chester			

MAP 3 - SPRAY IRRIGATION FACILITIES
Christina Basin Water Quality Management Strategy
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Permit No	Owner	Watershed	Subwatershed	State	County	Latitude	Longitude	Reissue Date	low Limit (mgd	Average Flow (mgd)	Parameters	Contact for Data
	Wallace Spray System	Brandywine Creek	EB Brandywine Creek	PA	Chester							
	Spray Irrigation, Inc.	Brandywine Creek	EB Brandywine Creek	PA	Chester							
	Marsh Spray System	Brandywine Creek	Marsh Creek	PA	Chester							
	Pocopson Home	Brandywine Creek	Pocopson Creek	PA	Chester							
	Unionville-Chadds Ford Schools MS & HS	Red Clay Creek	EB Red Clay Creek	PA	Chester							
	Rosedale	Red Clay Creek		PA	Chester	395101	753958					
	University of Pennsylvania - New Bolton Center	Red Clay Creek	Southbrook Creek	PA	Chester	394533	755334		0.0500			
	Chester Co. Commissioners - Pocopson Home	Brandywine Creek	EB Brandywine Creek	PA	Chester	395402	753920		0.0150			

MAP 3 - NONPOINT-SOURCE STORMWATER QUALITY SAMPLING STATIONS

Christina Basin Water Quality Management Strategy

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No	USGS Gage	Description	Watershed	Subwatershed	State	County	Latitude	Longitude	D A (sq mi)	Land Use	Period of Record	Contact for Data
1	1479000	White Clay Creek near Newark, DE	White Clay Creek	MS White Clay Creek	DE	New Castle	394147	754031	89.1	Overall	1931 - Present	
2	1480000	Red Clay Creek near Woodale, DE	Red Clay Creek	MS Red Clay Creek	DE	New Castle	394552	753808	47.0	Overall	1943 - Present	
3	1481500	Brandywine Creek at Wilmington, DE	Brandywine Creek	MS Brandywine Creek	DE	New Castle	394609	753425	314.0	Overall	1946 - Present	
4	1478000	Christina River at Cooches Bridge	Christina River	MS Christina River	DE	New Castle	391814	754342	20.5	Overall	1943 - Present	
5	1480095	Little Mill Creek near Newport, DE	Christina River	Little Mill Creek	DE	New Castle	394354	753614	5.2	Urban	1997 - Present	
6		Unnamed Tributary to Valley Creek at US Rt. 30	Brandywine Creek	Valley Creek	PA	Chester			1.5	Residential Sewered	1997 - Present	
7		Unnamed Tributary to Broad Run north of Rt. 162	Brandywine Creek	Broad Run	PA	Chester			1.4	Residential Non-sewered	1997 - Present	
8		Doe Run at Rt. 841 near Springdell	Brandywine Creek	Doe Run	PA	Chester			11.7	Agricultural Row Crop	1997 - Present	
9	1480300	WB Brandywine Creek near Honeybrook, PA	Brandywine Creek	WB Brandywine Creek	PA	Chester	400422	755140	18.7	Agricultural Livestock	1997 - Present	
10		Trout Run at Rt. 41 at Tough Kenamon	White Clay Creek	Trout Run	PA	Chester			1.3	Agricultural Mushroom	1997 - Present	
11	1480675	Marsh Creek near Glenmoore, PA	Brandywine Creek	Marsh Creek	PA	Chester	400552	754431	8.6	Forested	1997 - Present	

MAP 3 - COMBINED SEWER OVERFLOWS (CSOS)
Christina Basin Water Quality Management Strategy
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CSO No	Description	Owner	Watershed	Subwatershed	State	County	Latitude	Longitude	Size	Drainage Area	Contact for Data
2	Diversion manhole in 12th St. adjacent to Pump Station	City of Wilmington	Christina River	Tidal Brandywine Creek	DE	New Castle					
3	Regulator behind 11th St. Pump Station	City of Wilmington	Christina River	Tidal Brandywine Creek	DE	New Castle					
4a	Regulator at Locust & 13th Sts.	City of Wilmington	Christina River	Tidal Brandywine Creek	DE	New Castle					
4b	Foot of Church St. Diversion at Pine & 26th Sts.	City of Wilmington	Christina River	Tidal Brandywine Creek	DE	New Castle					
4c	Foot of 16th St. Bridge. Diversion at Jessup & Pine Sts.	City of Wilmington	Christina River	Tidal Brandywine Creek	DE	New Castle					
4d	Foot of Buena Vista St. Regulator at foot of Hutton St.	City of Wilmington	Christina River	Tidal Brandywine Creek	DE	New Castle					
4e	North +/- 560 ft. of Market St. Bridge. Regulator at Glen Ave.	City of Wilmington	Christina River	Tidal Brandywine Creek	DE	New Castle					
4f	Foot of Washington St. Bridge. Diversion at foot of bridge	City of Wilmington	Christina River	Tidal Brandywine Creek	DE	New Castle					
5	Foot of Orange St. Regulator at RR tracks.	City of Wilmington	Christina River	Tidal Christina River	DE	New Castle					
6	Foot of Shipley St. Diversion at RR tracks.	City of Wilmington	Christina River	Tidal Christina River	DE	New Castle					
7	Foot of Market St. Diversion at RR tracks.	City of Wilmington	Christina River	Tidal Christina River	DE	New Castle					
9a	East side of 4th St. Bridge. Diversion at Claymont & Christina Sts.	City of Wilmington	Christina River	Tidal Christina River	DE	New Castle					
9b	Siphon chamber south side of river sewer interceptor overflow.	City of Wilmington	Christina River	Tidal Christina River	DE	New Castle					
9c	At foot of RR bridge. Diversion at Lobdell & Bradford Sts.	City of Wilmington	Christina River	Tidal Christina River	DE	New Castle					
10	Foot of Church St. Regulator at Locust & A Sts.	City of Wilmington	Christina River	Tidal Christina River	DE	New Castle					
11	Foot of King St. Diversion at RR tracks.	City of Wilmington	Christina River	Tidal Christina River	DE	New Castle					
12	Foot of French St. Diversion at French & Water Sts.	City of Wilmington	Christina River	Tidal Christina River	DE	New Castle					
13	Foot of Lombard St. Regulator at Front & Lombard Sts.	City of Wilmington	Christina River	Tidal Christina River	DE	New Castle					
14	Foot of Front/Church Sts. Diversion at Front & Church Sts.	City of Wilmington	Christina River	Tidal Christina River	DE	New Castle					
15	Foot of Front/Church Sts. Regulator at Front & Church Sts.	City of Wilmington	Christina River	Tidal Christina River	DE	New Castle					
16	Foot of 4th St. Regulator at RR tracks.	City of Wilmington	Christina River	Tidal Christina River	DE	New Castle					
17	Siphon chamber west side of Christina River, sewer interceptor overflow.	City of Wilmington	Christina River	Tidal Christina River	DE	New Castle					
18	Foot of 9th St. Regulator at foot of 9th St.	City of Wilmington	Christina River	Tidal Brandywine Creek	DE	New Castle					
19	Siphon chamber west side of Brandywine Creek, sewer interceptor overflow.	City of Wilmington	Christina River	Tidal Brandywine Creek	DE	New Castle					
20	Foot of Church St. Bridge. Regulator at Church & 11th Sts.	City of Wilmington	Christina River	Tidal Brandywine Creek	DE	New Castle					
21a	Foot of Kirkwood St. Diversion at foot of Kirkwood St.	City of Wilmington	Christina River	Tidal Brandywine Creek	DE	New Castle					
21b	Foot of Pine St. Regulator at foot of Pine St.	City of Wilmington	Christina River	Tidal Brandywine Creek	DE	New Castle					
21c	Foot of 14th St. Regulator at foot of 14th St.	City of Wilmington	Christina River	Tidal Brandywine Creek	DE	New Castle					
22b	Foot of Walnut St. Diversion at Walnut & 16th Sts.	City of Wilmington	Christina River	Tidal Brandywine Creek	DE	New Castle					
22c	Foot of King St. Diversion at King & Race Sts.	City of Wilmington	Christina River	Tidal Brandywine Creek	DE	New Castle					
23	Foot of West St. Diversion at West & Park Sts.	City of Wilmington	Christina River	Tidal Brandywine Creek	DE	New Castle					
24	Foot of Jackson St. Diversion at Jackson & Park Sts.	City of Wilmington	Christina River	Tidal Brandywine Creek	DE	New Castle					
25	North +/- 1,500 ft. of I-95 bridge. Regulator at end of Rattlesnake Run.	City of Wilmington	Christina River	Tidal Brandywine Creek	DE	New Castle					
26	North +/- 300 ft. of I-95 bridge. Regulator at end of Elliot Run.	City of Wilmington	Christina River	Tidal Brandywine Creek	DE	New Castle					
27	Foot of Webb St. Regulator at foot of Webb St.	City of Wilmington	Christina River	Tidal Brandywine Creek	DE	New Castle					
28	Foot of Grant Ave. Diversion at Grant & Rodman	City of Wilmington	Christina River	Tidal Brandywine Creek	DE	New Castle					
29	Canby Park at RR tracks. Regulator at RR tracks.	City of Wilmington	Christina River	Tidal Brandywine Creek	DE	New Castle					
30	End of Shipley Run at river. Twin regulators at Madison & Linden.	City of Wilmington	Christina River	Tidal Christina River	DE	New Castle					
31	East 35th St. at Bowers. Diversion at Eastlawn & Governor Printz Blvd.	City of Wilmington	Christina River	Tidal Brandywine Creek	DE	New Castle					

APPENDIX F

MAP 5 - LAND USE SUMMARIES

MAP 5 - LAND USE SUMMARY
Christina Basin Water Quality Management Strategy
May 21, 1998

No.	Station ID	Stream Name	Street	Drainage Area (Acres)	Drainage Area (Sq. Mi.)	LAND USE (ACRES) Single Family Residential	Multi-Family Residential	Office	Industrial	Transport/ Utility	Commercial	Institutional	Public/Private Open Space	Wooded	Agricultural	Mining	Water	Vacant
		Brandywine Creek Watershed																
1	B1	Upper West Branch at Honeybrook		11,833.60	18.49	802.21	29.95			62.26	89.62	53.99	4.81	2,403.26	8,017.16	38.39	22.84	312.51
2	B2	Upper West Branch at Hibernia		16,665.60	26.04	3,347.24	121.02		10.83	253.16	55.88	71.94	181.43	7,066.85	5,758.74		189.05	187.35
3	B3	Lower West Branch at Coatesville		11,289.60	17.64	2,084.18	318.96		488.36	472.03	151.30	117.17	70.32	4,097.28	3,189.90	60.98	63.75	226.93
4	B4	Lower West Branch at Embreeville		10,937.60	17.09	797.11				166.78	8.98	121.99		3,866.45	5,681.63		131.46	166.31
5	B5	Buck Run		17,619.20	27.53	1,881.52	26.13			259.23	128.22	64.30	20.84	4,804.59	10,232.63	7.98	82.66	180.09
6	B6	Doe Run		14,444.80	22.57	402.18				169.56	34.09	14.68	6.82	2,483.85	11,219.20		45.54	71.33
7	B7	Broad Creek		4,121.60	6.44	1,159.44	47.66			103.76	13.34	19.31	16.30	1,175.45	1,534.79		5.21	48.48
8	B8	Upper East Branch at Struble Creek		21,145.60	33.04	2,981.01	89.27		38.47	188.14	37.53	34.08	110.87	7,764.09	9,355.19		356.90	222.79
9	B9	Upper East Branch at Shamona Creek		6,400.00	10.00	1,729.30	63.80		83.82	135.26	54.66	77.52	78.82	2,352.61	1,610.48		54.27	162.49
10	B10	Lower East Branch		13,395.20	20.93	3,179.00	330.98		231.58	244.94	306.31	107.80	318.12	4,941.21	3,365.48	33.57	126.07	207.07
11	B11	Marsh Creek		12,287.20	19.98	2,192.85	3.12		9.16	252.80	74.95	15.29	43.96	5,023.02	4,424.86	15.38	576.86	151.73
12	B12	Beaver Creek		11,577.60	18.09	2,654.41	292.59		41.88	299.30	340.96	163.90	246.97	3,462.63	3,748.02		23.62	301.14
13	B13	Valley Creek		13,216.00	20.65	3,543.54	426.61		187.04	600.22	459.68	134.30	263.99	4,407.00	2,500.75	234.14	56.73	407.35
14	B14	Main Stem above Chadds Ford		15,718.40	24.56	4,476.06	229.63		9.30	221.23	165.04	165.40	279.99	4,598.48	5,024.21		149.51	315.12
15	B15	Peoquion Creek		5,849.60	9.14	1,479.08	26.93			12.96	9.45	51.25	69.73	1,299.20	2,818.14		16.22	38.27
16	B16	Main Stem below Chadds Ford		16,934.40	26.46	3,280.97	101.36	46.77	21.07	155.29	733.33	243.58	3,467.73	5,788.60	2,939.19		189.64	22.44
17	B17	Main Stem through Wilmington		3,878.40	6.06	221.10	777.30	111.80	747.80	302.84	270.18	241.11	504.34	537.56	60.90		98.34	
			Subtotal =	207,814.40	324.71	36,140.98	2,879.51	158.66	1,867.30	3,850.76	2,933.54	1,697.61	5,685.06	66,072.23	81,481.17	389.54	2,188.67	3,021.38
		Red Clay Creek Watershed																
18	R1	West Branch		11,180.80	17.47	1,547.00	38.35		130.80	55.00	131.20	114.20	29.19	2,389.00	6,540.00		45.93	164.60
19	R2	East Branch		6,374.40	9.96	1,237.00	24.50			54.78	148.30	52.68	244.30	1,458.00	3,018.00	16.11	25.14	126.90
20	R3	Burris Run		4,550.40	7.11	1,216.00				16.80	5.51		87.20	1,141.00	1,934.00		7.29	144.20
21	R4	Main Stem above Woodside		7,968.00	12.45	3,097.00		13.13	95.74	27.27	52.01	37.56	498.10	2,791.00	1,169.00		265.80	
22	R5	Main Stem below Woodside		4,550.40	7.11	2,519.00	96.70	30.81	20.69	171.06	350.62	157.54	515.79	584.80	55.58		47.02	
			Subtotal =	34,624.00	54.19	9,616.00	159.55	43.94	877.23	319.91	687.64	361.98	1,374.58	8,333.80	12,716.58	16.11	391.18	435.70
		White Clay Creek Watershed																
23	W1	West Branch		6,515.20	10.18	1,141.18				88.47	28.36	36.68	9.19	1,707.74	3,377.05		5.07	132.72
24	W2	Middle Branch		10,156.80	15.87	1,663.61				94.68	51.42	4.65	7.03	2,523.23	5,672.91		57.71	82.58
25	W3	East Branch above Avondale		11,993.60	18.74	764.38			5.70	242.63	139.10	20.50	153.96	2,683.74	7,820.49		49.81	113.82
26	W4	East Branch below Avondale		9,171.20	14.33	1,943.33			60.00	10.67	70.13	40.30	53.64	2,938.83	3,835.84	2.80	102.67	110.01
27	W5	Mill Creek		8,268.80	12.92	4,089.55	360.01	92.47		256.04	364.44	395.17	846.90	975.75	909.84		9.10	
28	W6	Pike Creek		4,249.60	6.64	2,364.73	319.79			101.75	67.24	103.41	388.78	548.76	358.04			
29	W7	Middle Run		2,489.60	3.89	517.13	0.71	3.14		56.60	11.98	34.58	81.29	1,049.46	736.44			
30	W8	Main Stem above Newark		6,476.80	10.12	979.07	131.59	100.28	8.00	37.44	10.63	78.17	305.94	3,508.93	1,272.62		49.22	
31	W9	Main Stem above Delaware Park		5,792.00	9.05	1,928.16	458.55	70.85	159.55	426.99	628.92	376.55	547.86	603.24	526.81		52.04	
32	W10	Main Stem at Churchmans Marsh		3,526.40	5.51	464.92	94.19	193.92	13.34	390.05	653.47	206.62	571.19	461.32	148.93		328.91	
			Subtotal =	68,640.00	107.25	15,866.05	1,364.84	460.66	159.55	1,703.31	2,025.67	1,296.63	2,956.76	17,001.01	24,658.96	2.80	645.54	441.14
		Christina River Watershed																
33	C1	East/West Branch above Coochs Bridge		13,478.40	21.06	3,805.59	310.00	23.95	436.41	675.54	565.74	132.96	898.29	2,772.58	3,780.45		13.72	
34	C2	Muddy Run		5,542.40	8.66	1,072.23	147.14		91.47	206.99	106.19	69.31	588.44	2,127.79	855.98		61.40	217.09
35	C3	Bellevue Run		4,115.20	6.43	1,206.53	401.39			137.57	272.45	21.76	350.80	1,408.37	350.95		34.72	
36	C4	Little Mill Creek		5,907.20	9.23	2,175.64	688.39	203.95	309.18	277.19	351.09	282.30	694.62	843.03	49.29		35.63	
37	C5	Main Stem above Smalley's Pond		6,828.80	10.67	1,912.96	596.82	76.31		415.11	701.75	60.02	477.16	1,847.11	707.01		37.16	323.97
38	C6	Main Stem Lower Tidal		14,048.00	21.95	2,146.65	975.49		1,191.18	2,272.43	1,487.56	250.63	2,821.25	1,759.18	253.12		571.32	
			Subtotal =	49,920.00	78.00	12,321.40	3,119.23	304.19	2,028.24	3,984.83	3,514.76	816.92	5,801.09	10,758.06	5,996.80	0.00	755.95	539.06
			Totals =	360,998.40	564.06	73,944.43	7,523.13	967.45	4,232.33	9,858.61	9,161.62	4,173.14	15,817.49	102,165.09	124,853.51	408.45	3,977.35	4,437.28

MAP 5 - LAND USE SUMMARY
ristina Basin Water Quality Management Strategy
May 21, 1998

LAND USE (ACRES)							LAND USE (% OF D.A.)											
titutional	Public/Private Open Space	Wooded	Agricultural	Mining	Water	Vacant	Single Family Residential	Multi-Family Residential	Office	Industrial	Transport/ Utility	Commercial	Institutional	Public/Private Open Space	Wooded	Agricultural	Mining	Water	Vacant
53.99	4.81	2,403.26	8,017.16	38.89	22.84	312.51	6.78	0.25	0.00	0.00	0.33	0.76	0.46	0.04	20.31	67.75	0.32	0.19	2.64
71.94	181.43	7,066.85	5,758.74		189.05	187.35	20.08	0.73	0.00	0.06	1.52	0.34	0.43	1.09	42.40	34.55	0.00	1.13	1.12
117.17	70.22	4,997.28	3,189.80	60.98	63.75	226.93	18.46	2.89	0.00	4.33	3.74	1.34	1.04	0.62	36.29	28.25	0.54	0.56	2.01
121.99		3,866.45	5,681.63		131.46	166.31	7.29	0.00	0.00	0.00	1.52	0.08	1.12	0.00	35.35	51.95	0.00	1.20	1.52
64.30	20.84	4,804.59	10,232.63	7.08	82.66	180.09	10.28	9.15	0.00	0.00	1.47	0.73	0.36	0.12	27.27	58.08	0.04	0.47	1.02
14.68	6.82	2,483.85	11,219.20		45.54	71.33	2.78	0.00	0.00	0.00	1.17	0.24	0.10	0.05	17.20	77.67	0.00	0.32	0.49
19.21	16.20	1,175.45	1,534.79		5.21	48.48	28.13	1.16	0.00	0.00	2.52	0.32	0.47	0.40	28.52	37.24	0.00	0.13	1.18
34.08	110.87	7,764.09	9,325.19		356.90	222.79	14.10	0.42	0.00	0.18	0.89	0.18	0.16	0.52	36.72	44.10	0.00	1.69	1.05
77.52	78.82	7,352.61	1,516.48		54.27	162.49	27.62	1.00	0.00	1.28	2.11	0.85	1.23	1.28	36.76	25.16	0.00	0.85	2.54
107.80	318.12	4,941.21	3,365.48	33.57	126.07	207.07	23.73	2.47	0.00	1.73	1.83	2.29	0.80	2.37	36.89	25.12	0.25	0.94	1.55
15.29	43.96	5,023.02	4,424.86	15.38	576.86	151.73	17.15	0.02	0.00	0.07	1.98	0.59	0.12	0.34	29.28	34.60	0.12	4.51	1.19
163.90	246.97	3,462.63	3,748.02		23.62	301.14	22.93	2.53	0.00	0.36	2.59	2.95	1.42	2.13	29.91	32.37	0.00	0.20	2.60
134.20	263.99	4,407.09	2,500.75	234.14	56.73	407.35	26.81	3.18	0.00	1.42	4.54	3.48	1.02	2.60	33.35	18.92	1.77	0.43	3.08
165.40	279.99	4,598.48	5,024.21		149.51	315.12	28.48	1.46	0.00	0.06	1.41	1.05	1.05	1.78	29.26	31.96	0.00	0.95	2.00
51.25	69.73	1,299.20	2,848.14		16.22	38.27	25.29	0.46	0.00	0.00	0.22	0.16	0.88	1.19	22.21	48.69	0.00	0.28	0.65
243.58	3,467.73	5,788.60	2,939.19		189.64	22.44	19.37	0.60	0.28	0.12	0.92	4.33	1.44	20.48	34.18	17.36	0.00	1.12	0.13
241.11	504.34	537.56	69.90		98.34		5.20	20.05	2.88	19.28	7.83	6.97	6.22	13.09	13.96	1.37	0.00	2.54	0.00
1,697.61	5,685.06	66,072.23	81,481.17	389.54	2,188.67	3,021.28	17.39	1.39	0.08	0.90	1.85	1.41	0.82	2.74	31.79	39.21	0.19	1.05	1.45
114.29	29.19	2,389.00	6,540.00		45.93	164.60	13.84	0.34	0.00	1.17	0.49	1.17	1.02	0.26	21.37	58.49	0.00	0.41	1.47
52.68	244.30	1,428.00	3,018.00	16.11	25.14	126.90	19.41	0.58	0.00	0.00	0.86	2.33	0.83	5.85	22.40	47.35	0.25	0.39	1.99
	87.20	1,141.00	1,934.00		7.29	144.20	26.72	0.00	0.00	0.00	0.37	0.12	0.00	1.92	25.07	42.50	0.00	0.16	3.17
37.56	498.10	2,791.00	1,169.00		265.80		58.87	0.00	0.16	0.32	0.28	0.65	0.47	6.25	35.03	14.67	0.00	3.34	0.00
157.54	515.79	584.80	55.58		47.02		55.36	2.13	0.68	0.45	3.76	7.71	3.46	11.34	12.85	1.22	0.00	1.03	0.00
364.98	1,374.58	8,333.80	12,716.58	16.11	391.18	435.70	27.37	0.46	0.13	0.51	0.92	1.99	1.05	3.97	24.07	36.73	0.05	1.13	1.26
36.68	0.19	1,709.74	3,377.05		5.07	132.72	17.52	0.00	0.00	0.00	1.33	0.44	0.56	0.00	28.23	51.83	0.00	0.08	2.04
4.65	7.00	2,523.23	5,672.91		57.71	82.58	16.38	0.00	0.00	0.00	0.93	0.51	0.05	0.07	24.84	55.85	0.00	0.57	0.81
20.50	153.96	2,983.74	7,820.49		49.81	115.82	6.37	0.00	0.00	0.05	2.02	1.36	0.17	1.28	22.38	65.21	0.00	0.42	0.97
40.30	53.64	2,938.83	3,835.84	2.80	102.67	110.01	21.19	0.00	0.00	0.65	0.12	0.76	0.44	0.58	32.04	41.82	0.03	1.12	1.20
295.17	846.90	975.75	999.84		0.16		49.46	4.55	1.12	0.00	3.10	4.41	4.78	10.24	11.90	11.00	0.00	0.00	0.00
103.41	388.78	548.76	358.04				55.65	7.53	0.00	0.00	2.39	1.58	2.43	9.15	12.91	8.43	0.00	0.00	0.00
24.58	81.29	1,049.46	736.44				20.77	0.98	0.33	0.00	2.29	0.48	1.39	3.27	42.15	29.38	0.00	0.00	0.00
78.17	305.94	3,508.95	1,272.62		49.22		15.12	2.03	1.55	0.12	0.58	0.16	1.21	4.72	54.18	19.65	0.00	0.76	0.00
376.55	547.86	603.24	526.81		52.04		33.46	7.92	1.22	2.75	7.37	10.86	6.50	9.46	10.41	9.19	0.00	0.90	0.00
206.62	571.19	461.32	148.93		328.91		13.18	2.67	5.50	0.38	11.06	18.53	5.86	16.20	13.08	4.22	0.00	9.33	0.00
1,296.63	2,956.76	17,001.01	24,658.96	2.80	645.34	441.14	23.18	1.99	0.67	0.22	2.48	2.95	1.89	4.21	24.77	35.93	0.00	0.94	0.64
122.96	888.79	2,772.58	3,780.45		11.72		28.23	2.20	0.18	3.24	5.01	4.79	6.99	6.59	20.57	28.05	0.00	0.09	0.00
69.31	588.44	2,127.79	855.98		61.40	217.09	19.35	2.65	0.00	1.65	3.73	1.92	1.25	10.62	38.39	15.44	0.00	1.11	3.92
21.70	330.83	1,408.57	350.95		34.72		29.37	9.75	0.00	0.00	3.54	5.41	0.53	8.04	34.22	8.53	0.00	0.84	0.00
282.30	694.62	843.03	49.29		35.63		36.83	11.65	3.45	5.23	4.69	5.94	4.78	11.76	14.27	0.83	0.00	0.60	0.00
60.02	477.16	1,847.11	707.01		37.16	321.97	28.01	8.74	1.12	0.00	6.08	10.28	0.88	6.99	27.05	10.35	0.00	0.54	4.71
250.63	2,821.25	1,759.18	253.12		571.32		15.28	6.94	0.00	8.48	16.18	10.59	1.78	20.08	12.52	1.80	0.00	4.07	0.00
816.92	5,801.09	10,758.06	5,996.80	9.09	751.95	539.96	24.68	6.23	0.61	4.06	7.98	7.04	1.84	11.62	21.55	12.01	0.00	1.51	1.09
173.14	15,817.49	102,165.09	124,853.51	408.45	3,977.35	4,437.28													

APPENDIX G

MAP 9 - HAZARDOUS WASTE, SUPERFUND, AND LANDFILL SITES

MAP 9 - HAZARDOUS WASTE, SUPERFUND, AND LANDFILL SITES
Christina Basin Water Quality Management Strategy
May 21, 1998

ID No	Facility	Category	Contaminant Class	Description	Location	Watershed	Subwatershed	State	County	Latitude	Longitude	Status	Placed on List	Contact for Data
TSD03	DuPont Chestnut Run	Hazardous Waste Site	Petroleum,solvents,metals	Research facility, Haz. waste storage pad		Christina River	Little Mill Creek	DE	New Castle					
TSD02	DuPont Experimental Station	Hazardous Waste Site	Solvents,metals,pesticides,herbicides	Research facility, Haz. waste incinerator		Brandywine Creek	MS through Wilmington	DE	New Castle					
TSD13	DuPont Glasgow	Hazardous Waste Site	Solvents,pesticides	Research and Manufacturing		Christina River	Muddy Run	DE	New Castle					
	General Chemical	Hazardous Waste Site	Solvents,metals,pesticides,herbicides	Sulfuric acid manufacturer				DE	New Castle					
	Harper Thiel	Hazardous Waste Site	Metals	Electroplater				DE	New Castle					
TSD05	Hercules Research Center	Hazardous Waste Site	Solvents,metals,pesticides,herbicides,PCBs	Research facility		Red Clay Creek	MS below Wooddale	DE	New Castle					
RR01	Clean Earth	Resource Recovery Facility	Solvents	Pet. Contam. Soil Roaster		Christina River	MS Lower Tidal	DE	New Castle					
RR02	VFL	Resource Recovery Facility	Metals	Sewage Sludge Recycler		Christina River	MS Lower Tidal	DE	New Castle					
N01	Breiterbuch's Auto Salvage	Used Tire Piles	Petroleum	3,000 tires		Christina River	MS Lower Tidal	DE	New Castle					
N02	Little Jimmy's Auto Salvage	Used Tire Piles	Petroleum	3,000 tires		Christina River	MS Lower Tidal	DE	New Castle					
N03	Joe Morgan's Auto Salvage	Used Tire Piles	Petroleum	6,000 tires		Christina River	MS Lower Tidal	DE	New Castle					
N04	Delaware Auto Salvage	Used Tire Piles	Petroleum	50 tires		Christina River	MS Lower Tidal	DE	New Castle					
N05	B and F Towing	Used Tire Piles	Petroleum	3,000 tires		Christina River	MS Lower Tidal	DE	New Castle					
N06	Skyline Auto Salvage	Used Tire Piles	Petroleum	50 tires		Christina River	MS Lower Tidal	DE	New Castle					
N07	Necastro Auto Parts	Used Tire Piles	Petroleum	8,000 tires		Christina River	MS Lower Tidal	DE	New Castle					
N08	Two Guys Auto Parts	Used Tire Piles	Petroleum	30,000 tires		Christina River	MS Lower Tidal	DE	New Castle					
N09	1-A-Used Auto Parts	Used Tire Piles	Petroleum	5,000 tires		Christina River	MS Lower Tidal	DE	New Castle					
N10	Don Wilson Auto Parts	Used Tire Piles	Petroleum	10,000 tires		Christina River	MS Lower Tidal	DE	New Castle					
N11	A. M. Domino Auto Salvage	Used Tire Piles	Petroleum	15,000 tires		Christina River	MS Lower Tidal	DE	New Castle					
N12	Caspers Auto Parts	Used Tire Piles	Petroleum	75,000 tires		Christina River	MS Lower Tidal	DE	New Castle					
N13	City of Wilmington	Used Tire Piles	Petroleum	500 tires		Brandywine Creek	MS through Wilmington	DE	New Castle					
N14	Ed & Son Auto Salvage	Used Tire Piles	Petroleum	35,000 tires		Brandywine Creek	MS through Wilmington	DE	New Castle					
N15	Earl Van Den Heuvel	Used Tire Piles	Petroleum	1,500 tires		Christina River	MS Lower Tidal	DE	New Castle					
N16	Eastern Auto Salvage	Used Tire Piles	Petroleum	1,000 tires		Christina River	MS Lower Tidal	DE	New Castle					
N17	Keith Harris	Used Tire Piles	Petroleum	8,000 tires		Christina River	Muddy Run	DE	New Castle					
N23	Continental Auto Salvage	Used Tire Piles	Petroleum	3,000 tires		Christina River	MS Lower Tidal	DE	New Castle					
L0009	Air National Guard	Leaking Underground Storage Tank	petroleum		New Castle	Christina River	MS Lower Tidal	DE	New Castle					
L0016	Amoco Rt. 273 & Chapman Rd.	Leaking Underground Storage Tank	petroleum					DE	New Castle					
L0018	Amoco Glasgow 896 and 40	Leaking Underground Storage Tank	petroleum					DE	New Castle					
L0020	AMTRAK Bear	Leaking Underground Storage Tank	petroleum					DE	New Castle					
L0022	896 Deli (Anthony August)	Leaking Underground Storage Tank	petroleum		2505 Pulaski Hwy., Newark	Christina River	Muddy Run	DE	New Castle					
L0026	Arco Cumberland Farms	Leaking Underground Storage Tank	petroleum		Rt. 4 and Kiamensi Rd., Stanton	Red Clay Creek	MS below Wooddale	DE	New Castle					
L0029	Arco Glasgow 896 and Rt. 40	Leaking Underground Storage Tank	petroleum		Glasgow (Shell)	Christina River	Muddy Run	DE	New Castle					
L0032	Arco Lancaster and Ford	Leaking Underground Storage Tank	petroleum		2711 Lancaster Ave., Wilmington	Christina River	Little Mill Creek	DE	New Castle					
L0038	Avon Newark	Leaking Underground Storage Tank	petroleum		2100 Ogletown Rd., Newark	White Clay Creek	MS above DE Park	DE	New Castle					
L0042	Brandywine Raceway	Leaking Underground Storage Tank	petroleum					DE	New Castle					
L0052	Calvary Baptist Church	Leaking Underground Storage Tank	petroleum					DE	New Castle					
L0056	Chevron Gulf Glasgow 896	Leaking Underground Storage Tank	petroleum		2394 Pulaski Hwy., Glasgow	Christina River	Muddy Run	DE	New Castle					
L0060	Chrysler Mopar Division	Leaking Underground Storage Tank	petroleum			Christina River	EB/WB above Cooches Br.	DE	New Castle					
L0061	Chrysler Assembly Plant	Leaking Underground Storage Tank	petroleum			Christina River	EB/WB above Cooches Br.	DE	New Castle					
L0069	Kings Kirkwood Conoco (Mobil)	Leaking Underground Storage Tank	petroleum					DE	New Castle					
L0070	Chrystal Clear Gas	Leaking Underground Storage Tank	petroleum					DE	New Castle					
L0072	DOT - Ogletown	Leaking Underground Storage Tank	petroleum		Newark	White Clay Creek	MS above DE Park	DE	New Castle					
L0076	Air National Guard	Leaking Underground Storage Tank	petroleum					DE	New Castle					
L0088	Diamond Fuel Oil - Ast Spill	Leaking Underground Storage Tank	petroleum		Heald and Lobdell Sts., Wilmington	Christina River	MS Lower Tidal	DE	New Castle					
L0095	Diamond State Telephone	Leaking Underground Storage Tank	petroleum					DE	New Castle					
L0103	DuPont Country Club	Leaking Underground Storage Tank	petroleum		Rockland Rd., Wilmington	Brandywine Creek	MS below Chadds Ford	DE	New Castle					
L0106	DuPont Stine/Haskell	Leaking Underground Storage Tank	petroleum		Newark	Christina River	EB/WB above Cooches Br.	DE	New Castle					
L0107	DuPont Cheatnut Run	Leaking Underground Storage Tank	petroleum					DE	New Castle					
L0108	DuPont Eagle Run	Leaking Underground Storage Tank	petroleum					DE	New Castle					
L0109	DuPont Tatnall Building	Leaking Underground Storage Tank	petroleum		Wilmington	Brandywine Creek	MS through Wilmington	DE	New Castle					
L0111	DuPont Glasgow	Leaking Underground Storage Tank	petroleum		Glasgow	Christina River	Muddy Run	DE	New Castle					
L0117	Ethelmans Truck Stop	Leaking Underground Storage Tank	petroleum					DE	New Castle					
L0118	Exxon Rose Hill Garage	Leaking Underground Storage Tank	petroleum					DE	New Castle					
L0119	Exxon Rt. 273 & Chapman Rd.	Leaking Underground Storage Tank	petroleum		Newark	Christina River	MS Lower Tidal	DE	New Castle					
L0122	Exxon Service Center I-95	Leaking Underground Storage Tank	petroleum			Christina River	MS above Smalley's Pond	DE	New Castle					
L0125	Exxon Castle Mall	Leaking Underground Storage Tank	petroleum		Newark	Christina River	EB/WB above Cooches Br.	DE	New Castle					
L0131	Exxon Newport Gap Pike	Leaking Underground Storage Tank	petroleum					DE	New Castle					
L0132	Exxon Ogletown & Harmony	Leaking Underground Storage Tank	petroleum		Newark	White Clay Creek	MS above DE Park	DE	New Castle					
L0134	Exxon Rose Hill Garage	Leaking Underground Storage Tank	petroleum		(see as N8711074)	Christina River	MS Lower Tidal	DE	New Castle					
L0138	Exxon Second & Union	Leaking Underground Storage Tank	petroleum			Christina River	Little Mill Creek	DE	New Castle					
L0144	Gates Engineering	Leaking Underground Storage Tank	petroleum		-			DE	New Castle					
L0151	Getty Kirkwood Highway	Leaking Underground Storage Tank	petroleum					DE	New Castle					
L0153	Shell Godwin's	Leaking Underground Storage Tank	petroleum		804 S. College Ave., Newark	Christina River	EB/WB above Cooches Br.	DE	New Castle					
L0154	Greenhill Car Wash	Leaking Underground Storage Tank	petroleum					DE	New Castle					
L0155	Gulf I-95 Service Center	Leaking Underground Storage Tank	petroleum			Christina River	MS above Smalley's Pond	DE	New Castle					
L0163	Kayo Oil Co. Conoco, Elsmere	Leaking Underground Storage Tank	petroleum		1500 Kirkwood Hwy., Elsmere	Christina River	Little Mill Creek	DE	New Castle					
L0169	Kershaw Construction	Leaking Underground Storage Tank	petroleum		473 Old Airport Rd., New Castle	Christina River	MS Lower Tidal	DE	New Castle					
L0182	Lawn Doctor Abbott	Leaking Underground Storage Tank	petroleum		Castle Mall, 995 S. Chapel	Christina River	EB/WB above Cooches Br.	DE	New Castle					
L0186	Lynam's Mobil	Leaking Underground Storage Tank	petroleum		1716 Delaware Ave., Wilmington	Brandywine Creek	MS through Wilmington	DE	New Castle					
L0193	Merit Oil Company	Leaking Underground Storage Tank	petroleum					DE	New Castle					
L0202	Gulf Hessey	Leaking Underground Storage Tank	petroleum		235 E. Delaware Ave., Newark	White Clay Creek	MS above DE Park	DE	New Castle					
L0204	Newark Public Well #15	Leaking Underground Storage Tank	petroleum					DE	New Castle					
L0205	NVF Corporation	Leaking Underground Storage Tank	petroleum		Newark	White Clay Creek	MS above DE Park	DE	New Castle					
L0206	Shell (Arco) Ogletown	Leaking Underground Storage Tank	petroleum					DE	New Castle					
L0217	Pencader Presbyterian	Leaking Underground Storage Tank	petroleum		Glasgow	Christina River	Muddy Run	DE	New Castle					
L0227	Mobil Rash/Sterling	Leaking Underground Storage Tank	petroleum					DE	New Castle					
L0242	Shell Ogletown and Marrows Rd.	Leaking Underground Storage Tank	petroleum		Newark	White Clay Creek	MS above DE Park	DE	New Castle					
L0245	Shell Oil Company Kirkwood & 7	Leaking Underground Storage Tank	petroleum		Wilmington	Red Clay Creek	MS below Wooddale	DE	New Castle					
L0252	St. Frances Hospital	Leaking Underground Storage Tank	petroleum					DE	New Castle					
L0253	Stanton Supply Company	Leaking Underground Storage Tank	petroleum					DE	New Castle					
L0258	Sunoco Concord Pike, Talleyville	Leaking Underground Storage Tank	petroleum		Talleyville, 3930 Concord Pike	Brandywine Creek	MS below Chadds Ford	DE	New Castle					
L0259	Sunoco Concord Pike, Fairfax	Leaking Underground Storage Tank	petroleum		Fairfax-2401 Concord Pike	Brandywine Creek	MS below Chadds Ford	DE	New Castle					
L0262	Tatnall School	Leaking Underground Storage Tank	petroleum					DE	New Castle					
L0269	Texaco Meadowood Deli	Leaking Underground Storage Tank	petroleum					DE	New Castle					
L0271	Texaco Pike Creek (Ault Court)	Leaking Underground Storage Tank	petroleum		Ault Court Linden Heath, Wilmington	White Clay Creek	Pike Creek	DE	New Castle					
L0272	Three Fs Tire Inc., East	Leaking Underground Storage Tank	petroleum			Red Clay Creek	MS below Wooddale	DE	New Castle					
L0281	Volkswagon of N.A.	Leaking Underground Storage Tank	petroleum					DE	New Castle					
L0283	Wilmington Trust Corp Commons	Leaking Underground Storage Tank	petroleum					DE	New Castle					
L0286	Windover/Kent Apartments	Leaking Underground Storage Tank	petroleum					DE	New Castle					
L0294	VA Medical Center	Leaking Underground Storage Tank	petroleum					DE	New Castle					
L0298	Sunoco Elkton Road	Leaking Underground Storage Tank	petroleum		287 Elkton Rd., Newark	Christina River	EB/WB above Cooches Br.	DE	New Castle					
L0299	Hough Associates-Chevron	Leaking Underground Storage Tank	petroleum					DE	New Castle					
L0306	Arco Prices Corner (Getty)	Leaking Underground Storage Tank	petroleum					DE	New Castle					
L0311	Allens Kerosene Inc.	Leaking Underground Storage Tank	petroleum					DE	New Castle					
L0321	Motor Lodge Gulf (896)	Leaking Underground Storage Tank	petroleum		1107 S. College Ave., Newark	Christina River	EB/WB above Cooches Br.	DE	New Castle					
L0329	Wilmington Public Works Yard	Leaking Underground Storage Tank	petroleum					DE	New Castle					

L0332	Forbes Steel and Wire - Wilmington	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L0345	Rubinson and Frankel	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L0350	Delcastle Ve-Tech	Leaking Underground Storage Tank	petroleum		Wilmington	White Clay Creek	MS at Churchman's Marsh		DE	New Castle				
L0357	Chrysler Corp. Assembly Plant	Leaking Underground Storage Tank	petroleum		Newark Assembly Plant, Newark	Christina River	EB/WB above Cooches Br.		DE	New Castle				
L0377	Mobil (Oglctown)	Leaking Underground Storage Tank	petroleum		4029 Ogletown Rd., Newark	White Clay Creek	MS above DE Park		DE	New Castle				
L0379	Chrysler Assembly Plant	Leaking Underground Storage Tank	petroleum		PO Box 6040, Newark	Christina River	EB/WB above Cooches Br.		DE	New Castle				
L0395	Conoco - Surface Transportation	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L0398	Global Gas Station	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L0401	Southern States Newark Service	Leaking Underground Storage Tank							DE	New Castle				
L0407	Mobil Service Center	Leaking Underground Storage Tank	petroleum		1106 S. College Ave., Newark	Christina River	EB/WB above Cooches Br.		DE	New Castle				
L0409	Jardell Co. (Sears)	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L0411	Louviers Country Club	Leaking Underground Storage Tank	petroleum		Newark	White Clay Creek	MS above Newark		DE	New Castle				
L0413	Conoco Inc., Surface Transport	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L0418	Sandlewood Apts.	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L0433	Chrysler Assembly Plant	Leaking Underground Storage Tank	petroleum		550 S. College Ave., Newark	Christina River	EB/WB above Cooches Br.		DE	New Castle				
L0451	Sardo Warehouses (gasoline)	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L0452	Sardo Warehouses (heating oil)	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L0471	D and J Auto Service	Leaking Underground Storage Tank	petroleum		Wilmington	Christina River	Little Mill Creek		DE	New Castle				
L0475	Merit Oil Station	Leaking Underground Storage Tank	petroleum		506 DuPont Hwy., New Castle	Christina River	MS Lower Tidal		DE	New Castle				
L0480	Martin/Oldsmobile/Honda	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L0488	Kirkwood Army Reserve Center	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L0505	Ciba-Geigy Corp (Newport)	Leaking Underground Storage Tank	petroleum		(REFER TO SUPERFUND)	Christina River	MS Lower Tidal		DE	New Castle				
L0523	Southwood Farms	Leaking Underground Storage Tank	petroleum		Hockessin	White Clay Creek	Mill Creek		DE	New Castle				
L0543	J.V. Auto Service	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L0548	Wilmington Chemical Co.	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L0557	Deltech-Stanton	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L0575	Straight Line Filters	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L0577	Del Campo Baking Co.	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L0578	Airco Industrial Gases Inc.	Leaking Underground Storage Tank	petroleum		Claymont	Christina River	EB/WB above Cooches Br.		DE	New Castle				
L0593	Brecks Mill	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L0595	Gulf-Lawrence's Hockessin	Leaking Underground Storage Tank	petroleum		41 and Yorklyn Rd., Hockessin	White Clay Creek	Mill Creek		DE	New Castle				
L0596	J. Schoeneman, Inc.	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L0599	Sunoco Hockessin	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L0607	DuPont Chestnut Run, Bldg. 717	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L0611	Sears Tire and Battery Center	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L0616	GEC Industries Inc.	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L0630	Conoco - 1701 Pennsylvania Ave.	Leaking Underground Storage Tank	petroleum		1701 Pennsylvania Ave., Wilmington	Brandywine Creek	MS through Wilmington		DE	New Castle				
L0633	Sandlewood Apts.	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L0635	Getty Service Station - Newark	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L0656	Exxon - Lovering Ave.	Leaking Underground Storage Tank	petroleum		1705 Lovering Ave., Wilmington	Brandywine Creek	MS through Wilmington		DE	New Castle				
L0664	Certified Auto Salvage	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L0674	Diamond State Telephone	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L0676	Louviers Maintenance Yard	Leaking Underground Storage Tank	petroleum		(see N9109200)	White Clay Creek	MS above Newark		DE	New Castle				
L0678	7-11 Store (1126-23128), Mem. Dr.	Leaking Underground Storage Tank	petroleum		Rt. 13 and Mem. Dr., New Castle	Christina River	MS Lower Tidal		DE	New Castle				
L0695	Air National Guard	Leaking Underground Storage Tank	petroleum		2701 GWAP New Castle Co. Airport	Christina River	MS Lower Tidal		DE	New Castle				
L0704	Union Park Pontiac	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L0718	Kirkwood Motors, Inc.	Leaking Underground Storage Tank	petroleum		4800 Kirkwood Hwy., Wilmington	White Clay Creek	Mill Creek		DE	New Castle				
L0734	Greggs Bus Service	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L0747	U of DE General Service Bldg	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L0757	1145 Limited	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L0760	DuPont County Club Clubhouse	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L0765	Airport Trust #2	Leaking Underground Storage Tank	petroleum		Lobdelle and Heald Sts., Wilmington	Christina River	MS Lower Tidal		DE	New Castle				
L0784	Gulf Christiana Gateway	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L0791	Cusertus Service Center	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L0794	Interstate Fuels	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L0803	Wilmington Public Works Yard	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L0811	Martin Oldsmobile/GMC #2	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L0835	Diamond State Telephone	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L0841	James Julian, Heald Street	Leaking Underground Storage Tank	petroleum		1100 S. Heald St., Wilmington	Christina River	MS Lower Tidal		DE	New Castle				
L0848	Metro Bldg. Supply	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L0862	DuPont Nemours Equip Center	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L0863	DuPont County Club Equip. Center	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L0864	DuPont C.C. Golf Cart Storage	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L0865	DuPont CC Montchanin Equ. Centr.	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L0866	Louviers CC Equipment Center	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L0875	B and M Auto	Leaking Underground Storage Tank	petroleum		525 S. Market St., Wilmington	Christina River	MS Lower Tidal		DE	New Castle				
L0885	Barone's Mobil (Getty #08643)	Leaking Underground Storage Tank	petroleum		2801 Concord Pike, Wilmington	Brandywine Creek	MS below Chadds Ford		DE	New Castle				
L0895	Ron's Getty Station #08606	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L0902	Bideman Golf Course	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L0918	Greggs Bus Service	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L0925	Mergenthaler Property	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L0929	DE Turnpike - Htg Oil - Maint. Fac.	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L0930	7-11 (1126-22003) Christiana Rd.	Leaking Underground Storage Tank	petroleum		284 Christiana Rd., New Castle	Christina River	MS Lower Tidal		DE	New Castle				
L0934	Del Campo Bakery Sert Incident	Leaking Underground Storage Tank	petroleum		2006 Rodman St., Wilmington	Christina River	Little Mill Creek		DE	New Castle				
L0936	Winterthur Museum	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L0948	DE Turnpike Auth Maint Fac (WO)	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L0984	AMTRAK-West Yard SubStation	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L0990	Port of Wilmington	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L1009	Hagley Museum	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L1080	Stratford Apts.	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L1016	Hodgeson Vo-Tech	Leaking Underground Storage Tank	petroleum		Glasgow	Christina River	Muddy Run		DE	New Castle				
L1019	Kirkwood Texaco - Rice's Tex.	Leaking Underground Storage Tank	petroleum		3625 Kirkwood Hwy., Wilmington	Red Clay Creek	MS below Wooddale		DE	New Castle				
L1029	Port of Wilmington Dry Cargo Warehouse	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L1052	Mobil Ogletown - Waste Oil	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L1057	Elsmere Police Dept.	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L1075	Dugan and Son Inc.	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L1104	DuPont Glasgow	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L1109	Winterthur Museum	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L1117	Glasgow Citgo	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L1125	Tipton Trucking Tank Removals	Leaking Underground Storage Tank	petroleum		Townsend and Lobell Sts., Wilm	Christina River	MS Lower Tidal		DE	New Castle				
L1127	Delaware Auto Service	Leaking Underground Storage Tank	petroleum		1603 Pennsylvania Ave., Wilmington	Brandywine Creek	MS through Wilmington		DE	New Castle				
L1143	Univ. of Delaware Worrilow Hall	Leaking Underground Storage Tank	petroleum		Univ. of Delaware, Newark	White Clay Creek	MS above DE Park		DE	New Castle				
L1144	UPS, A Street	Leaking Underground Storage Tank	petroleum		700 A Street, Wilmington	Christina River	MS Lower Tidal		DE	New Castle				
L1147	Lincoln Camera Shop	Leaking Underground Storage Tank	petroleum		2001 Delaware Ave., Wilmington	Brandywine Creek	MS through Wilmington		DE	New Castle				
L1159	Kingdom Hall - Jehovah's Wtn.	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L1162	Port of Wilmington	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L1163	W. Carl Cullen, Inc.	Leaking Underground Storage Tank	petroleum		2034 Sunset Lake Rd., Newark	Christina River	EB/WB above Cooches Br.		DE	New Castle				
L1164	Forrest Sheet Metal	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L1177	Exxon - 820 S. College Newark	Leaking Underground Storage Tank	petroleum		820 S. College Ave., Newark	Christina River	EB/WB above Cooches Br.		DE	New Castle				
L1182	Jehovah's Witnesses (Newark)	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L1195	BP 400 Martin Luther King Blvd	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L1203	Rollins Cablevision	Leaking Underground Storage Tank	petroleum						DE	New Castle				
L1212	Transcargo, Inc.	Leaking Underground Storage Tank	petroleum						DE	New Castle				

L1223	Cumberland Farms Glasgow	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1270	Herlihy Residence	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1272	Panetrol, Inc.	Leaking Underground Storage Tank	petroleum		9 N. Colonial Ave., Elsmere	Christina River	Little Mill Creek		DE	New Castle					
L1288	Louis Dreyfus Energy #3	Leaking Underground Storage Tank	petroleum		Townsend and Lobdell Sts., Wilm	Christina River	MS Lower Tidal		DE	New Castle					
L1292	Independent Living	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1296	Conoco Surface Transportation	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1300	Hagley Museum Barley Mill	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1301	Hagley Museum Press House	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1311	Univ. of Delaware - 55 W. Main St.	Leaking Underground Storage Tank	petroleum		55 W. Main St., Newark	White Clay Creek	MS above DE Park		DE	New Castle					
L1320	Colonial School Transport Dept.	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1324	Mario Medori	Leaking Underground Storage Tank	petroleum		402 Meco Dr., Wilmington	Christina River	Little Mill Creek		DE	New Castle					
L1348	Delaware Racing Assn Equip, Bldg.	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1349	Delaware Racing Assn. Watertower	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1350	Delaware Racing Assn. Abandon. House	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1351	Delaware Racing Assn.Track Infield	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1357	Christiana Fire Co. Station #12	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1358	Hollingsworth Property-Cottman	Leaking Underground Storage Tank	petroleum		3410 Old Capital Trail, Wilmington	White Clay Creek	MS at Churchman's Marsh		DE	New Castle					
L1359	Hollingsworth Property-Cottman	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1360	Hollingsworth Prop. Engine Tech.	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1361	Hollingsworth Property-Cottman	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1362	Hollingsworth Property-N. Pump Island	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1363	Hollingsworth Property - Pump Island	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1365	Delaware Racing Assn. Track Infield	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1378	Winterthur Museum,Bldg. 46	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1392	Jaques Amblard	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1403	Property of Myrtle Williams	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1404	Lewis Flower Shop	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1411	American Red Cross	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1412	Take a Break, Inc	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1419	Newark Lumber Company	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1427	Allied Properties Inc.	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1431	Spenkman Co.	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1436	Stratford Apts.	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1444	Michael Skibicki	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1445	Donald F. Deavon	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1447	TCI Cablevision of NCCo	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1451	Stroehmann Bakeries, Inc.	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1452	Texaco 505 N. DuPont Hwy., N.C.	Leaking Underground Storage Tank	petroleum		505 N. DuPont Hwy., New Castle	Christina River	MS Lower Tidal		DE	New Castle					
L1453	Woodlawn Trustees	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1454	Port of Wilmington (Dole WH.)	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1462	Hagley Museum	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1466	E.C. Towing	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1468	Alderman Nissan	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1488	Salesianum School	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1490	U of DE Field House	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1495	Sharp Estate	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1497	AMTRAK Station Wilmington	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1517	USA Training Academy Inc.	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1520	Tatnall School	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1525	Meadowwood Texaco	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1531	Christiana Fire Co. #12	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1537	Price Mercedes Benz	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1543	City of Newark - Old Police Bldg	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1555	Stockwell Antiquaries	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1560	Metal Masters Co.	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1572	Mill Creek Fire Co.	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1576	Gallaher Elementary School	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1577	Mill Creek Fire Company	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1580	A.I. DuPont Institute	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1582	Calvary Baptist Church	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1587	Sandalwood Apts. #3	Leaking Underground Storage Tank	petroleum		Sandalwood Dr., Newark	Christina River	MS above Smalley's Pond		DE	New Castle					
L1590	Oak Tree Apartments	Leaking Underground Storage Tank	petroleum		Newark Drive, Newark	Christina River	EB/WB above Cooches Br.		DE	New Castle					
L1592	Hagley Museum Main Library	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1597	Penske Truck Leasing	Leaking Underground Storage Tank	petroleum		1600 Matassino Dr., New Castle	Christina River	MS Lower Tidal		DE	New Castle					
L1599	Union Park Pontiac - New Car Lot	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1600	Union Park Pontiac- Showroom	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1605	A.I. Dupont Institute	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1606	Union Park Pontiac	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1619	Amoco	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1625	Wilmington Fire Department	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1636	Crown Automart	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1642	Advanced Auto Care	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1645	NVF Company	Leaking Underground Storage Tank	petroleum		Yorklyn	Red Clay Creek	MS above Wooddale		DE	New Castle					
L1646	Sunoco Hockessin	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1655	Eastern Auto Salvage	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1656	Rizzo Property	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1662	Kings-Andy's Citgo	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1658	MBNA Milford Crossroads, Clubhouse	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1663	Pettinaro Old Shop	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1666	Dollar Family Store	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1668	Krapkcandoit	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1670	M/M Robert Smith Residence	Leaking Underground Storage Tank	petroleum		1411 Old Baltimore Pike, Newark	Christina River	Muddy Run		DE	New Castle					
L1678	Morrison Conoco	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1683	Emsilie Residence	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1684	Enterprise Flasher Co.	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1690	M.A. Zoccola and Sons, Inc.	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1707	Winterthur Museum	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1726	USA Training Academy	Leaking Underground Storage Tank	petroleum		955 S. Chapel St., Newark	Christina River	EB/WB above Cooches Br.		DE	New Castle					
L1727	Merit Gas Station	Leaking Underground Storage Tank	petroleum		5801 Kirkwood Hwy., Wilmington	White Clay Creek	Mill Creek		DE	New Castle					
L1734	Sardo and Sons, Inc	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1737	A.I. Dupont Institute	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1774	Louis Dreyfus Energy #4	Leaking Underground Storage Tank	petroleum		S. Heald and Lobdell St., Wilm	Christina River	MS Lower Tidal		DE	New Castle					
L1811	DELDOT	Leaking Underground Storage Tank	petroleum		Rt. 7 and Churchman's Rd.	White Clay Creek	MS at Churchman's Marsh		DE	New Castle					
L1815	MBNA Corp., Ogletown	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1827	Stratford Apts.	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1828	Rollins Leasing Corp.	Leaking Underground Storage Tank	petroleum		51 Boulden Blvd., New Castle	Christina River	MS Lower Tidal		DE	New Castle					
L1833	Tatnall School	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1859	Allens Kerosene	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1875	Allens Kerosene	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1878	Village of Windover/Kent	Leaking Underground Storage Tank	petroleum						DE	New Castle					
L1891	Little Sisters of the Poor	Leaking Underground Storage Tank	petroleum		185 Salem Church Rd., Newark	Christina River	MS above Smalley's Pond		DE	New Castle					
L1903	Brandywine Management	Leaking Underground Storage Tank	petroleum		4TH and Spruce, Wilmington	Christina River	MS Lower Tidal		DE	New Castle					
L1931	A.I. Dupont Institute - Sk H.O.	Leaking Underground Storage Tank	petroleum						DE	New Castle					

L1945	Ciba Geigy #2	Leaking Underground Storage Tank	petroleum					DE	New Castle					
L1978	Ingleside Retirement Apts.	Leaking Underground Storage Tank	petroleum		1005 N. Franklin St., Wilmington	Brandywine Creek	MS through Wilmington	DE	New Castle					
L1983	Taylor, Wm. Residence	Leaking Underground Storage Tank	petroleum		54 Quartzmill Rd., Newark	White Clay Creek	MS above Newark	DE	New Castle					
L2002	Gene's Gulf Service	Leaking Underground Storage Tank	petroleum		1001 West 4TH St., Wilmington	Christina River	MS Lower Tidal	DE	New Castle					
L2009	Winterthur Museum	Leaking Underground Storage Tank	petroleum					DE	New Castle					
L2018	Avir Corp., Sardo Warehouse	Leaking Underground Storage Tank	petroleum		6TH St., New Castle	Christina River	MS Lower Tidal	DE	New Castle					
L2019	Suburban Cable	Leaking Underground Storage Tank	petroleum					DE	New Castle					
L2020	Coca-Cola Bottling Co.	Leaking Underground Storage Tank	petroleum		Gray & 2ND, Greenhill & 2ND, Wilm	Christina River	Little Mill Creek	DE	New Castle					
LF01	DuPont Cherry Island	Landfills	Metals	Industrial Waste LF		Christina River	MS Lower Tidal	DE	New Castle					
LF05	Booker, Booker & Ryan	Landfills	Metals	Dry Waste LF		Christina River	MS Lower Tidal	DE	New Castle		inactive			
LF06	Taylor	Landfills	Metals	Dry Waste LF		Christina River	Muddy Run	DE	New Castle		inactive			
LF07	Timko	Landfills	Metals	Dry Waste LF		White Clay Creek	MS at Churchman's Marsh	DE	New Castle		inactive			
LF08	Petrillo Bros.	Landfills	Metals	Dry Waste LF		Christina River	MS Lower Tidal	DE	New Castle		inactive			
LF15	DSWA NSWMC #1	Landfills	VOCs,metals	MSW LF		Christina River	MS Lower Tidal	DE	New Castle		inactive			
LF16	Whittington Sd & Gravel	Landfills	VOCs,metals	Dump		Christina River	MS above Smalley's Pond	DE	New Castle					
LF24	Curtis Paper	Landfills	Metals	Industrial Waste	James River Corp.	White Clay Creek	MS above Newark	DE	New Castle					
LF25	DELDOT Kiamensi Yard	Landfills	VOCs,metals	Dry Waste, Misc.		Red Clay Creek	MS below Wooddale	DE	New Castle					
LF26	DELDOT Benr Yard	Landfills	VOCs,metals	Dry Waste, Misc.		Christina River	MS Lower Tidal	DE	New Castle					
LF27	Fibre Processing Corp.	Landfills	Other	Industrial Waste		Christina River	MS Lower Tidal	DE	New Castle					
LF28	Dasiy Concrete	Landfills	Metals	Dry Waste LF		Christina River	MS Lower Tidal	DE	New Castle					
DE081	NVF State Line Landfill	Superfund Site	HSCA	Landfill	Victor Posner/ Watson Brown	Red Clay Creek	MS above Wooddale	DE	New Castle					
DE166	Spatz Fiberglass	Superfund Site	HSCA	Molded fiberglass products manufacturer	Don Lickle	Red Clay Creek	MS above Wooddale	DE	New Castle					
DE071	NVF (Yorklyn)	Superfund Site	HSCA	Fiber product manufacturer	NVF	Red Clay Creek	MS above Wooddale	DE	New Castle					
DE072	Reevis & Reevis Clay Pit	Superfund Site	HSCA	Former Dump Site	Unknown	White Clay Creek	Mill Creek	DE	New Castle					
DE094	Container Corporation of America	Superfund Site	HSCA	Inactive landfill	Industrial Park Trust	Brandywine Creek	MS through Wilmington	DE	New Castle					
DE025	Capitol Recovery	Superfund Site	HSCA	Criminal case, no site	Home Dell Construction Co.	Brandywine Creek	MS through Wilmington	DE	New Castle					
DE111	Kruse Playground Site	Superfund Site	HSCA	al gas facility, leater tannery,currently used as a p	City of Wilmington	Brandywine Creek	MS through Wilmington	DE	New Castle					
DE174	Electric Hose & Rubber Recon	Superfund Site	HSCA	Former wire and hose manufacturer	Unknown	Brandywine Creek	MS through Wilmington	DE	New Castle					
DE159	Wilmington Train Yard	Superfund Site	HSCA	Train maintenance yard	Amtrak	Christina River	MS Lower Tidal	DE	New Castle					
DE158	Atlantic Avenue	Superfund Site	HSCA	uried drums discovered during utility constructio	Unknown	Christina River	Little Mill Creek	DE	New Castle					
DE114	Wilmington Coal Gas Co.-Southern Section	Superfund Site	HSCA	Former Coal Gasification Plant	Delmarva Power & Light	Christina River	MS Lower Tidal	DE	New Castle					
DE140	High Voltage Maintenance Site	Superfund Site	HSCA	Warehouse and maintenance facility	Harbor Associates	Christina River	MS Lower Tidal	DE	New Castle					
DE176	Ametek Inc.	Superfund Site	HSCA	Plastic products manufacturer	Amatek Inc. / Haveg Div.	Red Clay Creek	MS above Wooddale	DE	New Castle					
DE191	Pettinaro Transformer Site	Superfund Site	HSCA	Electric power transformer substation	Gregory Pettinaro	Christina River	MS Lower Tidal	DE	New Castle					
DE256	Hornalite	Superfund Site	HSCA	Optical plastics manufacturer	Brookside Drive, Wilmington	Christina River	Little Mill Creek	DE	New Castle					
DE187	Applied Technology Inc.	Superfund Site	HSCA	Unknown	Shellhorn & Hill	Christina River	MS Lower Tidal	DE	New Castle					
DE185	Meco Drive Site (Boxwood)	Superfund Site	HSCA	Industrial site	Meco Drive, Wilmington	Christina River	MS Lower Tidal	DE	New Castle					
DE169	Potta Property	Superfund Site	HSCA	mer ore processing plant/ currently bulk storage a	FA Potts / DE Contr. Co.	Christina River	MS Lower Tidal	DE	New Castle					
DE229	Newport Drum Site	Superfund Site	HSCA	Drum site	Maryland Ave., Newport	White Clay Creek	MS at Churchmans Marsh	DE	New Castle					
DE165	Estate of Lester Nolan	Superfund Site	VCP	Drum site	Ernest Kehrer	Christina River	MS Lower Tidal	DE	New Castle					
DE067	Halby Chemical	Superfund Site	NPL	Former chemical manufacturing facility	Brandywine Chemical Co.	Christina River	MS Lower Tidal	DE	New Castle					
DE099	City of Wilm. Marine Terminal	Superfund Site	HSCA	Marine terminal	City of Wilmington	Christina River	MS Lower Tidal	DE	New Castle					
DE079	Mt. Pleasant Railroad Dump	Superfund Site	HSCA	Former dump site	Tileon Construction	White Clay Creek	Mill Creek	DE	New Castle					
DE230	North American Smelting Co.	Superfund Site	VCP	Abandoned smelter operation	City of Wilmington	Christina River	MS Lower Tidal	DE	New Castle					
DE054	O & T Realty	Superfund Site	HSCA	Landfill	Michael Timko	Red Clay Creek	MS below Wooddale	DE	New Castle					
DE047	Harvey and Harvey Landfill	Superfund Site	VCP	ormer landfill currently used of container storag	Thomas Harvey, Jr.	Christina River	MS Lower Tidal	DE	New Castle					
DE271	Ciba-Geigy Seep	Superfund Site	EPA removal		James and Water St., Newport	Christina River	MS Lower Tidal	DE	New Castle					
DE020	E.I. DuPont, Newport Landfill	Superfund Site	NPL	Pigment manufacturing facility	DuPont Co.	Christina River	MS Lower Tidal	DE	New Castle					
DE214	Gore, WL & Assoc. Inc. - Newark	Superfund Site	HSCA	Manufacturing facility	W.L Gore & Associates	White Clay Creek	MS above Newark	DE	New Castle					
DE019	Koppers Co. Facilities Site	Superfund Site	NPL	Wood preserving facility	E.I. DuPont Denemours Inc.	White Clay Creek	MS at Churchmans Marsh	DE	New Castle					
DE162	Windy Hills	Superfund Site	HSCA	Former dump site	Unknown	White Clay Creek	MS above DE Park	DE	New Castle					
DE199	NVF Newark	Superfund Site	HSCA	Fiber products manufacturer	NVF Corp.	White Clay Creek	MS above DE Park	DE	New Castle					
DE052	Newark Housing Auth. Landfill	Superfund Site	HSCA	Inactive landfill	City of Newark	White Clay Creek	MS above DE Park	DE	New Castle					
DE018	FMC Corp.	Superfund Site	HSCA	Former landfill	FMC Corp.	White Clay Creek	MS above DE Park	DE	New Castle					
DE175	Motor Wheel Corporation	Superfund Site	HSCA	Wheel manufacturer	Goodyear Tire & Rubber Co./MWC	White Clay Creek	MS above DE Park	DE	New Castle					
DE062	SES Inc.	Superfund Site	HSCA	Research facility	SES Inc.	White Clay Creek	MS above DE Park	DE	New Castle					
DE163	Del. Chapel Place	Superfund Site	BPA II	Buried railcars	Mrs. Vivian Fike	White Clay Creek	MS above DE Park	DE	New Castle					
DE035	Newark Concrete	Superfund Site	HSCA	Dump site	John Petrillo	White Clay Creek	MS above DE Park	DE	New Castle					
DE095	Clayville Dump	Superfund Site	HSCA	Former dump site	Albert H. Marta / Albert W. Clayve	Christina River	MS Lower Tidal	DE	New Castle					
DE184	Brookside Dump	Superfund Site	HSCA	Dump site	Burkowitch & Greenstein	White Clay Creek	MS above DE Park	DE	New Castle					
DE039	Newark Landfill	Superfund Site	HSCA	Inactive landfill	City of Newark / Univ. of Del.	White Clay Creek	MS above DE Park	DE	New Castle					
DE105	Chrysler Assembly Plt.	Superfund Site		Automobile Assembly	Chrysler Assembly Plant	Christina River	EB/WB above Cooches Br.	DE	New Castle					
DE034	Chapmans Rd.	Superfund Site	HSCA	Former rendering plant	Marshall Smith III	Christina River	MS above Smalley's Pond	DE	New Castle					
DE125	DuPont Haskell Labs	Superfund Site	HSCA	Laboratories and research facility	DuPont Co.	Christina River	EB/WB above Cooches Br.	DE	New Castle					
DE161	Robscott Manor	Superfund Site	HSCA	Residential development/possible dump site	Unknown	Christina River	EB/WB above Cooches Br.	DE	New Castle					
DE195	Wilmington Suburban Water Co.	Superfund Site	HSCA	Water pumping facility with sludge lagoons	Wilmington Suburban Water Co.	Christina River	MS above Smalley's Pond	DE	New Castle					
DE210	Wilm Sub Water Co.-Christiana	Superfund Site	HSCA	Water pumping facility with sludge lagoons	Smalley's Dam Rd., Newark	Christina River	MS Lower Tidal	DE	New Castle					
DE248	DuPont Reston Products	Superfund Site	HSCA	acturer/ current research and development of circ	10 Dawson Drive, Newark	Christina River	MS above Smalley's Pond	DE	New Castle					
DE259	Newark Munition Site	Superfund Site	HSCA	Former WWII munitions storage area	Danson Drive, Newark	Christina River	MS above Smalley's Pond	DE	New Castle					
DE173	Syntech	Superfund Site	HSCA	Specialty chemical manufacturer	Walter Z. Heldt	Christina River	MS above Smalley's Pond	DE	New Castle					
DE193	Salem Church - Muddy Run Dump	Superfund Site	HSCA	ce dump- commercial, industrial, and household	Thomas & Harriet Staz	Christina River	Muddy Run	DE	New Castle					
DE155	Glasgow Drive Dump Site	Superfund Site			Delle Donne Associates	Christina River	Belltown Run	DE	New Castle					
DE141	Rt. 40 Steel Drum Site	Superfund Site	HSCA	Drum collection and resale company	Wm. Merritt Burke / James Beeson	Christina River	Belltown Run	DE	New Castle					
DE1003	Del. Air National Guard	Superfund Site	HSCA	Air Force National Guard Base	Rt. 9, New Castle	Christina River	MS Lower Tidal	DE	New Castle					
DE1034	Anchor Motor Freight	Superfund Site	VCP	Tractor sales and service facility		Christina River	/W Branch above Coochs B	DE	New Castle					
DE1039	Eagle Run	Superfund Site	VCP	Former manufacturing/ warehouse		Christina River	MS Lower Tidal	DE	New Castle					
DE1033	Victoria Woods	Superfund Site	HSCA	Residential development-vegitative debris pits		Christina River	MS Lower Tidal	DE	New Castle					
DE283	Necastro Auto Salvage	Superfund Site	HSCA	Auto salvage business	495 Old Airport Rd., New Port	Christina River	MS Lower Tidal	DE	New Castle					
DE1005	Toni Dry Cleaners	Superfund Site	HSCA	Dry cleaner	1606 Kirkwood Hwy., Elsmere	Christina River	Little Mill Creek	DE	New Castle					
DE1041	Dravo Marsh	Superfund Site	HSCA	Freshwater tidal		Christina River	MS Lower Tidal	DE	New Castle					
DE1043	Wilmington Coal Gas - Western Section	Superfund Site	HSCA	Former coal gasification plant		Christina River	Little Mill Creek	DE	New Castle					
DE1046	Wilmington Coal Gas - Northern Property	Superfund Site	VCP	Former coal gasification plant		Christina River	Little Mill Creek	DE	New Castle					
DE285	Browntown	Superfund Site		400 acre area within the city of Wilmington		Christina River	MS Lower Tidal	DE	New Castle					
DE1055	250 South Madison	Superfund Site		Freshwater tidal marsh		Christina River	MS Lower Tidal	DE	New Castle					
DE286	Bell Alley	Superfund Site				Christina River	MS Lower Tidal	DE	New Castle					
DE1044	CSX Property	Superfund Site	VCP	Vacant lot		Christina River	MS Lower Tidal	DE	New Castle					
DE1051	Pusey and Jones Shipyard	Superfund Site	PA/SI	d, current use industrial (metal fabrication & railcar refurbishing)		Christina River		DE	New Castle					
DE1040	400 South Madison Street	Superfund Site	HSCA	Former ship building site w/waste pile		Christina River	MS Lower Tidal	DE	New Castle					
DE1026	Terminal Avenue	Superfund Site	HSCA	Road widening project		Christina River	MS Lower Tidal	DE	New Castle					
DE168	Walker's Mill Mobile Home Park	Superfund Site	HSCA	le home park with possible groundwater contamin	Rt. 594, Bridgeville	Christina River	MS Lower Tidal	DE	New Castle					
DE270	Budd Metal	Superfund Site	VCP	Former metal fabrication business	Heald St., New Castle	Christina River	MS Lower Tidal	DE	New Castle					
DE097	Sixteenth Street Quarry	Superfund Site			14th & Spruce St., Wilmington	Brandywine Creek	MS through Wilmington	DE	New Castle					
DE280	Atlas Sanitation	Superfund Site	HSCA	Filled area	P.O. Box 2633, Wilmington	Brandywine Creek	MS through Wilmington	DE	New Castle					
DE281	Diamond State Salvage	Superfund Site	EPA removal	Salvage operation	702 E. 14th St., Wilmington	Brandywine Creek	MS through Wilmington	DE	New Castle					
DE215	Bell Property Disposal Pit	Superfund Site	Solid Waste		Old Wilmington Rd. (Rd 275), New Castle 1972	White Clay Creek	Mill Creek	DE	New Castle		no further action		5/89	
DE023	DuPont Experimental Station	Superfund Site	RCRA		Rt. 141 between Rts. 202 & 52, Wilmington 1972	Brandywine Creek	MS through Wilmington	DE	New Castle		RCRA		11/79	
DE197	Theil, Mary (Estate of)	Superfund Site	RCRA		3101 Miller Rd., Wilmington 19802	Brandywine Creek	MS through Wilmington	DE	New Castle		RCRA		12/88	
DE1048	Hercules Farm	Superfund Site	VCP		Wilmington	Christina River	Little Mill Creek	DE	New Castle		VCP		9/95	
DE131	Gates Engineering Co., Inc.	Superfund Site	RCRA		100 S. West St., Wilmington 19899	Christina River	MS Lower Tidal	DE	New Castle		RCRA		6/86	
DE1002	Haynes Park	Superfund Site	RCRA		Miller Rd/30th&32nd St., Wilmington 19803	Christina River	MS Lower Tidal	DE	New Castle		no further action			
DE176	Ametek, Inc.	Superfund Site	HSCA		900 Greenback Rd., Wilmington 19808	Red Clay Creek	MS below Wooddale	DE	New Castle		no further action			
DE1004	Harbor Associates Property	Superfund Site	HSCA		Madison Rd., Wilmington 19801			DE	New Castle		no further action			
DE090	Airport Property Site	Superfund Site	Solid Waste		Hollow Rd., New Castle 19720	Christina River	Little Mill Creek	DE	New Castle		no further action			

DE064	Tisdel Property	Superfund Site	Solid Waste		Kiamensi Rd., Newport 19804	Red Clay Creek	MS below Wooddale	DE	New Castle			no further action			
DE1049	Dupont Louviers-MBNA	Superfund Site	VCP		Newark	White Clay Creek	MS above Newark	DE	New Castle			VCP			
DE122	Sussex Co. Landfill#1 Bridgeville	Superfund Site	HSCA		County Rd 594, Bridgeville 19933	Christina River	MS Lower Tidal	DE	New Castle			no further action			
DE073	Minquadale Gravel Pit	Superfund Site	Solid Waste		Rt 13 Minquadale, Wilmington 19720	Christina River	MS Lower Tidal	DE	New Castle			no further action			
DE075	Bread and Cheese Island	Superfund Site	Solid Waste		Off Rt 4, Newport 19804	White Clay Creek	MS at Churchmans Marsh	DE	New Castle			no further action			
DE282	Cress Collision Services, Inc.	Superfund Site	SI		453 Old Airport Rd., Newport 19720	Christina River	MS Lower Tidal	DE	New Castle			SI			
DE1050	Dupont Louviers-Gore	Superfund Site	VCP		Newark	White Clay Creek	MS above Newark	DE	New Castle			VCP			
DE120	Porter Chevrolet	Superfund Site	Solid Waste		Cleveland Ave & Kirkwood Hwy, Newark 1971	White Clay Creek	MS above DE Park	DE	New Castle			no further action			
DE051	Atlantic Aviation	Superfund Site	RCRA		Wilmington Airport, Wilmington 19720	Christina River	MS Lower Tidal	DE	New Castle			RCRA			
DE091	Mill Rd Landfill	Superfund Site	Solid Waste		Mill Rd off Rt. 2, Newark 19711	Christina River	EB/WB above Cooches Br.	DE	New Castle			no further action			
DE171	Raintree	Superfund Site	Solid Waste		Smalley's Dam Road, Chritiana 19711	Christina River	MS above Smalley's Pond	DE	New Castle			no further action			
DE1032	Dawson Drive Site	Superfund Site	VCP		Newark	Christina River	EB/WB above Cooches Br.	DE	New Castle			VCP			
DE088	Dupont Glasgow Borrow Pit	Superfund Site	RCRA		Rt. 896, Glasgow 19720	Christina River	Muddy Run	DE	New Castle			RCRA			
DE086	Parkway Gravel Co.	Superfund Site	Low Priority		Rt 40, Red Lion Glasgow 19702	Christina River	MS above Smalley's Pond	DE	New Castle			no further action			
DE1022	Fox Run Open Space #2 (Trailer)	Superfund Site	HSCA O&M		Bear, 19706	Christina River	Belltown Run	DE	New Castle			HSCA			
PA01	AIW Frank	EPA Superfund Site	TCE, PCE, and 1,1,1-TCEA		Intersection Rt. 202/30, Exton	Brandywine Creek	Valley Creek	PA	Chester	400151	753609	active	10/89		
PA02	Blosenski Landfill	EPA Superfund Site	Organics,metals,PCBs		Rt. 340, Wagontown	Brandywine Creek	upper WB at Hibernia	PA	Chester	400112	755433	active	9/86		
PA03	Foote Mineral Company	EPA Superfund Site	CB's, lithium, boron, TCE, PCE, chromium		Swedesford&Bacton Hill Rd., Frazer	Brandywine Creek	Valley Creek	PA	Chester	400219	753516	active	2/92		
PA04	Harkman/Welsh Road Landfill	EPA Superfund Site	PAH's, metals, VOC's		Welsh Rd., Honeybrook	Brandywine Creek	upper WB at Honeybrook	PA	Chester	4007009	7554509	active	9/84		
PA05	William Dick Lagoons	EPA Superfund Site	TCE, chloroform, benzene, acetone, other		Telegraph Rd., West Caln Twp.	Brandywine Creek	upper WB at Hibernia	PA	Chester	4002309	7554009	active	7/87		
PA06	Strasburg Landfill	EPA Superfund Site	PVC's, 1,2-dichloroethane, TCA		Strasburg Rd., Newlin Twp.	Brandywine Creek	lower WB at Embreeville	PA	Chester	3956309	7546109	active	3/89		
PA07	East Brandywine Township	Landfill		Solid Waste Disposal Site	East Brandywine	Brandywine Creek	upper EB at Shamona Cr.	PA	Chester	400223	754319	inactive			
PA08	E. Marlborough-Newlin-W. Marl.	Landfill		Solid Waste Disposal Site	Newlin Twp.	Brandywine Creek	lower WB at Embreeville	PA	Chester	395504	754305	inactive			
PA09	Londonderry & Highland	Landfill		Solid Waste Disposal Site	Londonderry Twp.	Brandywine Creek	Doe Run	PA	Chester	395314	755301	inactive			
PA10	Robert Hooper Landfill	Landfill		Solid Waste Disposal Site	West Brandywine	Brandywine Creek	upper WB at Hibernia	PA	Chester	400343	755004	inactive			
PA11	South Coatesville Landfill	Landfill		Solid Waste Disposal Site	South Coatesville Borough	Brandywine Creek	lower WB at Coatesville	PA	Chester	395734	754902	inactive			
PA12	SECCRA Landfill	Landfill		Solid Waste Disposal Site	Kennett Twp.	Red Clay Creek	EB-Red Clay Creek	PA	Chester	395114	754225	inactive			
PA13	City of Coatesville Landfill	Landfill		Solid Waste Disposal Site	Valley Twp.	Brandywine Creek	upper WB at Hibernia	PA	Chester	395946	754941	inactive			
PA14	Parkesburg Landfill	Landfill		Solid Waste Disposal Site	Sadsbury Twp.	Brandywine Creek	Buck Run	PA	Chester	395717	755418	inactive			
PA15	Barkman Landfill	Landfill		Solid Waste Disposal Site	Honeybrook Twp.	Brandywine Creek	upper WB at Honeybrook	PA	Chester	400713	755455	inactive			
PA16	Perry Phillips	Landfill		Solid Waste Disposal Site	West Caln Twp.	Brandywine Creek	upper WB at Hibernia	PA	Chester	400105	755438	inactive			
PA17	Kennett Township	Landfill		Solid Waste Disposal Site	Kennett Twp.	Red Clay Creek	EB-Red Clay Creek	PA	Chester	3950359	7540309	inactive			
PA18	New Garden Township	Landfill		Solid Waste Disposal Site	New Garden Twp.	White Clay Creek	EB below Avondale	PA	Chester	3947009	7543309	inactive			
PA19	East Fallowfield Landfill	Landfill		Solid Waste Disposal Site	East Fallowfield Twp.	Brandywine Creek	Buck Run	PA	Chester	3956309	7551009	inactive			
PA20	London Grove-West Grove	Landfill		Solid Waste Disposal Site	London Grove Twp.	White Clay Creek	EB above Avondale	PA	Chester	3951309	7540109	inactive			
PA21	Downingtown-Sunoco	Landfill		Solid Waste Disposal Site	East Bradford Twp.	Brandywine Creek	lower EB-Brandywine Cr.	PA	Chester	3958509	7540109	inactive			
PA22	East Bradford	Landfill		Solid Waste Disposal Site	East Bradford Twp.	Brandywine Creek	lower EB-Brandywine Cr.	PA	Chester	3959009	7540209	inactive			
PA23	Kennett Square Borough	Landfill		Solid Waste Disposal Site	Kennett Twp.	Red Clay Creek	WB-Red Clay Creek	PA	Chester	3950109	7543209	inactive			
PA24	Wallace	Landfill		Solid Waste Disposal Site	Wallace Twp.	Brandywine Creek	upper EB at Struble Lake	PA	Chester	4004509	7544509	inactive			
PA25	Lanchester Landfill	Landfill		Solid Waste Disposal Site	Honeybrook Twp.	Brandywine Creek	upper WB at Honeybrook	PA	Chester	400637	755643	active			
PA26	SECCRA Landfill	Landfill		Solid Waste Disposal Site	London Grove Twp.	White Clay Creek	EB above Avondale	PA	Chester	395150	755034	active			

Notes:
Hazardous Substance Cleanup Act (HSCA)
National Priority List (NPL)
Environmental Protection Agency (EPA)
Brownfield Preliminary Assessment (BPA)
Voluntary Cleanup Program (VCP)

APPENDIX H

MAP 10 - EXISTING BEST MANAGEMENT PRACTICES

MAP 10 - EXISTING BEST MANAGEMENT PRACTICES (BMPs)
Christina Basin Water Quality Management Strategy
May 21, 1998

I.D. No.	Owner	Type of BMP	Latitude	Longitude	Date Recorded	Municipality	State	County	Watershed	Subwatershed	Area (acres)	Description of BMP
BC003		Agriculture					DE	New Castle	Brandywine Cr.			
RCN004		Agriculture					DE	New Castle	Red Clay Cr.			
RCN005		Agriculture					DE	New Castle	Red Clay Cr.			
RCN001		Agriculture					DE	New Castle	Red Clay Cr.			
RCN003		Agriculture					DE	New Castle	Red Clay Cr.			
RCN006		Agriculture					DE	New Castle	Red Clay Cr.			
BC002		Agriculture					DE	New Castle	Brandywine Cr.			
RCS001		Agriculture					DE	New Castle	Red Clay Cr.			
BC005		Agriculture					DE	New Castle	Brandywine Cr.			
WCN008		Agriculture					DE	New Castle	White Clay Cr.			
DCN003		Agriculture					DE	New Castle	White Clay Cr.			
WCS026		Agriculture					DE	New Castle	White Clay Cr.			
WCS010		Agriculture					DE	New Castle	White Clay Cr.			
WCN002		Agriculture					DE	New Castle	White Clay Cr.			
WCS028		Agriculture					DE	New Castle	White Clay Cr.			
WCS005		Agriculture					DE	New Castle	White Clay Cr.			
WCS009		Agriculture					DE	New Castle	White Clay Cr.			
WCN013		Agriculture					DE	New Castle	White Clay Cr.			
WCS002		Agriculture					DE	New Castle	White Clay Cr.			
WCS008		Agriculture					DE	New Castle	White Clay Cr.			
WCS013		Agriculture					DE	New Castle	White Clay Cr.			
WCS015		Agriculture					DE	New Castle	White Clay Cr.			
CRE001		Agriculture					DE	New Castle	Christina River			
CRW002		Agriculture					DE	New Castle	Christina River			
CRW005		Agriculture					DE	New Castle	Christina River			
CRW006		Agriculture					DE	New Castle	Christina River			
CRW008		Agriculture					DE	New Castle	Christina River			
PA1	Walmore Holstiens, Inc	Agriculture					PA	Chester	Red Clay/White Clay Cr.			
PA2	Highpoint Acres	Agriculture					PA	Chester	Red Clay/White Clay Cr.			
PA3	Modern Mushroom	Agriculture					PA	Chester	Red Clay/White Clay Cr.			
PA4	New Bolton Center	Agriculture					PA	Chester	Red Clay/White Clay Cr.			
PA5	White Clay Valley Farms (Gouge)	Agriculture					PA	Chester	Red Clay/White Clay Cr.			
PA6	Ed Cannon	Agriculture					PA	Chester	Red Clay/White Clay Cr.			
PA7	Karl Boer	Agriculture					PA	Chester	Red Clay/White Clay Cr.			
PA8	Hudson Farms	Agriculture					PA	Chester	Red Clay/White Clay Cr.			
PA9	Ed Leo	Agriculture					PA	Chester	Red Clay/White Clay Cr.			
PA10	Ed Leo	Agriculture					PA	Chester	Red Clay/White Clay Cr.			
PA11	Pryme Pak/Nutra Soil	Agriculture					PA	Chester	Red Clay/White Clay Cr.			
PA12	Fazio Mushroom	Agriculture					PA	Chester	Red Clay/White Clay Cr.			
PA13	Versagli Mushroom Co.	Agriculture					PA	Chester	Red Clay/White Clay Cr.			
PA14	Elite Mushroom Co.	Agriculture					PA	Chester	Red Clay/White Clay Cr.			
PA15	Elite Mushroom Co.	Agriculture					PA	Chester	Red Clay/White Clay Cr.			
PA16	Willis Hocking	Agriculture					PA	Chester	Red Clay/White Clay Cr.			
PA17	Ken's Mushroom	Agriculture					PA	Chester	Red Clay/White Clay Cr.			
PA18	Raimund's Mushrooms	Agriculture					PA	Chester	Red Clay/White Clay Cr.			
PA19	Hy-Tech Mushroom Compost, Inc.	Agriculture					PA	Chester	Red Clay/White Clay Cr.			
PA20	Laurel Valley Farms	Agriculture					PA	Chester	Red Clay/White Clay Cr.			
PA21	Earthgro Inc.	Agriculture					PA	Chester	Red Clay/White Clay Cr.			
PA22	Pietro Industries	Agriculture					PA	Chester	Red Clay/White Clay Cr.			
PA23	A&F Mushrooms	Agriculture					PA	Chester	Red Clay/White Clay Cr.			
PA24	Donald Speakman	Agriculture					PA	Chester	Red Clay/White Clay Cr.			
PA25	Mark Lafferty	Agriculture					PA	Chester	Red Clay/White Clay Cr.			
PA26	Phillip Lafferty	Agriculture					PA	Chester	Red Clay/White Clay Cr.			
PA27	Kaolin Mushroom	Agriculture					PA	Chester	Red Clay/White Clay Cr.			
PA28	Alpine Mushroom	Agriculture					PA	Chester	Red Clay/White Clay Cr.			

PA29	M&v Enterprises	Agriculture					PA	Chester	Red Clay/White Clay Cr.				
PA30	Phillip Mushroom Farms	Agriculture					PA	Chester	Red Clay/White Clay Cr.				
PA31	Wilkinson Farms Inc.	Agriculture					PA	Chester	Red Clay/White Clay Cr.				
PA32	Edmidio Frezzo, Jr.	Agriculture					PA	Chester	Red Clay/White Clay Cr.				
PA33	Landhope Farms	Agriculture					PA	Chester	Red Clay/White Clay Cr.				
PA34	Guizzetti and Sons	Agriculture					PA	Chester	Red Clay/White Clay Cr.				
PA35	Watercress Farms	Agriculture					PA	Chester	Red Clay/White Clay Cr.				
PA36	Charles Young	Agriculture					PA	Chester	Red Clay/White Clay Cr.				
PA37	Vico N. Bertolgi	Agriculture					PA	Chester	Red Clay/White Clay Cr.				
PA38	Vincent Ghione	Agriculture					PA	Chester	Red Clay/White Clay Cr.				
PA39	Caputo and Guest	Agriculture					PA	Chester	Red Clay/White Clay Cr.				
PA40	Marlboro Mushrooms	Agriculture					PA	Chester	Red Clay/White Clay Cr.				
PA41	Starr Roses	Agriculture					PA	Chester	Red Clay/White Clay Cr.				
PA42	Bill Nichols	Agriculture					PA	Chester	Red Clay/White Clay Cr.				
PA43	James Fieni	Agriculture					PA	Chester	Red Clay/White Clay Cr.				
PA44	John D'Amico	Agriculture					PA	Chester	Red Clay/White Clay Cr.				
PA45	Emerson Mushroom	Agriculture					PA	Chester	Red Clay/White Clay Cr.				
PA46	Gourmet Delight Mushroom Co.	Agriculture					PA	Chester	Red Clay/White Clay Cr.				
PA47	Jay Dudkewitz (Clover Hill Farms)	Agriculture					PA	Chester	Red Clay/White Clay Cr.				
PA48	North Creek Nurseries	Agriculture					PA	Chester	Red Clay/White Clay Cr.				
PA49	Jeanee Belasik	Agriculture					PA	Chester	Red Clay/White Clay Cr.				
PA50	Joanne Sharpless Cruse	Agriculture					PA	Chester	Red Clay/White Clay Cr.				
PA51	Steven Witsil	Agriculture					PA	Chester	Red Clay/White Clay Cr.				
PA52	Hartefeld National Golf Course	Agriculture					PA	Chester	Red Clay/White Clay Cr.				
PA53	C.P. Yeatman and Sons	Agriculture					PA	Chester	Red Clay/White Clay Cr.				
PA54	Custom Casing	Agriculture					PA	Chester	Red Clay/White Clay Cr.				
PA55	Frebro Inc.	Agriculture					PA	Chester	Red Clay/White Clay Cr.				
PA56	John A. Arrell	Agriculture					PA	Chester	Red Clay/White Clay Cr.				
PA57	William Brown	Agriculture					PA	Chester	Red Clay/White Clay Cr.				
PA58	Hugh Lofting	Agriculture					PA	Chester	Red Clay/White Clay Cr.				
PA59	Moorehead Kerr	Agriculture					PA	Chester	Red Clay/White Clay Cr.				
PA60	David Walton, Jr.	Agriculture					PA	Chester	Red Clay/White Clay Cr.				
PA61	White Clay Preserve	Agriculture					PA	Chester	Red Clay/White Clay Cr.				
PA62	Betty Weymuth	Agriculture					PA	Chester	Red Clay/White Clay Cr.				
PA63	Oakshire Mushrooms	Agriculture					PA	Chester	Red Clay/White Clay Cr.				
PA64	Paramount Nursery	Agriculture					PA	Chester	Red Clay/White Clay Cr.				
PA65	F.E. Hunter	Agriculture					PA	Chester	Red Clay/White Clay Cr.				
PA66	Kenneth and Mildred Sellers	Agriculture					PA	Chester	Red Clay/White Clay Cr.				
PA67	Needhams Mushroom Farms	Agriculture					PA	Chester	Red Clay/White Clay Cr.				
PA68	Howard Mark	Agriculture					PA	Chester	Red Clay/White Clay Cr.				
PA69	Pratt Mushrooms	Agriculture					PA	Chester	Red Clay/White Clay Cr.				
PA70	William C. Ellis	Agriculture					PA	Chester	Red Clay/White Clay Cr.				
DE1	Feryn Farms	Stormwater			03/02/95		DE	New Castle	Brandywine	Main Stem Below Chadds Ford			Detention
DE2	Freedom Court	Stormwater			02/16/95		DE	New Castle	Brandywine	Main Stem Below Chadds Ford			Detention
DE3	Woodburne	Stormwater			11/29/95		DE	New Castle	Brandywine	Main Stem Below Chadds Ford			Wet Pond
DE4	Mansion Park	Stormwater			12/09/95		DE	New Castle	Brandywine	Main Stem Below Chadds Ford			Detention
DE5	Meghan's Court	Stormwater			07/31/90		DE	New Castle	Brandywine	Main Stem Below Chadds Ford			Detention
DE6	Dunsmore	Stormwater			01/10/91		DE	New Castle	Brandywine	Main Stem Below Chadds Ford			Detention
DE7	Red Mill Industrial Park	Stormwater			02/13/91		DE	New Castle	Brandywine	Main Stem Below Chadds Ford			Detention
DE8	Timber Farms 1	Stormwater			12/13/91		DE	New Castle	Brandywine	Main Stem Below Chadds Ford			Wet Pond
DE9	Timber Farms 2	Stormwater			12/13/91		DE	New Castle	Brandywine	Main Stem Below Chadds Ford			Wet Pond
DE10	English Creek	Stormwater			11/14/91		DE	New Castle	Brandywine	Main Stem Below Chadds Ford			Detention
DE11	Christina's Brace	Stormwater			12/18/92		DE	New Castle	Brandywine	Main Stem Below Chadds Ford			Wet Pond
DE12	The Oaks	Stormwater			10/18/92		DE	New Castle	Brandywine	Main Stem Below Chadds Ford			Wet Pond
DE13	Richard's Lane 1	Stormwater			07/30/93		DE	New Castle	Brandywine	Main Stem Below Chadds Ford			Detention
DE14	The Woods at Middle Run	Stormwater			07/12/94		DE	New Castle	Brandywine	Main Stem Below Chadds Ford			
DE15	Norwegian Woods	Stormwater			08/01/95		DE	New Castle	Brandywine	Main Stem Below Chadds Ford			Wet Pond
DE16	Medori Industrial Park	Stormwater			05/19/96		DE	New Castle	Brandywine	Main Stem Below Chadds Ford			
DE17	Lewis Commercial Center	Stormwater			10/13/93		DE	New Castle	Brandywine	Main Stem Below Chadds Ford			Wet Pond
DE18	Brookstone	Stormwater			11/15/95		DE	New Castle	Brandywine	Main Stem Below Chadds Ford			Wet Pond
DE19	Alders Lane	Stormwater			02/27/91		DE	New Castle	Brandywine	Main Stem Below Chadds Ford			Detention
DE20	Weldin Ridge 1	Stormwater			07/13/94		DE	New Castle	White Clay	Mill Creek			Wet Pond
DE21	Valley Pointe	Stormwater			08/01/95		DE	New Castle	White Clay	Mill Creek			Wet Pond

DE22	Pepper Ridge	Stormwater			01/10/91		DE	New Castle	White Clay	Mill Creek		Wet Pond
DE23	Tupelo Ridge	Stormwater			11/14/94		DE	New Castle	White Clay	Mill Creek		Detention
DE24	Wynleigh	Stormwater			11/29/95		DE	New Castle	Brandywine	Main Stem Below Chadds Ford		Detention
DE25	Sunset Village	Stormwater			12/20/93		DE	New Castle	White Clay	Mill Creek		
DE26	Middle Run Crossing 1	Stormwater			07/30/93		DE	New Castle	White Clay	Mill Creek		Wet Pond
DE27	Linden Way 1	Stormwater			05/11/92		DE	New Castle	White Clay	Mill Creek		Detention
DE28	Limestone Hills 1- West Section	Stormwater			02/25/92		DE	New Castle	White Clay	Mill Creek		Detention
DE29	Breckenridge 1	Stormwater			05/12/93		DE	New Castle	Red Clay	Main Stem Above Wooddale		Detention
DE30	Woodcrest Court	Stormwater			08/01/95		DE	New Castle	White Clay	Mill Creek		Detention
DE31	Wyndom	Stormwater			10/25/95		DE	New Castle	White Clay	Mill Creek		Wet Pond
DE32	Tall Trees	Stormwater			03/31/95		DE	New Castle	White Clay	East Branch Below Avondale		Detention
DE33	Bromley	Stormwater			08/12/93		DE	New Castle	White Clay	Mill Creek		Wet Pond
DE34	Kendall	Stormwater			09/29/93		DE	New Castle	White Clay	Mill Creek		Detention
DE35	Shipley Chase	Stormwater			05/27/94		DE	New Castle	White Clay	Mill Creek		Detention
DE36	The Millace	Stormwater			11/23/94		DE	New Castle	White Clay	Mill Creek		Detention
DE37	Talleyrand	Stormwater			05/30/93		DE	New Castle	Red Clay	Main Stem Below Wooddale		Detention
DE38	Vineyards	Stormwater			09/20/93		DE	New Castle	White Clay	Mill Creek		Detention
DE39	Woodcrest Estates	Stormwater			05/12/94		DE	New Castle	White Clay	Mill Creek		Detention
DE40	Westover Hills	Stormwater			01/25/95		DE	New Castle	Red Clay	Main Stem Above Wooddale		Wet Pond
DE41	Buckingham Green 1	Stormwater			07/27/94		DE	New Castle	White Clay	Mill Creek		Wet Pond
DE42	Carpenters Row	Stormwater			02/16/96		DE	New Castle	Christina	Little Mill Creek		Detention
DE43	Hayman Place	Stormwater			09/05/90		DE	New Castle	White Clay	Mill Creek		Detention
DE44	Woodside Court	Stormwater			01/30/92		DE	New Castle	White Clay	Mill Creek		
DE45	Hawthorne Estates	Stormwater			08/01/95		DE	New Castle	Brandywine	Main Stem Below Chadds Ford		Wet Pond
DE46	Kentmere	Stormwater			11/29/95		DE	New Castle	White Clay	Mill Creek		Wet Pond
DE47	Charwood Estates	Stormwater			03/11/92		DE	New Castle	Christina	Little Mill Creek		Detention
DE48	Appleby Manor	Stormwater			11/10/93		DE	New Castle	White Clay	Mill Creek		
DE49	Hawks Nest	Stormwater			12/22/94		DE	New Castle	White Clay	Mill Creek		Detention
DE50	Altersgate	Stormwater			09/11/91		DE	New Castle	Christina	Little Mill Creek		Detention
DE51	Richard's Lane	Stormwater			06/30/93		DE	New Castle	White Clay	Mill Creek		Detention
DE52	Weldin Ridge 2	Stormwater			07/13/94		DE	New Castle	White Clay	Mill Creek		Wet Pond
DE53	Middle Run Crossing 2	Stormwater			07/30/93		DE	New Castle	White Clay	Mill Creek		Wet Pond
DE54	Middle Run Crossing 3	Stormwater			07/30/93		DE	New Castle	Christina	Little Mill Creek		
DE55	Linden Way 2	Stormwater			05/11/92		DE	New Castle	White Clay	Mill Creek		Detention
DE56	The Woods at Pike Creek	Stormwater			03/11/92		DE	New Castle	White Clay	East Branch Below Avondale		
DE57	Breckenridge 2	Stormwater			05/12/93		DE	New Castle	White Clay	Pike Creek		Wet Pond
DE58	Buckingham Greene 2	Stormwater			07/27/94		DE	New Castle	White Clay	East Branch Below Avondale		Wet Pond
DE59	Pike Place	Stormwater			06/14/95		DE	New Castle	Red Clay	Main Stem Below Wooddale		Wet Pond
DE60	Salem Trace	Stormwater			04/26/95		DE	New Castle	Red Clay	Main Stem Below Wooddale		Detention
DE61	The Reserve at Ironside	Stormwater			05/15/96		DE	New Castle	Red Clay	Main Stem Below Wooddale		
DE62	Woodland Industrial Park	Stormwater			04/29/92		DE	New Castle	White Clay	Mill Creek		
DE63	Westover Woods 1	Stormwater			07/16/92		DE	New Castle	White Clay	Mill Creek		Wet Pond
DE64	Westover Woods 2	Stormwater			08/01/95		DE	New Castle	Brandywine	Main Stem Below Chadds Ford		Detention
DE65	Perch Creek 1	Stormwater			03/24/93		DE	New Castle	Christina	Little Mill Creek		Wet Pond
DE66	Perch Creek 2	Stormwater			03/24/93		DE	New Castle	White Clay	East Branch Below Avondale		Wet Pond
DE67	Perch Creek 3	Stormwater			03/24/93		DE	New Castle	White Clay	Mill Creek		Detention
DE68	Perch Creek 4	Stormwater			03/24/93		DE	New Castle	White Clay	Pike Creek		Wet Pond
DE69	Perch Creek 5	Stormwater			09/29/93		DE	New Castle	White Clay	Mill Creek		Wet Pond
DE70	Perch Creek 6	Stormwater			04/24/96		DE	New Castle	White Clay	Mill Creek		
DE71	Woodland Village 1	Stormwater			11/15/94		DE	New Castle	Red Clay	Main Stem Below Wooddale		
DE72	Woodland Village 2	Stormwater			11/15/94		DE	New Castle	White Clay	East Branch Below Avondale		
DE73	Sandy Brae	Stormwater			02/28/96		DE	New Castle	White Clay	Mill Creek		Wet Pond
DE74	Adam's Run	Stormwater			10/19/90		DE	New Castle	White Clay	Pike Creek		Wet Pond
DE75	Rosetree Hunt	Stormwater			09/24/90		DE	New Castle	White Clay	Pike Creek		Detention
DE76	Farmington	Stormwater			05/04/90		DE	New Castle	Red Clay	Main Stem Below Wooddale		
DE77	Stateline Estates 1	Stormwater			05/27/94		DE	New Castle	Christina	Little Mill Creek		
DE78	Stateline Estates 2	Stormwater			05/27/94		DE	New Castle	Christina	Little Mill Creek		
DE79	Beaulieu II	Stormwater			04/26/95		DE	New Castle	Red Clay	Main Stem Below Wooddale		Wet Pond
DE80	Frenchtown Woods Townhouses 1	Stormwater			05/27/96		DE	New Castle	Red Clay	Main Stem Below Wooddale		Detention
DE81	Micucio Property	Stormwater			05/30/91		DE	New Castle	Red Clay	Main Stem Below Wooddale		
DE82	Newtown Village 1	Stormwater			03/25/92		DE	New Castle	White Clay	Mill Creek		Wet Pond
DE83	Newtown Village 2	Stormwater			03/25/92		DE	New Castle	Christina	Little Mill Creek		Detention
DE84	Oakwood	Stormwater			09/27/91		DE	New Castle	Christina	Little Mill Creek		Detention

DE85	Brookfield in Tayortowne	Stormwater			02/27/94		DE	New Castle	Christina	Little Mill Creek		Wet Pond
DE86	Forest Glen at Pinewood 1	Stormwater			06/10/93		DE	New Castle	Christina	Little Mill Creek		Wet Pond
DE87	Forest Glen at Pinewood 2	Stormwater			06/10/93		DE	New Castle	Red Clay	Main Stem Below Wooddale		Detention
DE88	Chandeleur Woods 1	Stormwater			12/18/94		DE	New Castle	Christina	Little Mill Creek		Wet Pond
DE89	Chandeleur Woods 2	Stormwater			12/18/94		DE	New Castle	White Clay	Pike Creek		Wet Pond
DE90	Chandeleur Woods 3	Stormwater			12/18/94		DE	New Castle	Red Clay	Main Stem Below Wooddale		
DE91	Gloria's Village	Stormwater			09/14/94		DE	New Castle	Red Clay	Main Stem Below Wooddale		
DE92	Stone Mill	Stormwater			02/14/96		DE	New Castle	White Clay	Pike Creek		
DE93	Christiana Hollow	Stormwater			11/29/95		DE	New Castle	White Clay	Pike Creek		
DE94	Bellwether Manor	Stormwater			04/12/95		DE	New Castle	White Clay	Mill Creek		Wet Pond
DE95	Fieldstone Crossing	Stormwater			07/12/95		DE	New Castle	Christina	Little Mill Creek		Wet pond
DE96	Village of Becks Pond 1	Stormwater			09/30/92		DE	New Castle	White Clay	Pike Creek		Detention
DE97	Village of Becks Pond 2	Stormwater			09/30/92		DE	New Castle	White Clay	Pike Creek		Wet Pond
DE98	Raven Glen at Wellington Woods	Stormwater			07/29/92		DE	New Castle	White Clay	Pike Creek		Detention
DE99	Gray Acres 1	Stormwater			07/24/91		DE	New Castle	White Clay	Pike Creek		Wet Pond
DE100	Gray Acres 2	Stormwater			07/24/91		DE	New Castle	White Clay	Pike Creek		
DE101	Whethersfield	Stormwater			07/12/90		DE	New Castle	White Clay	Pike Creek		Detention
DE102	Forest Glen	Stormwater			04/05/95		DE	New Castle	White Clay	Pike Creek		Wet Pond
DE103	Buckley 1	Stormwater			07/31/91		DE	New Castle	White Clay	Mill Creek		Detention
DE104	Riveredge Estates	Stormwater			10/27/93		DE	New Castle	White Clay	Middle Run		Wet Pond
DE105	Rutledge	Stormwater			07/09/91		DE	New Castle	White Clay	Pike Creek		Wet Pond
DE106	Llangollen Green 1	Stormwater			12/12/90		DE	New Castle	White Clay	Pike Creek		Wet Pond
DE107	Llangollen Green 2	Stormwater			12/12/90		DE	New Castle	White Clay	Pike Creek		
DE108	Springfields 1	Stormwater			06/22/90		DE	New Castle	White Clay	Middle Run		Detention
DE109	Springfields 2	Stormwater			06/22/90		DE	New Castle	White Clay	Main Stem Above Newark		Detention
DE110	Lums Pond Estates	Stormwater			06/24/92		DE	New Castle	White Clay	Mill Creek		Wet Pond
DE111	Bear Crossing	Stormwater			02/23/94		DE	New Castle	White Clay	Mill Creek		Wet Pond
DE112	Colton Meadow	Stormwater			02/28/96		DE	New Castle	Red Clay	Main Stem Below Wooddale		
DE113	Mariner's Watch 1	Stormwater			01/14/92		DE	New Castle	White Clay	Pike Creek		
DE114	Mariner's Watch 2	Stormwater			01/14/92		DE	New Castle	White Clay	Pike Creek		
DE115	Mariner's Watch 3	Stormwater			01/14/92		DE	New Castle	White Clay	Pike Creek		
DE116	Mariner's Watch 4	Stormwater			01/14/92		DE	New Castle	White Clay	Pike Creek		
DE117	Brennan Estates 1	Stormwater			11/15/95		DE	New Castle	White Clay	Mill Creek		
DE118	Brennan Estates 2	Stormwater			11/15/92		DE	New Castle	White Clay	Mill Creek		
DE119	Brennan Estates 3	Stormwater			11/15/95		DE	New Castle	White Clay	Mill Creek		
DE120	Brennan Estates 4	Stormwater			11/15/95		DE	New Castle	White Clay	Pike Creek		
DE121	Brennan Estates 5	Stormwater			11/15/95		DE	New Castle	White Clay	Pike Creek		
DE122	Brennan Estates 6	Stormwater			11/15/95		DE	New Castle	White Clay	Pike Creek		
DE123	Brennan Estates 7	Stormwater			11/15/95		DE	New Castle	White Clay	Pike Creek		
DE124	Brennan Estates 8	Stormwater			11/15/95		DE	New Castle	White Clay	Mill Creek		
DE125	Brennan Estates 9	Stormwater			11/15/95		DE	New Castle	White Clay	Mill Creek		
DE126	Rose Hill at Lexington Farms	Stormwater			01/30/92		DE	New Castle	White Clay	Mill Creek		Wet Pond
DE127	York Farms	Stormwater			11/01/90		DE	New Castle	White Clay	Mill Creek		Detention
DE128	Mansion Farm	Stormwater			06/29/95		DE	New Castle	Red Clay	Main Stem Below Wooddale		Wet Pond
DE129	Amberwood 1	Stormwater			08/01/95		DE	New Castle	White Clay	Pike Creek		
DE130	Amberwood 2	Stormwater			08/01/95		DE	New Castle	White Clay	Pike Creek		
DE131	Amberwood 3	Stormwater			08/01/95		DE	New Castle	White Clay	Mill Creek		
DE132	Villages at Fairview Ponds 1	Stormwater			05/11/95		DE	New Castle	Christina	Little Mill Creek		
DE133	Villages at Fairview Ponds 2	Stormwater			05/11/95		DE	New Castle	White Clay	Mill Creek		
DE134	Villages at Fairview Ponds 3	Stormwater			05/11/95		DE	New Castle	White Clay	Mill Creek		
DE135	Meadow Glen	Stormwater			03/08/94		DE	New Castle	Red Clay	Main Stem Below Wooddale		Wet Pond
DE136	Nautical Cove	Stormwater			07/30/92		DE	New Castle	White Clay	Pike Creek		Wet Pond
DE137	Lea Eara Farms 1	Stormwater			06/13/90		DE	New Castle	White Clay	Pike Creek		Wet Pond
DE138	Lea Eara Farms 2	Stormwater			06/13/90		DE	New Castle	White Clay	Mill Creek		
DE139	Lea Eara Farms 3	Stormwater			03/25/92		DE	New Castle	White Clay	Pike Creek		Detention
DE140	Lea Eara Farms 4	Stormwater			03/25/92		DE	New Castle	White Clay	Middle Run		
DE141	Pine Tree Estates	Stormwater			02/28/96		DE	New Castle	White Clay	Mill Creek		
DE142	Amberville	Stormwater			05/30/96		DE	New Castle	White Clay	Main Stem at Churchmans Marsh		
DE143	Drawyers Creek	Stormwater			06/12/91		DE	New Castle	White Clay	Pike Creek		Detention
DE144	Augustine Creek	Stormwater			08/01/95		DE	New Castle	White Clay	Middle run		Wet Pond
DE145	Appoquin 1	Stormwater			07/30/93		DE	New Castle	White Clay	Middle Run		Detention
DE146	Appoquin 2	Stormwater			07/30/93		DE	New Castle	Red Clay	Main Stem Below Wooddale		
PAR10-G000	Thornbury Knoll, L.P.	Stormwater			04/06/93	Birmingham	PA	Chester	Brandywine		58	

PAR10-G001	Lancaster Co. Builders	Stormwater			04/14/93	Caln	PA	Chester	East Branch Brandywine		16.5	
PAS10-G002	Marsh Harbour Associates	Stormwater			04/27/93	U.Uwchlan	PA	Chester	Marsh Creek		35.67	
PAR10-G004	Christian and Elizabeth Crane	Stormwater			04/27/93	W.Caln Twp	PA	Chester	West Branch		22	
PAR10-G007	Triology Development Co. Inc.	Stormwater			04/27/93	E.Fallowfield	PA	Chester	Buck and Sucker Run		41.9	
PAR10-G012	G.Martin Cloud	Stormwater			05/06/93	E.Marlborough	PA	Chester	Pocopson		26.7	
PAS10-G006	Twin Valley School District	Stormwater			05/06/93	Honeybrook	PA	Chester	West Branch		19.5	
PAR10-G013	Downingtown Municipal Authority	Stormwater			05/12/93	Downingtown	PA	Chester	East Branch		5.96	
PAR10-G015	MPT, Inc.	Stormwater			05/10/93	E.Fallowfield	PA	Chester	Sadsbury and Buck Run		12.29	
PAR10-G017	B and B Company	Stormwater			05/14/93	E.Bradford+	PA	Chester	Plum Run		24.9	
						Birmingham						
PAR10-G018	Chestnut Estates	Stormwater			05/13/93	Borough of	PA	Chester	Octoraro		5	
						Parkersburg						
PAR10-G019	Whitford Ridge L.P.	Stormwater			05/18/93	W.Whiteland	PA	Chester	Valley		59	
PAR10-G020	Devon town Corp.	Stormwater			05/17/93	W.Bradford	PA	Chester	Brandywine		80	
PAS10-G011	The Hankin Group	Stormwater			05/17/93	Uwchlan	PA	Chester	Shamona		85	
PAS10-G012	PA. Dept. of Transportation	Stormwater			05/18/93	E.Caln and	PA	Chester	Brandywine and Valley		143	
						W.Whiteland			Indian Run		24.39	
PAS10-G013	Rouse/Chamberlin, LTD.	Stormwater			05/20/93	Wallace	PA	Chester	Indian Run, East Branch		24.39	
PAS10-G015	Rouse/Chamberlin, LTD.	Stormwater			05/25/93	Wallace	PA	Chester	Brandywine		17	
PAR10-G02	Bernard Hankin Builders	Stormwater			05/25/93	East Bradford	PA	Chester	Valley		7	
PAR10-G027	Jenny Meadow, Inc.	Stormwater			05/25/93	East Fallowfield	PA	Chester	Dennis Run, West Branch		8	
PAS10-G016	Atlantic Pipeline Corp.	Stormwater			05/28/93	Wallace and	PA	Chester	Brandywine		5.62	
						West Nanthmeal						
PAR10-G031	Fieldpoint Inc.	Stormwater			06/08/93	Birmingham	PA	Chester			20	
PAS10-G022	Benjamin Brubacher	Stormwater			06/10/93	W. Brandywine	PA	Chester	East Branch		51	
PAS10-G023	Icedale Assoc. Inc.	Stormwater			06/21/93	W. Brandywine	PA	Chester	West Branch		22	
PAS10-G025	Brandywine Knoll, L.P.	Stormwater			06/21/93	West Goshen	PA	Chester	Broad Run		49	
PAR10-G035	Ashbridge Construction Inc.	Stormwater			06/29/93	West Chester	PA	Chester	Taylor Run		8.5	
PAR10-G037	First Falcon Corporation	Stormwater			07/14/93	East Bradford	PA	Chester	Plum Run		21.5	
PAR10-G038	PA Dept. of Transportation	Stormwater			07/07/93	East Bradford	PA	Chester	Valley		19.1	
						+ W. Whiteland						
PAS10-G030	PA Dept. Of Transportation	Stormwater			07/08/93	East and West	PA	Chester	Valley		114	
						Whiteland						
PAS10-G031	J. Richard Vishneski	Stormwater			07/13/93	West Bradford	PA	Chester	East Branch		18	
PAS10-G035	Chester County Water Resource	Stormwater			07/16/93	West Caln	PA	Chester	Birch Run		30	
PAS10-G03	Lewis and Judith R. Larson	Stormwater			07/21/93	E. Fallowfield	PA	Chester	Denis run		10	
PAR10-G043	D&F Projects Inc.	Stormwater			08/04/93	HoneyBrook	PA	Chester	East Branch White Clay		25.2	
PAS10-G045	Fox Knoll Partnership	Stormwater			08/03/93	W. Goshen	PA	Chester	Broad Run		39.9	
PAS10-G049	First Strafford Corp.	Stormwater			08/13/93	Uwchlan	PA	Chester	East Branch		51.9	
PAS10-G050	Four Rams Inc.	Stormwater			08/16/93	W. Brandywine	PA	Chester	East Branch		7.91	
PAR10-G044	J. Richard Vishneski, Inc.	Stormwater			08/11/93	E. Bradford	PA	Chester	Taylor Run		62.9	
PAR10-G045	Mrs. Susan Harney	Stormwater			08/12/93	E. Bradford	PA	Chester	Taylor Run		51	
PAS10-G053	Wm. F. and Diane H. Hammill	Stormwater			08/23/93	Wallace	PA	Chester	Marsh		54.5	
PAR10-G058	Beacon Hill Development Co.	Stormwater			09/23/93	Valley	PA	Chester	Rock Run		34.5	
PAR10-G059	Becker Excavating, Inc.	Stormwater			09/24/93	Birmingham	PA	Chester	Brandywine			
PAS10-G059	David Albert	Stormwater			09/24/93	West Caln	PA	Chester	West Branch		44.36	
PAR10-G060	Willian E. Freas	Stormwater			10/13/93	Newlin	PA	Chester	West Branch		19.83	
PAS10-G063	Doutrich Homes, Inc.	Stormwater			10/18/93	W. Brandywine	PA	Chester	East and West Branch		20	
PAS10-G064	Stephen E Cushman	Stormwater			10/19/93	E. Brandywine	PA	Chester	East Branch		23.7	
PAR10-G061	Wayne Megill	Stormwater			10/18/93	Pennsbury	PA	Chester	Bennett's Run		20.5	
PAR10-G062	Sheridan Construction	Stormwater			10/18/93	West Goshen	PA	Chester	Taylor Run		38	
PAR10-G063	Windon Country Homes	Stormwater			10/21/93	E. Bradford	PA	Chester	Blackhorse Run		30	
PAR10-G067	Cordelia MacArthur	Stormwater			12/03/93	W. Bradford	PA	Chester	Untitled		15	
PAS10-G081	J. Richard Vishneski, Jr.	Stormwater			12/15/93	E. Bradford	PA	Chester	Taylor-East Branch		62.9	
PAR10-G069	Suntech Associates	Stormwater			12/17/93	Kennett	PA	Chester	Ring Run		10.5	
PAS10-G086	Stephen Cushman	Stormwater			12/29/93	West	PA	Chester	Beaver- East Branch		38.99	
PAR10-G072	United States Postal Service	Stormwater			12/28/93	East Caln	PA	Chester	Untitled		6.05	
PAS10-G091	Paul Graf	Stormwater			02/07/94	Wallace	PA	Chester	East Branch		8.5	
PAS10-G094	West Uwchalan Development Corp.	Stormwater			02/07/94	Uwchlan	PA	Chester	East Branch		141.6	
PAR10-G077	Birch Run Partnership	Stormwater			03/09/94	West Caln	PA	Chester	Trib. to West Branch		8	
PAR10-G079	Village Builders, Inc	Stormwater			03/17/94	West Bradford	PA	Chester	East Branch		16.9	
PAS10-G101	Dino P. Ruggieri	Stormwater			03/17/94	NewGarden	PA	Chester	Trib. to Red Clay		61	
PAS10-G102	Wm. H. Pusey and James Wagner	Stormwater			03/31/94	E. Brandywine	PA	Chester	Culbertson Run		13.49	

PAR10-G082	Uwchalan Development	Stormwater			04/07/94	Uwchlan	PA	Chester	East Branch		46.2	
PAR10-G084	Highview Development Co.	Stormwater			04/18/94	Valley	PA	Chester	Sucker Run-West Branch		11.37	
PAR10-G085	Rachel Mullin and Martha Ossman	Stormwater			04/20/94	E. Bradford	PA	Chester	Trib. to Plum Run		10	
PAS10-G109	M.D.&P.,Inc	Stormwater			05/02/94	HoneyBrook	PA	Chester	Tiib. to West Branch		23.3	
PAS10-G110	Southdown Properties Inc.	Stormwater			05/05/94	Upper	PA	Chester	East Branch		73.9	
PAR10-G091	Preferred Homes, Inc	Stormwater			05/13/94	W. Bradford	PA	Chester	East Branch		33	
PAR10-G092	Bruce Development Group, Inc.	Stormwater			06/06/94	W. Bradford	PA	Chester	East Branch		7	
PAR10-G093	The Hankin Group	Stormwater			06/03/94	W. Whitelan	PA	Chester	East Branch		17.82	
PAR10-G096	Green Hill Farms, Inc	Stormwater			06/09/94	W. Goshen	PA	Chester	Taylor run-East Branch		5.99	
PAR10-G097	Ram Land Development Corp.	Stormwater			06/15/94	E. Bradford	PA	Chester	West Branch		24.56	
PAS10-G137	Fred Schubert	Stormwater			10/24/94	W. Vincent	PA	Chester	East Branch		14.5	
PAS10-G120	Residential Dev. Corp.	Stormwater			06/16/94	Honeybrook	PA	Chester	Trib. to West Branch		45.58	
PAR10-G101	AMS Enterprises, Inc.	Stormwater			06/24/94	Caln	PA	Chester	Trib. to Beaver Creek		14.98	
PAR10-G103	Oscar Lasko	Stormwater			07/14/94	West Goshen	PA	Chester	Taylor Run		10.8	
PAS10-G128	Vernon MacIntyre	Stormwater			09/01/94	HoneyBrook	PA	Chester	West Branch		10	
PAR10-G109	Saw Mill Ventures	Stormwater			09/12/94	E. Fallowfield	PA	Chester	Trib. to West Branch		50	
PAS10-G136	Hough/Loew Associates, Inc	Stormwater			10/24/94	East Caln	PA	Chester	Untitled		60	
PAR10-G114	Bruce Development Group, Inc.	Stormwater			11/01/94	W. Bradford	PA	Chester	West Branch		5	
PAR10-G115	Edwin and Linda Abbott	Stormwater			11/03/94	Birmingham	PA	Chester	Untitled		6.3	
PAR10-G117	D.Kirk and Sandre Harman	Stormwater			11/21/94	Pocopson	PA	Chester	West Branch		5.5	
PAS10-G141	Joseph Piccone, Inc.	Stormwater			11/14/94	Upper Uwchlan	PA	Chester	Untitled		7.5	
PAR10-G119	Construction and Design Services	Stormwater			12/06/94	Parkesburg	PA	Chester	Trib. to Buck Run		43	
PAR10-G121	Ted Moser	Stormwater			12/29/94	West Goshen	PA	Chester	Taylor Run		22.65	
PAR10-G123	Roselund W. Jones	Stormwater			01/03/95	E. Bradford	PA	Chester	Taylor Run		9.3	
PAR10-G124	LHC Realty Corporation	Stormwater			01/03/95	West Bradford	PA	Chester	East Branch		24.1	
PAS10-G149	Merle Z. Eberly	Stormwater			01/19/95	W. Nantmeal	PA	Chester	East Branch		34.23	
PAR10-G002	The Wilkinson Group	Stormwater			04/17/93	London Grove	PA	Chester	East Branch W.C.C.		122.3	
PAR10-G003	Dawnwood Association	Stormwater			04/21/93	Franklin	PA	Chester	West Branch W.C.C.		91.2	
PAR10-G006	Greenpoint Farms Inc.	Stormwater			04/27/93	Penn Township	PA	Chester	Middle Branch		40	
PAR10-G022	Somerset Lakes Associates	Stormwater			05/19/93	New Garden	PA	Chester	Broad Run		103	
PAR10-G026	Wilkenson Group	Stormwater			05/25/93	London Grove	PA	Chester	East Branch W. C.C.		66.69	
PAR10-G043	Baytown, Inc.	Stormwater			07/29/93	London Grove	PA	Chester	East Branch W. C.C.		40	
PAR10-G048	Southeastern Chester Co. Refuse	Stormwater			08/19/93	London Grove	PA	Chester	White Clay		12.5	
PAR10-G050	Broad Run Valley, Inc.	Stormwater			08/27/93	New Garden	PA	Chester	Broad Run		30.53	
PAR10-G056	Old Baltimore Pike Association	Stormwater			09/17/93	Penn Township	PA	Chester	Untitled		17.7	
PAS10-G065	Campbell Development Corp	Stormwater			10/19/93	London Grove	PA	Chester	East Branch		25.04	
PAR10-G064	Wilkinson Merestone, Inc.	Stormwater			11/08/93	New Garden	PA	Chester	Broad Run		41.5	
PAS10-G072	Nancy Truit	Stormwater			11/12/93	London Grove	PA	Chester	East Branch		2.2	
PAS10-G073	Nolen Companies	Stormwater			11/12/93	West Goshen	PA	Chester	Broad Run		30	
PAR10-G065	John and Anne Leo	Stormwater			11/18/93	New Garden	PA	Chester	Trout Run		31.6	
PAR10-G070	KARS, Ltd.	Stormwater			12/28/93	New Garden	PA	Chester	Clay White Branch		6	
PAR10-G078	Clyde and Roseann Johnson	Stormwater			03/11/94	London Grove	PA	Chester	Trib. to East Branch W.C.C.		9.3	
PAR10-G080	Country Walk, Ltd.	Stormwater			03/18/94	London	PA	Chester	Middle and East Branch		48.9	
PAR10-G081	New Century Builders, Inc.	Stormwater			04/11/94	New London	PA	Chester	Middle Branch		16	
PAR10-G090	Robert Landis	Stormwater			05/11/94	New London	PA	Chester	White Clay		19.66	
PAS10-G111	Beneficial National Bank	Stormwater			05/09/94	New Garden	PA	Chester	Trib. to White Clay		43.7	
PAS10-G124	John Rouse	Stormwater			07/07/94	London Grove	PA	Chester	East Branch		267	
PAR10-G105	Old Oak Development Corp.	Stormwater			08/10/94	London Grove	PA	Chester	East Branch		22.6	
PAR10-G107	Robert and Susan Rzucidlo	Stormwater			08/16/94	New Garden	PA	Chester	Broad Run		11.3	
PAR10-G111	Avon Grove School District	Stormwater			09/22/94	London Grove	PA	Chester	East Branch		11.35	
PAS10-G001	1492 Golf Management Inc.	Stormwater			04/23/93	New Garden	PA	Chester	Bucktoe		200	
PAR10-G032	Bancroft Woods	Stormwater			06/15/93	New Garden	PA	Chester	Trib to West Branch R.C.C.		23	
PAR10-G028	Robert Bruce Balbirnie	Stormwater			05/28/93	E. Marlborough	PA	Chester	Trib to West Branch R.C.C.		7.2	
PAR10-G046	The harlan Corp.	Stormwater			08/16/93	E. Marlborough	PA	Chester	West Branch R.C.C.		13	
PAR10-G051	Kennett, Inc.	Stormwater			08/27/93	Kennett	PA	Chester	East Branch R.C.C.		7	
PAR10-G052	CLX Realty Company	Stormwater			09/03/93	E. Marlborough	PA	Chester	West Branch R.C.C.		83.94	
PAR10-G055	PA Dept of Transportation	Stormwater			09/15/93	E. Marlborough	PA	Chester	East Branch R.C.C.		8.25	
PAR10-G057	Campbell Development Corp.	Stormwater			09/24/93	Kennett	PA	Chester	East Branch R.C.C.		15.5	
PAR10-G066	John J Ciccarone	Stormwater			12/02/93	Kennett	PA	Chester	West Branch R.C.C.		10.1	
PAR10-G074	Willow Greene Joint Venture	Stormwater			02/10/94	E. Marlborough	PA	Chester	East Branch R.C.C.		20	
PAS10-G101	Dino P. Ruggieri	Stormwater			03/17/94	New Garden	PA	Chester	Trib. to Red Clay		61	
PAR10-G095	ABS Development Co.	Stormwater			06/06/94	New Garden	PA	Chester	West Branch R.C.C.		17.5	
PAR10-G100	Longwood Gardens, Inc.	Stormwater			06/24/94	E. Marlborough	PA	Chester	Red Clay		14.3	

PAR10-G110	Bruce Properties, Inc.	Stormwater			09/19/94	Kennett	PA	Chester	East Branch R.C.C.		7.67	
PAR10-G113	Paul Waters	Stormwater			10/24/94	New Garden	PA	Chester	Bucktoe		12.75	
PAR10-G116	Thomas C.T. Brokaw	Stormwater			11/17/94	New Garden	PA	Chester	Bucktoe		19.75	
PAR10-G118	Hartefeld Limited Partnership	Stormwater			11/29/94	New Garden	PA	Chester	West Branch R.C.C.		5.56	

APPENDIX I

MAP 13 - TOTAL SUSPENDED SEDIMENT LOADS
MAP 14 - PERCENT IMPERVIOUS AREA FOR SUBWATERSHEDS

TABLE 3
TOTAL SUSPENDED SOLID (TSS) LOADS
CHRISTINA RIVER BASIN

Station ID	Subwatershed	P Annual Precip. (in.)	F Conv. Factor (0.226)	Single Family Residential A	R	C	X	Multi - Family Residential A	R	C	X	Sum of X	L Annual Pollutant Load (lb)	Drainage Area (ac)	Unit Pollutant Load (lb/ac/yr)
	Brandywine Creek Watershed														
B1	Upper West Branch at Honeybrook	41	0.226	[illegible]	0.30	140	[illegible]	[illegible]	0.65	180.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
B2	Upper West Branch at Hibernia	41	0.226	3,347	0.30	140	140,584	121	0.65	180.00	14,159	796,700	7,382,836	16,656	443
B3	Lower West Branch at Coatesville	41	0.226	2,084	0.30	140	[illegible]	[illegible]	0.65	180.00	37,219	[illegible]	[illegible]	[illegible]	[illegible]
B4	Lower West Branch at Embreeville	41	0.226	797	0.30	140	33,478		0.65	180.00	0	622,696	5,769,903	10,938	528
B5	Buck Run	41	0.226	[illegible]	0.30	140	[illegible]	[illegible]	0.65	180.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
B6	Doe Run	41	0.226	402	0.30	140	16,893		0.65	180.00	0	1,093,896	10,134,572	14,445	703
B7	Broad Creek	41	0.226	[illegible]	0.30	140	[illegible]	[illegible]	0.65	180.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
B8	Upper East Branch at Struble Creek	41	0.226	2,981	0.30	140	125,202	89	0.65	180.00	10,445	1,080,398	[illegible]	21,140	473
B9	Upper East Branch at Downingtown	41	0.226	[illegible]	0.30	140	[illegible]	[illegible]	0.65	180.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
B10	Lower East Branch	41	0.226	3,179	0.30	140	133,518	331	0.65	180.00	38,725	666,508	6,175,866	13,395	461
B11	Marsh Creek	41	0.226	[illegible]	0.30	140	[illegible]	[illegible]	0.65	180.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
B12	Beaver Creek	41	0.226	2,654	0.30	140	111,485	293	0.65	180.00	34,233	659,955	6,115,145	11,578	528
B13	Valley Creek	41	0.226	[illegible]	0.30	140	[illegible]	[illegible]	0.65	180.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
B14	Main Stem above Chadds Ford	41	0.226	4,476	0.30	140	187,995	230	0.65	180.00	26,867	793,132	7,349,183	13,718	[illegible]
B15	Pocopson Creek	41	0.226	[illegible]	0.30	140	[illegible]	27	0.65	180.00	3,151	[illegible]	[illegible]	[illegible]	[illegible]
B16	Main Stem below Chadds Ford	41	0.226	3,281	0.30	140	137,801	101	0.65	180.00	11,835	630,716	5,844,315	16,594	345
B17	Main Stem through Wilmington	41	0.226	[illegible]	0.30	140	[illegible]	[illegible]	0.65	180.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
			Subtotal =	36,143				2,880					[illegible]	207,814	516
	Red Clay Creek Watershed														
R1	West Branch	41	0.226	[illegible]	0.30	140	[illegible]	[illegible]	0.65	180.00	[illegible]	[illegible]	[illegible]	[illegible]	610
R2	East Branch	41	0.226	1,227	0.30	140	51,554	25	0.65	180.00	2,947	375,770	3,477,264	[illegible]	546
R3	Burrows Run	41	0.226	[illegible]	0.30	140	[illegible]		0.65	180.00	0	[illegible]	[illegible]	[illegible]	[illegible]
R4	Main Stem above Woodale	41	0.226	3,097	0.30	140	130,074		0.65	180.00	0	271,557	2,516,248	7,968	316
R5	Main Stem below Woodale	41	0.226	[illegible]	0.30	140	[illegible]	[illegible]	0.65	180.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
			Subtotal =	9,454				160					17,299,228	34,624	500
	White Clay Creek Watershed														
W1	West Branch	41	0.226	[illegible]	0.30	140	[illegible]		0.65	180.00	0	[illegible]	[illegible]	[illegible]	[illegible]
W2	Middle Branch	41	0.226	1,664	0.30	140	69,872		0.65	180.00	0	628,040	5,819,499	10,157	573
W3	East Branch above Avondale	41	0.226	[illegible]	0.30	140	[illegible]		0.65	180.00	0	[illegible]	[illegible]	[illegible]	[illegible]
W4	East Branch below Avondale	41	0.226	1,943	0.30	140	81,620		0.65	180.00	0	465,870	4,316,756	9,171	[illegible]
W5	Mill Creek	41	0.226	[illegible]	0.30	140	[illegible]	[illegible]	0.65	180.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
W6	Pike Creek	41	0.226	2,365	0.30	140	99,319	320	0.65	180.00	37,416	220,640	2,045,317	4,250	[illegible]
W7	Muddy Run	41	0.226	[illegible]	0.30	140	[illegible]	1	0.65	180.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
W8	Main Stem above Newark	41	0.226	979	0.30	140	41,121	132	0.65	180.00	15,396	217,103	2,011,672	6,477	311
W9	Main Stem above Delaware Park	41	0.226	[illegible]	0.30	140	[illegible]	[illegible]	0.65	180.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
W10	Main Stem at Churchmans Marsh	41	0.226	465	0.30	140	19,527	94	0.65	180.00	11,020	301,580	2,794,437	3,526	792
			Subtotal =	15,866				1,365					38,310,974	68,840	558
	Christina River Watershed														
C1	East/West Branch above Coochs Bridge	41	0.226	[illegible]	0.30	140	[illegible]	[illegible]	0.65	180.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
C2	Muddy Run	41	0.226	1,072	0.30	140	45,034	147	0.65	180.00	17,235	251,928	2,334,348	5,543	421
C3	Belltown Run	41	0.226	[illegible]	0.30	140	[illegible]	[illegible]	0.65	180.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
C4	Little Mill Creek	41	0.226	2,175	0.30	140	91,368	688	0.65	180.00	80,542	417,108	3,864,931	[illegible]	[illegible]
C5	Main Stem above Smalleys Pond	41	0.226	[illegible]	0.30	140	[illegible]	[illegible]	0.65	180.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
C6	Main Stem Lower Tidal	41	0.226	2,147	0.30	140	90,158	975	0.65	180.00	114,132	1,406,548	13,033,070	14,048	928
			Subtotal =	12,323	0.30	140	517,499	3,119	0.65	180.00	364,950		34,297,716	49,930	687
				73,944				7,523						360,998	

L = (A)(P)(R)(C)(0.226)

Where:

L = Annual Pollutant Load (lb.)
A = Subwatershed Area (ac.)
P = Annual Precipitation (in.)
R = Runoff coefficient for existing land uses including:
- Openspace - Manufacturing
- Wooded A - Low, Medium, High Density Residential
- Commercial, Industrial, Office

C = Mean Pollutant Concentration (mg/l)
0.226=Conversion Factor

MAP 5 - LAND USE SUMMARY
CALCULATION OF PERCENT IMPERVIOUS AREA FOR WATERSHEDS
Christina Basin Water Quality Management Strategy
May 21, 1998

LAND USE (ACRES)

No.	Station ID	Stream Name	Street	Drainage Area (Acres)	Drainage Area (Sq. Mi.)	Single Family Residential	Multi-Family Residential	Office	Industrial	Transport/ Utility	Commercial	Institutional	Public/Private Open Space	Wooded	Agricultural	Mining	Water	Vacant
		Brandywine Creek Watershed																
1	B1	Upper West Branch at Honeybrook		11,820.80	18.47	102.21	29.65			82.56	89.62	57.99	4.81	2,103.26	8,015.19	28.30	22.84	313.51
2	B2	Upper West Branch at Hibernia		16,665.60	26.04	3,347.24	121.02		10.83	253.16	55.88	71.04	181.43	7,069.85	5,738.74		189.05	187.35
3	B3	Lower West Branch at Coatesville		11,289.60	17.64	2,084.18	218.96		488.36	412.05	151.39	117.17	70.35	4,097.38	3,199.80	66.08	53.75	226.93
4	B4	Lower West Branch at Embreeville		10,937.60	17.09	797.11				166.78	8.98	121.99		3,866.45	5,683.63		131.46	165.31
5	B5	Buck Run		17,619.20	27.53	1,811.52	26.13			290.21	128.72	64.30	20.84	4,814.59	10,272.65	7.08	82.66	100.99
6	B6	Doe Run		14,444.80	22.57	402.18				169.56	34.09	14.68	6.82	2,483.85	11,239.20		45.54	71.33
7	B7	Broad Creek		4,121.60	6.44	1,159.44	47.66			108.76	19.34	19.31	16.30	1,125.45	1,534.79		5.21	48.48
8	B8	Upper East Branch at Struble Creek		21,145.60	33.04	2,981.61	89.27		88.47	188.14	37.53	24.08	110.87	7,764.09	9,325.19		356.90	222.79
9	B9	Upper East Branch at Shamona Creek		6,400.00	10.00	1,729.30	63.00		31.82	135.26	54.66	27.52	26.82	2,452.61	1,610.48		54.27	162.49
10	B10	Lower East Branch		13,395.20	20.93	3,179.00	330.98		291.58	244.94	306.31	107.80	318.12	4,941.21	3,365.48	33.57	126.07	207.07
11	B11	Marsh Creek		12,787.20	19.98	2,192.85	3.10		9.16	252.80	74.20	15.29	43.96	5,023.92	4,424.85	13.38	575.84	151.75
12	B12	Beaver Creek		11,577.60	18.09	2,654.41	292.59		41.88	200.10	340.95	163.90	246.97	3,462.65	3,748.02		23.62	301.14
13	B13	Valley Creek		18,216.00	28.46	3,348.54	420.61		187.04	600.22	455.68	124.26	263.99	4,407.00	3,506.35	234.14	56.73	407.35
14	B14	Main Stem above Chadds Ford		15,718.40	24.56	4,476.06	229.63		9.30	221.23	165.04	165.40	279.99	4,598.48	5,024.21		149.51	315.12
15	B15	Pocopson Creek		5,849.60	9.14	1,470.08	20.93			12.96	5.45	51.25	60.73	1,290.21	2,848.14		16.32	38.73
16	B16	Main Stem below Chadds Ford		16,934.40	26.46	3,280.97	101.36	46.77	21.07	155.29	733.33	243.58	3,487.73	5,788.60	2,939.19		189.64	22.44
17	B17	Main Stem through Wilmington		3,878.40	6.06	221.10	777.50	111.89	747.89	303.84	270.18	241.10	504.38	537.56	60.50		98.34	
			Subtotal =	207,814.40	324.71	36,140.98	2,879.51	158.66	1,867.30	3,850.76	2,933.54	1,697.61	5,685.06	66,072.23	81,481.17	389.54	2,188.67	3,021.38
		Red Clay Creek Watershed																
18	R1	West Branch		11,180.80	17.47	1,547.00	38.35		130.80	55.00	131.20	114.20	29.19	2,389.00	6,540.00		45.93	164.60
19	R2	East Branch		6,374.40	9.96	1,237.00	24.50			36.76	148.90	37.68	264.50	1,428.00	3,818.00	16.11	25.18	128.00
20	R3	Burris Run		4,550.40	7.11	1,216.00				16.80	5.51		87.20	1,141.00	1,934.00		7.29	144.20
21	R4	Main Stem above Woodside		7,968.00	12.45	2,097.00		13.13	25.74	52.73	32.01	87.56	498.10	2,793.00	1,169.00		265.80	
22	R5	Main Stem below Woodside		4,550.40	7.11	2,319.00	96.70	30.81	20.69	171.06	350.62	157.54	515.79	584.80	55.58		47.02	
			Subtotal =	34,624.00	54.10	9,586.00	159.55	43.94	177.23	339.94	667.60	381.98	1,534.58	8,335.80	12,716.58	16.11	391.38	435.70
		White Clay Creek Watershed																
23	W1	West Branch		6,515.20	10.18	1,148.18				86.47	28.36	38.68	6.19	1,767.34	3,377.05		5.07	132.72
24	W2	Middle Branch		10,156.80	15.87	1,663.61				94.68	51.42	4.65	7.03	2,523.23	5,672.91		57.71	82.38
25	W3	East Branch above Avondale		11,993.60	18.74	764.38			5.93	242.63	159.10	23.30	103.96	2,683.36	7,879.47		40.81	115.82
26	W4	East Branch below Avondale		9,171.20	14.33	1,943.33			60.00	10.67	70.13	40.30	53.64	2,978.83	3,835.84	2.80	102.67	110.01
27	W5	Mill Creek		8,298.80	12.97	4,089.55	300.96	92.47		256.04	364.64	305.17	846.90	973.75	999.84		6.10	
28	W6	Pike Creek		4,249.60	6.64	2,264.73	319.79			101.75	67.24	103.41	288.78	548.76	358.04			
29	W7	Middle Run		2,489.60	3.89	313.15	0.71	3.14		56.60	11.98	84.54	87.29	1,049.06	738.44			
30	W8	Main Stem above Newark		6,476.80	10.12	979.07	131.59	100.28	8.00	37.64	10.63	78.17	305.94	3,508.93	1,272.62		49.22	
31	W9	Main Stem above Delaware Park		5,792.00	9.05	1,938.46	438.55	70.85	139.55	426.99	628.02	376.55	547.86	693.24	378.81		51.58	
32	W10	Main Stem at Churchmans Marsh		3,526.40	5.51	464.92	94.19	193.02	13.34	390.05	653.47	206.62	571.39	461.32	148.95		328.91	
			Subtotal =	68,640.00	107.25	15,866.35	1,264.80	469.66	159.55	1,703.31	2,025.47	1,206.43	2,954.76	17,001.01	24,658.96	2.80	643.54	441.14
		Christina River Watershed																
33	C1	East/West Branch above Coochs Bridge		13,478.40	21.06	3,865.50	310.00	23.95	436.41	675.54	645.74	152.96	888.79	2,772.58	3,780.35		21.72	
34	C2	Muddy Run		5,542.40	8.66	1,072.23	147.14		91.47	206.99	106.19	69.31	388.44	2,127.78	855.98		61.40	217.09
35	C3	Belltown Run		4,115.20	6.43	1,208.53	301.30			137.59	222.45	21.70	530.83	1,498.37	380.95		24.72	
36	C4	Little Mill Creek		5,907.20	9.23	2,173.44	688.39	203.93	309.18	277.15	351.09	282.30	694.62	843.03	49.29		35.63	
37	C5	Main Stem above Smalley's Pond		6,828.80	10.67	1,912.56	594.82	76.31		415.33	301.53	60.92	477.16	1,847.53	707.01		37.16	321.97
38	C6	Main Stem Lower Tidal		14,048.00	21.95	2,146.65	973.49		1,191.18	2,272.43	1,487.56	250.63	2,821.25	1,759.18	253.12		371.32	
			Subtotal =	49,920.00	78.00	12,321.40	3,115.23	304.19	2,028.24	3,984.62	3,314.76	836.92	5,801.09	10,798.66	5,995.80	0.00	551.95	539.06
			Totals =	360,998.40	564.06	73,944.43	7,523.13	967.45	4,232.33	9,858.61	9,161.62	4,173.14	15,817.49	102,165.09	124,853.51	408.45	3,977.35	4,437.28

PERCENT IMPERVIOUS

No.	Station ID	Single Family Residential	Multi-Family Residential	Office	Industrial	Transport/ Utility	Commercial	Institutional	Public/Private Open Space	Wooded	Agricultural	Mining	Water	Vacant	% Impervious
1	B1	30	65	60	72	90	85	55	0	0	0	60	100	0	3.96
2	B2	30	65	60	72	90	85	55	0	0	0	60	100	0	9.57
3	B3	30	65	60	72	90	85	55	0	0	0	60	100	0	10.45
4	B4	30	65	60	72	90	85	55	0	0	0	60	100	0	5.44
5	B5	30	65	60	72	90	85	55	0	0	0	60	100	0	5.82
6	B6	30	65	60	72	90	85	55	0	0	0	60	100	0	2.46
7	B7	30	65	60	72	90	85	55	0	0	0	60	100	0	12.12
8	B8	30	65	60	72	90	85	55	0	0	0	60	100	0	7.36
9	B9	30	65	60	72	90	85	55	0	0	0	60	100	0	13.82
10	B10	30	65	60	72	90	85	55	0	0	0	60	100	0	16.09
11	B11	30	65	60	72	90	85	55	0	0	0	60	100	0	12.54
12	B12	30	65	60	72	90	85	55	0	0	0	60	100	0	14.09
13	B13	30	65	60	72	90	85	55	0	0	0	60	100	0	20.23
14	B14	30	65	60	72	90	85	55	0	0	0	60	100	0	13.22
15	B15	30	65	60	72	90	85	55	0	0	0	60	100	0	6.98
16	B16	30	65	60	72	90	85	55	0	0	0	60	100	0	12.87
17	B17	30	65	60	72	90	85	55	0	0	0	60	100	0	40.28
Subtotal		30	65	60	72	90	85	55	0	0	0	60	100	0	13.14
18	R1	30	65	60	72	90	85	55	0	0	0	60	100	0	7.03
19	R2	30	65	60	72	90	85	55	0	0	0	60	100	0	9.62
20	R3	30	65	60	72	90	85	55	0	0	0	60	100	0	6.61
21	R4	30	65	60	72	90	85	55	0	0	0	60	100	0	16.26
22	R5	30	65	60	72	90	85	55	0	0	0	60	100	0	31.59
Subtotal		30	65	60	72	90	85	55	0	0	0	60	100	0	16.81
23	W1	30	65	60	72	90	85	55	0	0	0	60	100	0	7.21
24	W2	30	65	60	72	90	85	55	0	0	0	60	100	0	6.78
25	W3	30	65	60	72	90	85	55	0	0	0	60	100	0	6.29
26	W4	30	65	60	72	90	85	55	0	0	0	60	100	0	8.06
27	W5	30	65	60	72	90	85	55	0	0	0	60	100	0	27.56
28	W6	30	65	60	72	90	85	55	0	0	0	60	100	0	28.42
29	W7	30	65	60	72	90	85	55	0	0	0	60	100	0	9.54
30	W8	30	65	60	72	90	85	55	0	0	0	60	100	0	8.96
31	W9	30	65	60	72	90	85	55	0	0	0	60	100	0	38.24
32	W10	30	65	60	72	90	85	55	0	0	0	60	100	0	47.62
Subtotal		30	65	60	72	90	85	55	0	0	0	60	100	0	18.64
33	C1	30	65	60	72	90	85	55	0	0	0	60	100	0	21.61
34	C2	30	65	60	72	90	85	55	0	0	0	60	100	0	15.50
35	C3	30	65	60	72	90	85	55	0	0	0	60	100	0	23.89
36	C4	30	65	60	72	90	85	55	0	0	0	60	100	0	30.97
37	C5	30	65	60	72	90	85	55	0	0	0	60	100	0	29.99
38	C6	30	65	60	72	90	85	55	0	0	0	60	100	0	43.81
Subtotal		30	65	60	72	90	85	55	0	0	0	60	100	0	28.63