CONTAMINANT SOURCES

A contaminant source is a site that has released or has the potential to release toxics to the air, soil, groundwater, surface water, or sediment. Contaminant sources may include, but are not limited to, small businesses (such as dry cleaners and gas stations), large businesses (such as factories and refineries), landfills, farms, abandoned industrial sites, military facilities, mines, and septic systems.

Underground Storage Tanks, Landfills, Hazardous Wastes

Known and Potential Contaminants: General Classes

Known and potential contaminant sources are regulated and/or monitored by eight different groups within DNREC. The sections that follow describe the mission, regulated community, positive initiatives, information collected, and contact information for each group. The sources section that immediately follows includes a table listing the known and potential contaminant sources regulated by the group under discussion. Although the format of each table varies, each table includes the facility or site name, the map identification number, the general classes of known and/or potential contaminants present at the facility, and the media affected. The general classes of contaminants used for each table may include the following:

- *Solvents:* Include organic chemicals such as degreasers, paint thinners, alcohols, and certain chemical feedstocks. Many of these chemicals are carcinogenic or poisonous to humans and/or other organisms.
- *Metals:* Include lead, zinc, arsenic, and iron. Some metals are carcinogenic or poisonous to humans and/or other organisms. In high quantities, metals such as iron and manganese can make water unsuitable for drinking due to taste and staining, even though they might not cause specific health problems.
- *Petroleum:* Includes gasoline, fuel oil, jet fuel, kerosene, diesel fuel, and waste oil. Certain compounds contained within each product, such as benzene, are carcinogenic or poisonous to humans and/or other organisms. Petroleum vapors pose a serious explosive threat to buildings and utilities.
- *Pesticides/Herbicides:* Include compounds that are carcinogenic and/or poisonous to humans or other organisms. Many also have the potential to be biologically concentrated in the higher part of the food chain.
- *Polychlorinated Biphenols (PCBs):* This class of organic compounds formerly was used in electrical transformers and switches. These compounds are generally insoluble and break down slowly, if at all, under normal environmental conditions. They tend to accumulate in stream sediments where they can be directly or indirectly ingested by fish. Many polychlorinated biphenols are carcinogens.
- *Other:* Includes sulfate, chloride, nitrate, and ammonia. In high quantities, any of these contaminants can make water unsuitable for drinking for either health or aesthetic reasons. They can also have significant effects on freshwater and marine life. Some or all of these contaminants typically occur in landfill leachate.

Each source listed on the tables is also plotted on Map 4 and designated by its map identification number.

Any substance can be considered a contaminant in the proper context. Other contaminants discussed in this section include bacteria, nutrients (such as phosphorus and nitrogen), and sediment. These contaminants are typically related to land-use activities such as construction, agriculture, or forestry. Note that air contaminants are not discussed in this section. They are discussed in detail in the Air section.

Contaminant Sources

Underground Storage Tanks/Systems. An underground storage tank can be defined as any tank or a combination of tanks with associated piping used to contain regulated substances, the volume of which is 10% or more beneath the ground surface. An underground storage tank system includes all tanks, piping, and ancillary equipment (i.e., dispensers) and their containment system, if any.

Underground storage tanks and systems typically contain petroleum compounds including gasoline, diesel, kerosene, jet fuel, waste oil, and fuel oils. Tanks may also contain a wide range of hazardous substances.

Statewide, there are 3,013 registered underground storage tank facilities with a total of 9,662 registered tanks. Of this number, there are 1,265 active facilities, with 3,375 tanks in use. Of the tanks in use, 1,752 are located at 707 facilities in New Castle County, many of which located in the Piedmont Basin. Map 4 shows only the location of tank sites with a known release to groundwater. The map does not show the location of all tank facilities in use or tank facilities that have had a minimal release or have completed a cleanup. Any facility with underground storage tanks has release potential. The largest concentration of leaking underground storage tank sites is in the Christina watershed.

Tables 53 – 55 detail the sites regulated by the Underground Storage Tank Branch that have released petroleum compounds to groundwater in the Piedmont Basin. These tank facilities are also represented on Map 4. The sites are further broken down on the basis of impact severity with a numerical designation from 3 to 5, with 3 designating an

on-site dissolved-phase impact, 4 an on-site free-phase impact, and 5 an off-site impact. It is important to note that the table represents the condition of the sites at the time the table was compiled. The site status will change as remediation takes place.

From the compliance side's perspective, release prevention from operating tank facilities is the major emphasis. By December 1998, all bare-steel tank systems, a current total of 912 tanks, must be either closed, upgraded, or replaced.

Currently, 73% of the federally regulated tank population is in compliance with state leak-detection requirements. Ad-ditionally, the mandated financial responsibility regulations require that operating tank facilities carry insurance to clean up releases if they occur. In this time of rapid property transfers, the banking and real estate industries are driving the tank program. In response to this trend, the branch is educating these communities to assure regulatory compliance.

Landfills. Large quantities of solid waste are generated each year in the Piedmont Basin by households and offices; construction, demolition, and land-clearing activities; and by industry. Most of this waste has been or will be disposed of in excavations or diked areas called landfills. Because landfills concentrate large quantities of waste in a small area, they represent a significant threat to the surrounding environment if not properly managed. As rainwater percolates into a landfill, it leaches soluble material and decayed organic products from the waste. The resulting leachate typically contains large quantities of dissolved metals, salts, and organics. It may also contain hazardous chemicals if they were disposed of in the landfill. If the leachate seeps into groundwater it can make the water unsuitable for human use because of health risks and objectionable odors and taste. If the leachate is allowed to seep into streams, it can have serious consequences, poisoning stream life directly and depleting the oxygen dissolved in the stream water, limiting the kinds of animals that can live there. Besides leachate, landfills also generate methane and other organic gases as the organic matter in the waste decays. These gases are an environmental concern on the local scale because of odor problems and on the global scale because of their contribution to global warming.

Over time, the number of operating landfills in the Piedmont Basin has decreased, while the size of the average landfill has increased. Today, there are only two operating landfills in the basin: one municipal waste landfill and one construction- and demolition-debris industrial landfill. Together, these two facilities cover more than 400 acres, and they landfill over 700,000 tons of solid waste each year. Besides these operating landfills, there are closed or inactive landfills in the Piedmont Basin. These inactive sites are concentrated near the mouth of the Christina River in the Coastal Plain portion of the basin.

Landfills are regulated by DNREC's Solid Waste Management and Site Investigation and Restoration branches. Table 56 shows the Piedmont Basin landfills regulated by the Solid Waste Branch. All of these sites are shown on Map 4.

Hazardous Materials Management Facilities. Hazardous materials are chemical compounds that can cause serious health and environmental damage. Hazardous characteristics include toxicity, flammability, corrosivity, reactivity, radioactivity, etc. Hazardous materials can be both new (usable) and waste chemical compounds.

Hazardous Materials Management Facilities are businesses (small and large) that produce, store, use, and/or dispose of hazardous materials. These businesses can include food and fuel manufacturers, dry cleaners, and auto repair shops.

A waste can be any solid, liquid, or containerized gas that is no longer used and is either disposed of, recycled, or stored. A waste is hazardous if it exhibits the characteristics of ignitability, corrosivity, reactivity, or toxicity or is specifically listed within the *Delaware Regulations Governing Hazard-ous Waste, November 19, 1980, Revised, July 23, 1996.*

The contaminant sources map (Map 4) is intended to show the *general* distribution of hazardous waste generators and treatment, storage and disposal facilities. The map represents *approximate* locations only. One dot on the map may represent more than one facility (especially in industrial parks). As illustrated on the map, hazardous waste generators in the Piedmont Basin are concentrated in industrial parks, along Kirkwood Highway, and in the incorporated limits of the City of Wilmington. The Christina watershed and the tidal portion of the Brandywine Creek contain the greatest number of hazardous waste generators.

Table 57 presents a breakdown of generators by size and zip code in the Piedmont Basin. Conditionally exempt small-quantity generators are facilities that generate no more than 220 pounds of hazardous waste in any calendar month. Small-quantity generators produce more than 220 pounds, but less than 2,200 pounds of hazardous waste in any calendar month. Large-quantity generators generate more than 2,200 pounds of hazardous waste in any calendar month. As presented in the table, most of the hazardous waste generators in the Piedmont Basin are conditionally exempt and small-quantity generators.

The amount of hazardous waste produced is decreasing with time, due in part to DNREC's pollution prevention efforts. Many facilities continue to implement waste reduction opportunities that result not only in environmental benefits, but in economic savings as well.

Table 53

LEAKING UNDERGROUND STORAGE TANK SITES IN THE PIEDMONT BASIN

MAP ID #	SITE NAME	SITE LOCATION	GW ID #
L0009	AIR NATIONAL GUARD	NEW CASTLE	4
L0022	896 DELI (ANTHONY AUGUST)	2505 PULASKI HWY., NEWARK	4
L0026	ARCO CUMBERLAND FARMS	RTE. 4 & KIAMENSI RD., STANTON	3
L0028	ARCO FOULK & SILVERSIDE	WILMINGTON (SHELL)	4
L0029	ARCO GLASGOW 896 & 40 (SHELL)	GLASGOW	5
L0032	ARCO LANCASTER & FORD	2711 LANCASTER AVE, WILMINGTON	4
L0038	AVON NEWARK	2100 OGLETOWN RD., NEWARK	4
L0056	CHEVRON GULF GLASGOW 896	2394 PULASKI HWY., GLASGOW	3
L0060	CHRYSLER MOPAR DIVISION		3
L0061	CHRYSLER ASSEMBLY PLANT		3
L0072	DOT - OGLETOWN	NEWARK	3
L0088	DIAMOND FUEL OIL – AST SPILL	HEALD & LOBDELL ST., WILMINGTON	4
L0103	DUPONT COUNTRY CLUB	ROCKLAND ROAD, WILMINGTON	4
L0106	DUPONT STINE/HASKELL	NEWARK	4
L0109	DUPONT TATNALL BUILDING	WILMINGTON	5
L0111	DUPONT GLASGOW	GLASGOW	4
L0119	EXXON RTE. 273 & CHAPMAN RD.	NEWARK	4
L0122	EXXON SERVICE CENTER 1-95		4
L0125	EXXON CASTLE MALL	NEWARK	5
L0127	EXXON FOULK & SILVERSIDE	WILMINGTON	5
L0132	EXXON OGLETOWN & HARMONY	NEWARK	4
L0134	EXXON ROSE HILL GARAGE	SEE AS N8711074	3
L0138	EXXON SECOND & UNION		3
L0153	SHELL GODWIN'S	804 S. COLLEGE AVE., NEWARK	5
L0155	GULF I-95 SERVICE CENTER		4
L0163	KAYO OIL CO., CONOCO, ELSMERE	1500 KIRKWOOD HWY., ELSMERE	4
L0169	KERSHAW CONSTRUCTION	473 OLD AIRPORT RD., NEW CASTLE	4
L0182	LAWN DOCTOR ABBOTT	CASTLE MALL, 995 S. CHAPEL	5
L0186	LYNAM'S MOBIL	1716 DELAWARE AVE., WILMINGTON	3
L0202	GULF HESSEY	235 E. DELAWARE AVE., NEWARK	3
L0205	NVF CORPORATION	NEWARK	3
L0217	PENCADER PRESBYTERIAN	GLASGOW	3
L0242	SHELL OGLETOWN & MARROWS RD.	NEWARK	5
L0244	SHELL OIL COMPANY CLAYMONT	PHILA. PIKE & SEMINOLE AVE., CLAYMONT	4
L0245	SHELL OIL COMPANY KIRKWOOD & 7	WILMINGTON	4
L0247	SHELLHORN & HILL GULF		3
L0258	SUNOCO CONCORD PIKE, TALLEYVILLE	TALLEYVILLE, 3930 CONCORD PIKE	4

Table 54

LEAKING UNDERGROUND STORAGE TANK SITES IN THE PIEDMONT BASIN — CONT'D.

MAP ID #	SITE NAME	SITE LOCATION	GW ID #
L0259	SUNOCO CONCORD PIKE FAIRFAX	2401 CONCORD PIKE, FAIRFAX	4
L0266	TEXACO CLAYMONT	NAAMANS CREEK. & DEL. R., CLAYMONT	4
L0271	TEXACO PIKE CREEK (AULT COURT)	AULT CT., LINDEN HEATH, WILMINGTON	4
L0272	THREE J'S TIRE INC., EAST		3
L0298	SUNOCO ELKTON ROAD	287 ELKTON RD., NEWARK	4
L0300	SUNOLIN CHEMICAL COMPANY	P.O. BOX F, CLAYMONT	3
L0307	RON'S DISCOUNT ENERGY MART	PHILADELPHIA PIKE, CLAYMONT	5
L0321	MOTOR LODGE GULF (896)	1107 S. COLLEGE AVE., NEWARK	3
L0350	DELCASTLE VOTECH	W1LMINGTON	4
L0357	CHRYSLER CORP.-ASSEMBLY PLANT	NEWARK ASSEMBLY PLANT, NEWARK	3
L0377	MOBIL (OGLETOWN)	4029 OGLETOWN RD, NEWARK, DE	4
L0379	CHRYSLER ASSEMBLY PLANT	P.O. BOX 6040, NEWARK	3
L0396	PENNYHILL GULF (NOW BP)	WILMINGTON	5
L0407	MOBIL SERVICE CENTER	1106 S. COLLEGE AVENUE, NEWARK	4
L0411	LOUVIERS COUNTRY CLUB	NEWARK	4
L0433	CHRYSLER ASSEMBLY PLANT	550 S. COLLEGE, NEWARK	3
L0471	D AND J AUTO SERVICE	WILMINGTON	3
L0475	MERIT OIL STATION	506 DUPONT HWY., NEW CASTLE	4
L0495	DIAMOND STATE TELEPHONE	LEA BLVD.,WILMINGTON	3
L0505	CIBA-GEIGY CORP. NEWPORT	REFER TO SUPERFUND	3
L0523	SOUTHWOOD FARMS	HOCKESSIN	3
L0578	AIRCO INDUSTRIAL GASES, INC.	CLAYMONT	4
L0595	GULF-LAWRENCES HOCKESSIN	41 & YORKLYN RD., HOCKESSIN	4
L0B30	CONOCO-1701 PENNSYLVANIA AVE.	WlLMINGTON	3
L0656	EXXON LOVERING AVENUE	1705 LOVERING AVE., WILMINGTON	4
L0676	LOUVIERS MAINT. YARD	SEE N9109200	4
L0678	7-11 STORE 1126-23128, MEM. DR.	RTE. 13 & MEM. DR., NEW CASTLE	4
L0690	GULF 1700 MARSH RD.	1700 MARSH ROAD, WILMINGTON	4
L0695	AIR NATIONAL GUARD, 2701 GWAP	NEW CASTLE CO. AIRPORT	3
L0718	KIRKWOOD MOTORS, INC.	4800 KIRKWOOD HWY., WILMINGTON	4
L0784	GULF CHRISTIANA GATEWAY	LOBDELL & HEALD ST., WILMINGTON	4
L0841	JAMES JULIAN, HEALD STREET	1100 S. HEALD ST.,WILMINGTON	3
L0876	B AND M AUTO	525 S. MARKET ST., WlLMINGTON	3
L0885	BARONE'S MOB1L (GETTY #08643)	2801 CONCORD PIKE, WILMINGTON	3
L0930	7–11 1126-22003, CHRISTIANA RD.	284 CHRISTIANA RD., NEW CASTLE	5
L0934	DEL CAMPO BAKERY SERT INCIDENT	2006 RODMAN STREET, WILMINGTON	3
L1016	HODGSON VO-TECH	GLASGOW	3

Table 55

LEAKING UNDERGROUND STORAGE TANK SITES IN THE PIEDMONT BASIN — CONT'D.

MAP ID #	SITE NAME	SITE LOCATION	GW ID #
L1019	KIRKWOOD TEXACO – RICE'S TEX.	13625 KIRKWOOD HWY., WILMINGTON	13
L1125	TIPTON TRUCKING TANK REMOVALS	TOWNSEND & LOBDELL , WILMINGTON	4
L1127	DELAWARE AUTO SERVICE	1603 PENN. AVENUE, WILMINGTON	3
L1143	UNIV. OF DEL., WORRILOW HALL	UNIV. OF DEL., NEWARK	13
L1144	UPS, A STREET	700 A STREET, WILMINGTON	13
L1147	LINCOLN CAMERA SHOP	2001 DELAWARE AVE., WILMINGTON	13
L1163	W. CARL CULLEN, INC.	2034 SUNSET LAKE RD., NEWARK	l3
L1177	EXXON 820 S. COLLEGE, NEWARK	820 S. COLLEGE AVE.,NEWARK	3
L1225	AL'S AUTO SERVICE CENTER, INC.	4001 WASHINGTON ST., WILMINGTON	3
L1272	PANELTROL, INC.	9 N. COLONIAL AVE., ELSMERE	3
L1288	LOUIS DREYFUS ENERGY #3	TOWNSEND & LOBDELL, WILMINGTON	4
L1302	DE STATE POLICE, TROOP #1	603 PHILADELPHIA PIKE, WILMINGTON	5
L1311	UNIV. OF DEL., 55 W. MAIN STREET	55 W. MAIN ST., NEWARK	4
L1324	MARIO MEDORI	402 MECO DRIVE, WILMINGTON	3
L1358	HOLLINGSWORTH PROPERTY - COTTMA	3410 OLD CAPITAL TRAIL, WILMINGTON	4
L1452	TEXACO 505 N. DUPONT HWY., N.C.	505 N. DUPONT HWY., NEW CASTLE	4
L1455	GETTY PHIL. PIKE	PHIL. PIKE & DUPONT AVE.,WILMINGTON	4
L1587	SANDALWOOD APTS., #3	SANDALWOOD DRIVE, NEWARK	4
L1588	NORMAN E. WRIGHT TRUST	6515 GOV. PRINTZ BLVD., WILMINGTON	13
L1590	OAKTREE APARTMENTS	NEWARK DRIVE, NEWARK	3
L1597	PENSKE TRUCK LEASING	1600 MATASSINO DRIVE, NEW CASTLE	3
L1645	NVF COMPANY	YORKLYN	3
L1670	M/M ROBERT SMITH RESIDENCE	1411 OLD BALTIMORE PIKE, NEWARK	3
L1674	RYDER TRUCK RENTAL	6605 GOV. PRINTZ BLVD.,WILMINGTON	4
L1726	USA TRAINING ACADEMY	955 S. CHAPEL ST., NEWARK	4
L1727	MERIT GAS STATION	5801 KIRKWOOD HWY., WILMINGTON	3
L1774	LOUIS DREYFUS ENERGY #4	S. HEALD & LOBDELL ST., WILMINGTON	4
L1811	DELDOT	RTE. 7 & CHURCHMAN'S RD.	3
L1828	ROLLINS LEASING CORP.	51 BOULDEN BLVD., NEW CASTLE	4
L1891	LITTLE SISTERS OF THE POOR	185 SALEM CHURCH ROAD, NEWARK	3
L1903	BRANDYWINE MANAGEMENT	4TH & SPRUCE, WILMINGTON	5
L1978	INGLESIDE RETIREMENT APTS.	1005 N. FRANKLIN ST., WILMINGTON	4
L1983	WM. TAYLOR RESIDENCE	54 QUARTZ MILL RD., NEWARK	4
L2002	GENE'S GULF SERVICE	1001 WEST 4TH ST., WILMINGTON	4
L2018	AVIR CORP., SARDO WAREHOUSE	6TH ST., NEW CASTLE	3
L2020	COCA-COLA BOTTLING CO.	GRAY & 2ND, GREENHILL & 2ND, WILM.	3

All listed releases are petroleum related. Only sites with a groundwater impact are listed. Site status may change as corrective action is completed.

Table 58 lists facilities regulated by the Hazardous Waste Management Branch that are known to have contaminated the environment. All facilities regulated by this branch have the potential to release contaminants to the environment; however, most facilities manage their hazardous materials and potential pollutants in a responsible manner. "Potential to contaminate" *does not* mean that the facility has released or will release pollutants to the environment. "Potential" means that the facility uses or generates materials that could negatively impact human health and the environment.

The Toxics Release Inventory requires companies to report on listed chemicals manufactured, processed, or otherwise used above certain annual thresholds under the Emergency Planning and Community Right-to-Know Act. The following facilities in the Piedmont Basin submitted reports for 1994:

Allied Signal	General Chemical
Ametek Haveg Division	General Motors
Alloy Surfaces	Hercules Research Center
BOC Gases	Insteel Wire Products
Brandywine Compounding	Medal L.P.
Cabot Safety Corp.	Noramco of Delaware
Chrome Deposit	NVF Yorklyn
Chrysler	Pepsi-Cola Bottling
Ciba Geigy	Perma Flex Rollers
Citisteel	Rockland Technologies
Dupont Edgemoor	Rodel
Dupont Experimental Station	Roller Service
Dupont Holly Run	Speakman
FMC	Sun Refining and Marketing

Few of these facilities reported actual releases to land or water. The following facilities reported releases of over 100 pounds for the given chemical:

NVF Yorklyn	31,901 pounds of zinc to water
General Chemical	3,600 pounds of ammonia to water
DuPont Edgemoor	600 pounds of hydrochloric acid to water

The Hazardous Chemical Inventory requires all facilities that maintain material safety data sheets and have listed chemicals on-site above a certain quantity to report to DNREC. Information reported includes the maximum amount of the chemical on-site in the reporting year and its location on the site. A data base is maintained from approximately 1,200 reporting facilities each year and is used by local emergency planning committees.

Other. Besides the sources described above, there are a number of other potential and/or known contaminant sources in the Piedmont Basin that may be locally significant. These include the following:

- *Dredge Spoil Disposal Areas.* These areas contain sediment dredged from rivers and lakes. The dredged sediment, especially from industrial areas like the Port of Wilmington, are often contaminated with heavy metals, polychlorinated biphenyls, and/or semivolatile organic compounds. During dredging operations sediment is slurried into diked areas. Here, the sediment settles out and the clear water is allowed to drain back into the main water body. Contaminants from the dredge spoils can potentially

Table 56
SOLID WASTE MANAGEMENT BRANCH — PIEDMONT BASIN LANDFILLS
KNOWN/POTENTIAL CONTAMINANT SOURCES

MAP NO.	FACILITY	SOLVENTS	METALS	PETROLEUM	PEST./HERB.	PCBS	OTHER	DESCRIPTION
LF01	DuPont Cherry Island		P				P	Industrial Waste LF
LF02	DSWA NSWMC#2	P	P	P			P	MSWLF
LF03	DP&L Edgemoor		P				P	Coal Ash LF
LF04	DRPI		K				K	C&D/Industrial Waste LF
LF05	Booker, Booker & Ryan		P				P	Dry Waste LF–Closed
LF06	Taylor		P				P	Dry Waste LF–Closed
LF07	Timko		P				P	Dry Waste LF–Closed
LF08	Petrillo Bros		P				P	Dry Waste LF–Closed
RR01	Clean Earth			P				Pet. Contam. Soil Roaster
RR02	VFL		P				P	Sewage Sludge Recycler
RR03	Rolite		P				P	Ash Recycler

Abbreviations: K-Known contaminant source, P-Potential contaminant source (present on site), LF-Landfill, MSW-Municipal Solid Waste, C&D-Construction and Demolition Debris, Pest.-Pesticide, Herb.-Herbicide, PCBs-Polychlorinated Biphenols.

percolate into the groundwater below the disposal area, or they may travel back into the water body with the return water. The largest dredge spoil area in the Piedmont Basin is operated by the U.S. Army Corps of Engineers on Cherry Island at the mouth of the Christina River.

- *Salt Piles.* There is at least one large, uncovered road salt pile in the Piedmont Basin located on the west side of Interstate 495, just south of the Christina River. Rain has the potential to leach salt from the pile into groundwater. More investigation needs to be performed to determine if there are other uncovered salt piles in the basin.
- *Tire Piles.* There are 18 known piles of discarded tires in the Piedmont Basin ranging in size from fewer than 100 to over 75,000 tires. These piles are a concern because they are excellent breeding sites for mosquitoes and because they are a fire hazard. Tire pile fires are extremely hard to extinguish and they generate large quantities of noxious smoke. They also generate organic liquids as they burn that can contaminate groundwater. Most tire piles in the Piedmont Basin are located in the lower Christina River Valley and are listed in Table 59.
- *Auto Salvage Yards.* Salvage yards are a potential source of contamination from leaking fluids such

Table 57
NOTIFIED HAZARDOUS WASTE REGULATED FACILITIES IN THE PIEDMONT BASIN

ZIP CODE	AREA	NO. OF CONDITIONALLY EXEMPT SMALL QTY. GENERATORS OF HAZ. WASTE	NO. OF SMALL QTY. GENERATORS OF HAZ. WASTE	NO. OF LARGE QTY. GENERATORS OF HAZ. WASTE	NO. OF TREATMENT, STORAGE AND DISPOSAL FACILITIES OF HAZ. WASTE
19701	Bear	3	9	4	
19702	Newark	15	16	3	
19703	Claymont	7	12	2	
19707	Hockessin	3	2		
19711	Newark	16	48	8	
19713	Newark	21	23	4	
19714	Newark	3	4	1	
19715	Newark	1	1		
19716	Newark		1		
19720	New Castle	44	79	12	
19736	Yorklyn	1		2	
19801	Wilmington	14	23	4	
19802	Wilmington	9	22	3	
19803	Wilmington	9	14		1
19804	Newport	23	44	8	
19805	Wilmington	13	16	3	1
19806	Wilmington	3	10	2	
19807	Wilmington	1	2		
19808	Wilmington	15	32	3	
19809	Wilmington	4	7	2	1
19810	Wilmington	5	9		
19898	Wilmington	1	4	3	1
19899	Wilmington	3	7	2	
	Totals	**214**	**385**	**66**	**4**

as oil, grease, gasoline, antifreeze, and heavy metals such as lead from batteries. There are a number of large salvage yards in the lower Christina River Valley.

- *Resource Recovery Facilities.* There are three facilities in the Piedmont Basin that process contaminated waste (sewage sludge, coal ash, or petroleum-contaminated soil) into a usable product. Each of these facilities is a potential source of contaminants if the unprocessed waste material is not handled properly. These facilities are listed in Table 60.

Program Descriptions

Solid Waste Management Branch. DNREC's Solid Waste Management Branch is charged with assuring that landfills are built and operated in an environmentally responsible manner. This branch issues permits that require landfills to collect and treat the leachate and gas they may generate. Landfill facilities are also required to monitor groundwater and surface water for the presence of potential contaminants. Additionally, the Solid Waste Branch regulates recycling facilities, waste haulers, and infectious waste, and tracks tire piles.

In December 1994, Delaware adopted revised regulations governing solid waste. These new regulations, mandated by changes in federal solid waste regulations, increased the construction standards and monitoring requirements for landfills.

The Solid Waste Branch maintains a list of waste haulers and has compiled a recyclers' directory. Files are also maintained on the design, operation, and monitoring of all regulated facilities. Contact the branch at (302) 739-3820 for more information.

Underground Storage Tank Branch. The Underground Storage Tank Branch regulates petroleum and hazardous substance tanks through their entire life cycle. The branch derives its authority from Section 7, *Delaware Code,* Chapter 74, the Underground Storage Tank Act and Delaware's Regulations Governing Underground Storage Tank Systems. Two groups within this branch interface to assure complete regulatory compliance. The *underground* storage tank group monitors the compliance of in-use and out-of-service tanks and the installation of new tanks to prevent potential releases.

Table 58
HAZARDOUS WASTE MANAGEMENT BRANCH
KNOWN CONTAMINANT SOURCES — PIEDMONT BASIN FACILITIES

		CONTAMINANT CLASS						DATA AVAILABLE					
MAP NO.	FACILITY	SOLVENTS	METALS	PETROLEUM	PEST./HERB.	PCB	OTHER	AIR	SOIL	SEDIMENT	SURFACE WATER	GROUNDWATER	DESCRIPTION
	DuPont Chestnut Run	P	P	K			P		D,I				Research facility. Hazardous waste storage pad.
	DuPont Edgemoor	P	P				P						Titanium dioxide manufacturer.
	DuPont Experimental Station	K	K		K		K		D,I	D,I	D	D,I	Research facility. Hazardous waste incinerator.
	DuPont Glasgow	K		K			K		D,I	D	D	D,I	Research and manufacturing facility.
	General Chemical	K	K		K		K		D			D,I	Sulfuric acid manufacturer.
	Harper Thiel		K				P		D,I	D			Electroplater.
	Hercules Research Center	K	K		K	K	K		D,I	D	D	D,I	Research facility.
	Sun Company Marcus Hook Refinery	K		K								D,I	Petroleum refinery that straddles the PA/DE state line. PA DER has the lead for state oversight.

Abbreviations: K-Known Contaminant Source, P-Potential Contaminant Source (present on site), I-Media Impacted, D-Data Available

Table 59
USED TIRE PILES IN THE PIEDMONT BASIN

		CONTAMINANT CLASS						DATA AVAILABLE					
MAP NO.	FACILITY	SOLVENTS	METALS	PETROLEUM	PEST./HERB.	PCB	OTHER	AIR	SOIL	SEDIMENT	SURFACE WATER	GROUNDWATER	NUMBER OF TIRES
N01	Breitenbach's Auto Salvage			P			P						3,000
N02	Little Jimmy's Auto Salvage			P			P						3,00
N03	Joe Morgan's Auto Salvage			P			P						6,000
N04	Delaware Auto Salvage			P			P						50
N05	B and F Towing			P			P						3,000
N06	Skyline Auto Salvage			P			P						50
N07	Necastro Auto Parts			P			P						8,000
N08	Two Guys Auto Parts			P			P						30,000
N09	1-A-Used Auto Parts			P			P						5,000
N10	Don Wilson Auto Parts			P			P						10,000
N11	A.M. Domino Auto Salvage			P			P						15,000
N12	Caspers Auto Parts			P			P						75,000
N13	City of Wilmington			P			P						500
N14	Ed & Son Auto Salvage			P			P						35,000
N15	Earl Van Den Heuvel			P			P						1,500
N16	Eastern Auto Salvage			P			P						1,000
N17	Keith Harris			P			P						8,000
N25	Continental Auto Salvage			P			P						3,000

Abbreviations: K-Known Contaminant Source, P-Potential Contaminant Source (present on site), I-Media Impacted, D-Data Available

Table 60
RESOURCE RECOVERY FACILITIES IN THE PIEDMONT BASIN

		CONTAMINANT CLASS						DATA AVAILABLE					
MAP NO.	FACILITY	SOLVENTS	METALS	PETROLEUM	PEST./HERB.	PCB	OTHER	AIR	SOIL	SEDIMENT	SURFACE WATER	GROUNDWATER	DESCRIPTION
RR01	Clean Earth	P										D	Pet. Contam. Soil Roaster
RR02	VFL		P										Sewage Sludge Recycler
RR03	Rolite		P										Ash Recycler

Abbreviations: K-Known Contaminant Source, P-Potential Contaminant Source (present on site), I-Media Impacted, D-Data Available

The *leaking* underground storage tank group oversees the cleanup of known tank releases to minimize the threat to human health and the environment.

Many tank programs have been initiated to accommodate the regulated community. The Small Retail Gasoline Station Assistance Program offers low-interest loans for system upgrades to achieve regulatory compliance. The Contractor Certification Program was instituted to assure the proper installation, closure, and upgrade of tank systems. Technical publications are constantly reviewed to assure that the regulations and guidance documents keep pace with the changing environment. Educational opportunities are provided for consultants, contractors, site owners, and operators, along with the general public.

The Underground Storage Tank Branch maintains multiple data bases to track all aspects of the tank program. The branch's publication, *Think Tank*, reports on issues pertinent to the regulated community. Most records are available through the Freedom of Information Act. Branch representatives may be contacted at (302) 323-4588.

Hazardous Waste Management Branch. The Hazardous Waste Management Branch regulates a specific type of contaminant source — facilities that generate, treat, transport, store, or dispose of hazardous waste as defined by Section 7, *Delaware Code*, Chapter 63, and Delaware's Regulations Governing Hazardous Waste.

Within the Hazardous Waste Branch, two groups operate. The Compliance Monitoring and Development Group inspects facilities, tracks annual reports and manifests, develops the program and regulations, maintains the branch data base, and grants site closures. The Treatment, Storage, and Disposal Group issues permits and oversees corrective action at release sites.

The broad goal of the hazardous waste program is to protect human health and the environment by ensuring regulatory compliance, and thus, proper hazardous waste management. Historically, regulatory compliance was achieved through an inspection program of detecting violations and pursuing enforcement, including monetary penalties, as a means to correct violations and deter future ones. However, over the last several years the Hazardous Waste Management Branch has supplemented these seemingly negative activities with positive approaches to achieving regulatory compliance by providing educational opportunities for all hazardous waste generators.

Although it initially centered around hazardous waste regulatory compliance, the hazardous waste program continues to expand its educational focus. Through the cooperation of DNREC's Pollution Prevention Program, hazardous waste and pollution prevention staff conduct site visits to supply both regulatory and pollution prevention education. With the advent of multi-media, technical assistance is offered across many DNREC programs, thus advancing a more holistic approach to pollution prevention and regulatory compliance. The branch continues to view the educational approach as one that provides not only regulatory knowledge to achieve and maintain compliance, but one that also affords businesses the opportunity to reduce both solid and hazardous waste generation, which is not only a sound environmental practice, but a cost-effective one.

This branch has also devised a program targeting small business sectors, auto body shops, and dry cleaners for educationally based Hazardous Waste Compliance Assessments. In an effort to educate these businesses not only on hazardous waste issues, but the impacts of the Clean Air Act, the Hazardous Waste Management Branch works jointly with DNREC's Air Quality Management Section, to conduct educational workshops. The branch also conducts on-site assessments with the goal of educating these small businesses to the benefits of properly managing and disposing of their hazardous waste. The on-site assessments not only emphasize hazardous waste regulatory compliance, but multi-media compliance, liability issues, and pollution prevention techniques specific to the business sector.

In 1995, the branch expanded its educational goals to work with students entering the work force as automotive maintenance and repair professionals. As a result, hazardous waste regulatory classes are conducted throughout Delaware for students studying these professions in the state's vocational high schools. The students are given an excellent foundation in hazardous waste generation and management issues. This knowledge is invaluable whether the students start their own business or work for an established one.

Due to the success of educating high school students, the Hazardous Waste Branch has made the one-day hazardous waste regulatory class an annual event for seniors. The branch looks forward to conducting these classes each year and is expanding the program to include not only regulatory education, but pollution prevention education.

Another facet of the branch's educationally based program is Hazardous Waste Audits for new businesses that generate hazardous waste. The audits are courteous inspections that stress regulatory and liability concerns, pollution prevention techniques and technical assistance.

To assist hazardous waste generators in remaining up to date with frequent regulation revisions, the branch conducts annual workshops discussing proposed amendments to the *Delaware Regulations Governing Hazardous Waste*. The workshops provide all businesses with an avenue to learn the new and revised regulations, along with the opportunity to express their opinions and concerns.

For additional technical assistance, the branch has implemented the *Hazardous Waste Help Line* (302) 739-3689. The *Help Line* is staffed with a hazardous waste information expert that will work one-on-one to answer any questions businesses may have.

The results of the branch's non-threatening educational programs have been positive — an effect reflected in not only higher compliance rates, but also in the development of ongoing cooperation and trust between the branch and the business community. For the approximately 650 small and large businesses in the Piedmont Basin that manage hazardous waste, the ongoing educational programs, technical assistance, and compliance assessments performed by the Hazardous Waste Management Branch significantly lower the likelihood of hazardous waste being released to the environment. And that results in a cleaner and safer environment for Delaware.

The branch is also actively involved in investigating, evaluating risk, and cleaning up contamination at sites that have known releases of contaminants to the environment. The branch maintains a list of hazardous waste generators, transporters, and treatment, storage, and disposal facilities within the State of Delaware. Environmental sampling data are also available for sites where releases are known or suspected. The Hazardous Waste Management Branch contact is Nancy C. Marker at (302) 739-3689.

Site Investigation and Restoration Branch. The Site Investigation and Restoration Branch, formerly the Superfund Branch, identifies, investigates, and remediates sites that release or threaten to release hazardous substances into the environment. "Superfund" refers to the process established in 1980 by the Comprehensive Environmental Response, Compensation, and Liability Act to address the country's most serious hazardous substance release sites.

The federal Superfund Program established a National Priority List of the country's worst sites. Twenty-one were located in Delaware. See Tables 61 – 63. Realizing that nearly 300 Delaware sites would not be addressed by the federal program, the state legislature enacted the Hazardous Substance Cleanup Act or Section 7, *Delaware Code*, Chapter 91, in 1990.

In 1993, DNREC created the Voluntary Cleanup Program (VCP) to allow potentially responsible parties to come forward, identify releases, and voluntarily clean them up. The Site Investigation and Restoration Branch instituted the VCP to expedite site cleanups and promote the development and reuse of abandoned, idled, or underutilized industrial and commercial facilities known as brownfields. The VCP has been heavily promoted through public workshops, publications, and the branch's Web page.

Incentives such as tax credits, low-interest loans, and grants were created to promote participation in the VCP and encourage the development of brownfields. The Site Investigation and Restoration Branch continues to work with other state agencies and members of the private sector to refine and develop incentives and raise public awareness.

In an effort to streamline the remedial process, the branch has developed brief, standardized VCP agreements. The agreements are written in layman terms and allow the signatory to terminate the agreement, provided that certain conditions are met. This has reduced legal costs and expedited the initiation of investigations and cleanups. To further streamline the process, the branch has developed cleanup standards, which may be used in place of risk assessments. This enables a larger group of property owners, developers, and consultants to evaluate sites and make decisions regarding property acquisition and disposition.

Since 1995, 22 sites have been remediated under the VCP/Brownfield Program, putting approximately 236 acres back to use.

In addition to streamlining the remedial process, the branch has developed a computerized site-status data base, implemented an automated cost recovery system, expanded its field screening capabilities, and purchased mobile laboratory equipment. The branch continues to seek and acquire improved technology to increase efficiency and reduce the cost of environmental investigations and cleanups.

The Site Investigation and Restoration Branch also produces an annual report. Additional information contained within the administrative record is available for each site through the Freedom of Information Act. Branch representatives may be reached at (302) 323-4540.

Toxics Release Inventory. The Toxics Release Inventory is one of several reporting programs under the Emergency Planning and Community Right-to-Know Act. Manufacturing facilities are required to report releases, transfers, on-site waste management, and other information for any chemical listed that the facility makes, processes, or otherwise uses above an annual threshold. Facilities report by July 1 on activities for the previous calendar year to DNREC and the EPA.

As referenced earlier, DNREC's Air Quality Management Section receives and compiles these data for all reporting years (1987 through 1994). The Toxics Release Inventory data base is routinely updated and is available on e-mail, disk, or hard copy for selected information. The program also prepares an annual report. This report and other program information is available by contacting the section's Emergency Planning and Right-to-Know Program at (302) 739-4791.

Table 61

SUPERFUND SITES IN THE PIEDMONT BASIN, DELAWARE

ID. NO.	SITE NAME	CATEGORY	DESCRIPTION	WATERSHED
DE-025	Capitol Recovery	HSCA	Criminal case – no site	Brandywine Creek
DE-094	Container Corporation of America	HSCA	Inactive landfill	Brandywine Creek
DE-097	Sixteenth Street Quarry	HSCA	Quarry	Brandywine Creek
DE-111	Kruse Playground	HSCA	Former coal gas facility, leather tannery, currently used as a playground	Brandywine Creek
DE-174	Electric Hose & Rubber Recon.	HSCA	Former wire and hose manufacturer	Brandywine Creek
DE-280	Atlas Sanitation	HSCA	Filled area	Brandywine Creek
DE-281	Diamond State Salvage	EPA Removal	Salvage operation	Brandywine Creek
DE-020	E. l. DuPont, Newport Landfill (OU1, OU3-OU8)	NPL	Pigment manufacturing facility	Christina
DE-034	Chapmans Road	HSCA	Former rendering plant	Christina
DE-047	Harvey and Harvey Landfill	VCP	Former landfill currently used for container storage	Christina
DE 067	Halby Chemical	NPL	Former chemical manufacturing facility	Christina
DE-095	Clayville Dump	HSCA	Former dump site	Christina
DE-099	City of Wilmington Marine Terminal	HSCA	Marine terminal	Christina
DE-1003	Del. Air National Guard	HSCA	Air Force National Guard Base	Christina
DE-1005	Toni Dry Cleaners	HSCA	Dry cleaner	Christina
DE-1006	Fox Run Development	HSCA	Residential development – vegetative debris pits	Christina
DE-1026	Terminal Avenue	HSCA	Road widening project	Christina
DE-1033	Victoria Woods	HSCA	Residential development – vegetative debris pits	Christina
DE-1034	Anchor Motor Freight	VCP	Tractor sales and service facility	Christina
DE-1039	Eagle Run	VCP	Former manufacturing/warehouse	Christina
DE-1040	400 South Madison Street	HSCA	Former shipbuilding site w/waste pile	Christina
DE-1041	Dravo Marsh	HSCA	Freshwater tidal marsh	Christina
DE-1043	Wilmington Coal Gas Western Section	HSCA	Former coal gasification plant	Christina
DE-1044	CSX Property	VCP	Vacant lot	Christina
DE-1046	Wilmington Coal Gas Northern Property	VCP	Former coal gasification plant	Christina
DE-105	Chrysler Assembly Plant		Automobile assembly	Christina
DE-1051	Pusey and Jones Shipyard	PA/SI	Former shipyard, current use industrial (metal fabrication & rail car refurbishing)	Christina

Table 62
SUPERFUND SITES IN THE PIEDMONT BASIN OF DELAWARE — CONT'D.

ID. NO.	SITE NAME	CATEGORY	DESCRIPTION	WATERSHED
DE-1055	250 South Madison		Freshwater tidal marsh	Christina
DE-114	Wllmington Coal Gas Southern Section		Coal gas site	Christina
DE-125	DuPont – Haskell Labs	HSCA	Laboratories and research facility	Christina
DE-140	High Voltage Maintenance Site	HSCA	Warehouse and maintenance facility	Christina
DE-141	Rte. 40 Steel Drum Site	HSCA	Drum collection and resale company	Christina
DE-155	Glasgow Drive Dump Site	HSCA	Dump site	Christina
DE-158	Atlantic Avenue	HSCA	Buried drums discovered during utility construction	Christina
DE-159	Wilmington Train Yard	HSCA	Train maintenance yard	Christina
DE-161	Robscott Manor	HSCA	Residential development/possible dump site	Christina
DE-165	Estate of Lester Nolan	VCP	Dump site	Christina
DE-169	Potts Property	HSCA	Former ore processing plant/currently bulk storage area	Christina
DE-173	Syntech	HSCA	Specialty chemical manufacturer	Christina
DE-185	Meco Drive Site (Boxwood)	HSCA	Industrial site	Christina
DE-187	Applied Technology	HSCA	Unknown	Christina
DE-191	Petinaro Transformer Site	HSCA	Electric power transformer substation	Christina
DE-193	Salem Church – Muddy Run Dump	HSCA	Surface dump – commercial, industrial, and household debris	Christina
DE-I-95	Wilmington Suburban Water Co.	HSCA	Water pumping facility with sludge lagoons	Christina
DE-210	Wilmington Suburban Water Co. – Christiana	HSCA	Water pumping facility with sludge lagoons	Christina
DE-230	North American Smelting Co.	VCP	Abandoned smelter operation	Christina
DE-248	DuPont Reston Products	HSCA	Former manufacturer/current research and development of circuit boards site	Christina
DE-256	Homalib	HSCA	Optical plastics manufacturer	Christina
DE-259	Newark Munition Site	HSCA	Former WW II munitions storage area	Christina
DE-270	Budd Metal	VCP	Former metal fabrication business	Christina
DE-271	Ciba-Geigy Seep	EPA Removal		Christina
DE-282	Cress Collision Services Inc.	HSCA		Christina
DE-283	Necastro Auto Salvage	HSCA	Auto salvage business	Christina
DE-285	Browntown		400 acres within city of Wilmington	Christina
DE-286	Bell Alley			Christina
DE-046	Citi Steel Corporation	HSCA	Steel manufacturer	Naamans Creek
DE-050	Texaco Inc., Claymont Terminal	HSCA	Petroleum product terminal	Naamans Creek
DE-059	Olin Corp. – Sunolin Chemical	HSCA	Chemical manufacturer	Naamans Creek

Table 63
SUPERFUND SITES IN THE PIEDMONT BASIN OF DELAWARE — CONT'D.

ID. NO.	SITE NAME	CATEGORY	DESCRIPTION	WATERSHED
DE-249	Allied Chemical Drum site	HSCA	Spill site	Naamans Creek
DE-054	O & T Realty	HSCA	Landfill	Red Clay Creek
DE-071	NVF (Yorklyn)	HSCA	Fiber product manufacturer	Red Clay Creek
DE 081	NVF Stab Line Landfill	HSCA	Landfill	Red Clay Creek
DE-166	Spatz Fiberglass	HSCA	Molded fiberglass products manufacturer	Red Clay Creek
DE-176	Ametek Inc.	HSCA	Plastic products manufacturer	Red Clay Creek
DE-1001	Fox Point Park Phase I	HSCA	Former landfill	Shellpot
DE-024	Wilmington Municipal Sewage System	HSCA	Municipal sewage treatment plant	Shellpot Creek
DE-1011	Fox Point Park Phase II	HSCA	Former landfill	Shellpot Creek
DE-1054	Pure Green Industries	VCP	Former landfill	Shellpot Creek
DE-126	Juliano Site	HSCA	Residence	Shellpot Creek
DE-266	Amtrak Railyard	VCP	Railyard/maintenance facility	Shellpot Creek
DE-039	Newark Landfill	HSCA	Inactive landfill	White Clay Creek
DE-184	Brookside Dump	HSCA	Dump site	White Clay Creek
DE-018	FMC Corporation	HSCA	Former Landfill	White Clay Creek
DE-019	Koppers Co. Facilities Site	NPL	Wood preserving facility	White Clay Creek
DE-035	Newark Concrete	HSCA	Dump site	White Clay Creek
DE 044	Newport City Landfill	HSCA	Former landfill	White Clay Creek
DE-052	Newark Housing Authority Landfill	HSCA	Inactive landfill	White Clay Creek
DE-062	SES Incorporated	HSCA	Research facility	White Clay Creek
DE-072	Reevis & Reevis Clay Pit	HSCA	Former dump site	White Clay Creek
DE-079	Mt. Pleasant Railroad Dump	HSCA	Former dump site	White Clay Creek
DE-162	Windy Hills	HSCA	Former dump site	White Clay Creek
DE-163	Del Chapel Place	BPA ll	Buried rail cars	White Clay Creek
DE-175	Motor Wheel Corporation	HSCA	Wheel manufacturer	White Clay Creek
DE-199	NVF Newark	HSCA	Fiber products manufacturer	White Clay Creek
DE-214	W.L. Gore & Assoc. – Newark	HSCA	Manufacturing facility	White Clay Creek
DE-229	Newport Drum Site	HSCA	Drum site	White Clay Creek

Notes:
• *Hazardous Substance Cleanup Act (HSCA)* • *National Priority List (NPL)* • *Environmental Protection Agency (EPA)*
• *Brownfield Preliminary Assessment (BPA)* • *Voluntary Cleanup Program under HSCA (VCP)*
This is the current listing of the sites located in the Piedmont Basin of Delaware and is subject to change without notification.

On-Site Waste Disposal Systems, Agriculture, Silviculture, Resource Extraction, Hydromodification

Nonpoint source pollution is the deposition of pollutants to water by runoff, percolation, and atmosphere. The term can also be defined by negation as any human-induced pollution that does not come from a precisely defined location such as a drainage pipe discharging waste into a river.

While any contaminant may fall under Nonpoint Source Program jurisdiction, some contaminants are more clearly nonpoint source related. These include bacteria, nutrients, sediment, and polychlorinated biphenyls (PCBs).

Contaminant Descriptions

Bacteria. According to the 305(b) report, most of the Piedmont Basin's surface waters do not support primary contact use as a result of high indicator bacteria levels. This information by itself has strong implications. However, measuring indicator bacteria levels to determine human health risk is not a precise technology. As the name suggests, indicator bacteria are associated with the pathogens that cause human illness but are not themselves the concern. Several conditions can cause indicator bacteria counts to be misleading. A few are noted here:

- Normally, the correlation between indicator bacteria and illness-causing pathogen levels is good if the appropriate indicator bacteria are chosen for monitoring. Pathogens are not exactly correlated to indicator bacteria, however. Sometimes the indicator bacteria can die off before or after illness-causing pathogens. Also, pathogens may grow back after an initial die-off while the indicator bacteria do not. Indicator bacteria monitoring alone may not be accurate.
- Bacteria, including indicator bacteria, are present everywhere and are especially associated with organic matter. They exist throughout soils and plant matter even if pathogenic organisms do not. Research on pulp and paper mill effluent showed that total and fecal coliform levels were high, while no pathogenic organisms were present (Pipes 1992). Degraded waters may have high bacteria levels but not be a threat to human health.
- Higher risk is associated with human waste than animal waste pathogens. Yet indicator bacteria monitoring cannot differentiate between the two. One study suggests that a fecal coliform to fecal streptococci ratio of 4:1 is an indication that contamination is from a human source. However, the authors of that study warn that this ratio is only valid within a narrow set of conditions. The ratio is not meaningful in urban settings and should only be considered for samples coming from outfalls that are within a 24-hour travel time of the source (Geldreich, 1969). Water-quality standards are sometimes based on the assumption that indicator bacteria levels are associated with pathogens from human sources. Because high levels of fecal indicator bacteria can be present without human fecal sources existing, indicator bacteria monitoring may be too conservative.

Literature suggests that, in spite of the inexactness of indicator bacteria monitoring, it is still the most effective method we have to determine human health risk from pathogens. However, indicator bacteria monitoring is most effective if accompanied by a sanitary survey so that data can be evaluated in relationship to sources (Pipes, 1992).

Bacteria proliferation is correlated with the nutrient levels and temperature of a water body (Pipes, 1992). While the health risk indicated in the 305(b) information may be conservative, we can surmise from the data that water-quality degradation is occurring. Indicator bacteria counts also cause swimming closures. While those standards may be conservative, they are our best tool. The only way to reduce the number of closures is to reduce bacteria concentrations in surface waters.

Nutrients. Nitrogen and phosphorus are the major nutrients that cause eutrophication of surface waters. In the environmental protection field, eutrophication carries a negative connotation for causing nuisance levels of aquatic plant and algae growth. Excessive plant growth may cause odor problems; entangle swimmers, fishermen, and boaters; and may cause a reduction in the population, size, and diversity of fish as a result of oxygen depletion and excessive pH fluctuation from plant die-off.

Phosphorus is normally the nutrient that limits growth in fresh waters while nitrogen is typically the limiting nutrient in estuaries and bays. Adding more of a limiting nutrient to a water body will result in increased aquatic plant and algae growth.

Nitrogen. Nitrogen may reach surface waters by runoff of fertilizer and animal waste from agricultural and residential lands. Ritter (1984) noted, however, that base flow to streams was a greater nitrogen contributor than stormwater. Base flow is assumed to be entirely from groundwater (Johnson, 1976). A more pervasive concern, then, is leaching of nitrate to groundwater. Manure and chemical fertilizers from agricultural activities and residential lawn care, as well as localized concentrations of septic systems, may contribute to groundwater nitrate levels.

Phosphorus. Because phosphorus, by its chemical nature, is held tenaciously to soil particles, erosion

and runoff have always been considered to be the major cause of phosphorus loading. Groundwater is not considered a phosphorus-loading pathway. A study of 30 lake watersheds throughout the state noted that greater than 50% of phosphorus transport was in base flow (Ritter, 1992).

If phosphorus is not found in the groundwater that supplies base flow, the most likely source of base-flow phosphorus is stream and lake-bed sediments. Under low oxygen conditions, iron-bound phosphorus may be released from sediments. Also, organically bound phosphorus may be released when biota consume organic matter in the sediments. Historic erosion is the likely source of stream and lake-bed sediments, which may be releasing phosphorus currently.

Sediments. Eroded sediments both carry pollutants and are a pollutant. Pathogens, nutrients, and toxic substances are transported in sediments. Prevention is the less expensive solution.

Most of the problems caused by sediments acting as a transport mechanism are discussed elsewhere in this report:

- Indicator bacteria are present at degrading levels in nearly all of Delaware's surface waters. Much of the problem is associated with runoff-borne soil and organic matter.
- Nutrients are high in most of our waters. The sediments underlying streams and ponds are a major source of those nutrients. Some of the sediments are from detritus within the water body. The rest comes from erosion and runoff. Because phosphorus strongly adheres to soil particles, eroded sediments are thought to be the dominant mechanism for phosphorus loading.
- PCBs, the major toxic contaminant for which fish consumption advisories are issued, are typically soil-borne and transported by erosion and runoff. Waterways that currently have advisories can't be remediated, and more streams will have advisories placed on them if sediments are not controlled.
- Some ponds have a turbidity problem. The swimming area at Becks Pond, for example, has been permanently closed as a result of chronically high bacteria and turbidity levels.
- Many Piedmont Basin streams that have good habitat along their banks have poor habitat in the water. Stones, gravel, and branches, which supply spawning and feeding areas, have been buried by sediments. Even though the water quality is adequate, the stream is dead.
- The New Castle County Conservation District's dredging and excavation operations are not at a loss for work. Creeks and ponds that have filled in with sediments may be dredged to maintain water-body depth and reduce flooding. Although sedimentation is a natural process, human activities accelerate the rate. All of Delaware's citizens pay to maintain water bodies suffering from accelerated sedimentation.

Sediment erosion is both an urban and an agricultural problem. Where land is disturbed, erosion occurs. Sediment and stormwater control is at least one of, if not the major tool, for prevention of surface-water contamination from all other pollutants. Sediment and stormwater volume is a cause of stream habitat destruction.

Advanced methods for sediment and stormwater control are needed for both agricultural and urban communities. Regional land-use planning and zoning are imperative to successful urban control. The agricultural industry has long understood the importance of erosion control to sustaining profitable crop production. Tying existing efforts to water-quality improvements is the next step.

Polychlorinated Biphenyls (PCBs). Polychlorinated biphenyls (PCBs) are the major cause of fish consumption advisories in Delaware. PCBs were widely used before being banned, and they don't break down readily. Consequently, contamination is extensive. Erosion of contaminated soils into surface waters is the typical transport mechanism. The EPA allows contaminated sites to have a maximum of 50 ppm PCBs in the soil. While this level is safe in situ, erosion from several sites in a watershed may lead to hazardous levels in the bottom sediments of receiving waters (Rick Greene, personal communication).

Remediation of PCBs typically involves either leaving sediments in place so that they may be buried with further sedimentation over time or by dredging the sediments out. When dredged, large volumes of removed sediments must either be disposed of properly or treated before being used. A model is being developed that will help scientists and engineers evaluate the time required for sediments to be buried naturally. Knowing this will help them weigh remediation options more effectively. Neither treatment will work unless the source of contamination is stopped. Thus, erosion and stormwater runoff control is the first step to successful remediation.

Historic use of PCBs has left a legacy that we will be addressing for many years to come. The pervasive nature of PCB contamination makes remediation complex and challenging. Remediation is further complicated by the continual loading from erosion and runoff. If the source is not stopped, remediation is pointless.

Nonpoint Sources

Nonpoint sources are normally evaluated by dividing them into eight categories:

Table 64

LAND USE IN THE CHRISTINA BASIN
OCTOBER 22, 1996
(Compiled by Water Resources Agency for New Castle County)

LAND USE	AREA, SQUARE MILES (Percent of Total Land Use in State)	
	DELAWARE	PENNSYLVANIA
Urban/Surburban	87 (52%)	108 (27%)
Agricultural	18 (11%)	160 (40%)
Public/Private Open Space	21 (13%)	5 (1%)
Wooded	37 (22%)	123 (31%)
Water	3 (2%)	3 (1%)
Total	**166**	**399**

Table 65

PERCENT AGRICULTURAL LAND BY WATERSHED
(Delaware Portion Only)

WATERSHED	PERCENT
Shellpot Creek	2%
Naamans Creek	4%
Christina River	16%
White Clay Creek	26%
Brandywine Creek	26%
Red Clay Creek	27%

1. Agriculture
2. Silviculture
3. Construction
4. Urban Runoff
5. Resource Extraction/Exploration/Development
6. Land Disposal (runoff/leachate from permitted areas)
7. Hydrologic/Habitat Modification
8. Other (atmospheric deposition, waste storage leaks, etc.)

Since categories 3, 4, 6, and 8 are covered comprehensively in other sections of this document, they will not be evaluated here.

The Piedmont Basin is one of the most complex drainage basins in Delaware. Basin waters run extensively through Pennsylvania, and to a minor extent through Maryland, before reaching Delaware. Thus, we inherit the results of practices and land-use patterns in those states, and then add on our own. Successive land-use patterns layer their effects on top of those preceding, rendering an amalgamation that is challenging to unravel. See Table 64. This is especially so for the White Clay, Red Clay, and Brandywine creeks; most of these watersheds comprise rural lands in Pennsylvania, then become residential and urban in Delaware. Each landscape contributes its own type of nonpoint sources. Ultimately we cannot solve our water-quality problems in this basin without the help of adjoining states.

Agriculture in Delaware. New Castle County is experiencing a shift from agriculture to urbanization. From 1964 to 1984, the percentage of urban land use steadily increased, but the percentage of agricultural land stayed the same (J. MacKenzie, personal communication). See Table 65. As agricultural land became developments, forestland was cleared to make new agricultural land. Now, however, farmland acreage is not being replaced, and total acreage is diminishing.

Delaware is predominantly urban above the Christina River. A small acreage of the existing agricultural land is used for corn-soybean-small grain rotation for profit. Most of the farmland is kept in pasture or cropped for wildlife management on county and state preserves. The University of Delaware has a research farm in Newark.

Much of the agricultural land below the Christina River and above the Chesapeake and Delaware Canal is slated for development. Agriculture will not be a major land use in the near future.

Addressing agricultural practices in Delaware's Piedmont Basin is a low priority since very little agricultural land exists in northern New Castle County. Most existing agricultural land is in pasture and hay fields, which result in little pollution. Basin lands in Pennsylvania, however, are extensively agricultural.

Agriculture in Pennsylvania. The Piedmont Basin is comprised of 40% agricultural lands in the Pennsylvania portion. In Chester County, the primary types of agriculture are corn-soybean-wheat/hay rotation, dairy, and mushroom farming, with the dominant crop being mushrooms. See Table 66.

Erosion of sediments is the primary concern with grain-rotation crops in Pennsylvania as a result of steep slopes. Even if farmers are using minimum tillage practices, terraces and waterways are still necessary. According to the Watershed Plan and Environmental Assessment (1996) put together by the Conservation Districts in Delaware and Pennsylvania, 68,000 tons of sediment from cropland reach surface waters

Table 66

NUTRIENT RUNOFF ASSOCIATED WITH PROBLEM SOURCES OF AGRICULTURAL NONPOINT POLLUTION
(From Red-White Clay Creeks Watershed Plan and Environmental Assessment, 1996)

AGRICULTURAL NONPOINT	NITROGEN (LBS/YEAR)	PHOSPHORUS (LBS/YEAR)
Mushroom Operations:		
Field-spread spent substrate	79,000	5,000
Runoff from loading/unloading	33,000	3,000
Wash-down operations	150,000	15,000
Runoff from spent substrate	120,000	12,000
Livestock Operations:		
Livestock concentration areas	24,500	9,000
Field-spread manure	9,000	3,000
Milk-house waste effluent	500	1,000
Livestock stream access	27,000	5,000
Stream Banks	17,000	7,000
Cropland Runoff	221,000	90,000
Total	**681,000**	**150,000**

Table 67

SOIL EROSION AND NUTRIENT LOSSES FROM CROPLAND — RED – WHITE CLAY WATERSHED
(From Red–White Clay Creeks Watershed Plan and Environmental Assessment, 1996)

	PENNSYLVANIA	DELAWARE	TOTAL
Cropland (acres)	18,000	3,500	21,500
Sheet/Rill Erosion (Tons/Year)	162,000	25,000	187,000
Concentrated Flow Erosion (Tons/Year)	14,500	2,500	17,000
Total Erosion (Tons/Year)	176,500	27,500	204,000
Total Nitrogen (lbs/Year)	476,500	74,500	551,000
Total Phosphorus (lbs/Year)	194,000	30,000	224,000

each year from the Red and White Clay creeks alone. See Table 67. Fifty-five thousand tons of that sediment reach the mouth of the Christina River. The report notes that repairing ditches, culverts, and bridges as a result of that sediment costs about $60,000 per year.

Dairy operations will contribute nutrients, bacteria, and oxygen-demanding organic materials to surface waters if not properly managed. Proper use of manure and milk-house wastes, as well as removal of direct access of animals to streams, must be achieved to avoid pollutant loading.

Mushroom production facilities can cause sediment, pesticide, and bacteria loading to nearby surface waters. There are approximately 96 mushroom production facilities in the Piedmont Basin. Twenty-six of those facilities have signed up with the Conservation District to develop cooperative conservation plans. While large operations are currently working with the Conservation District, considerable effort is still required to provide numerous small operations with conservation management strategies.

General Agriculture. The Consolidated Farm Service Agency (formerly ASCS), the Natural Resource Conservation Service (formerly SCS), the Conservation Districts, University Extension Systems, and other agencies have been working with farmers to advance sustainable high-production farming. Erosion control has always been targeted with government incentives and engineering, and by advocating agronomic practices such as conservation tillage and cover cropping. When the chemical fertilizer industry came about, practices that maximized their effectiveness were promoted. When petroleum prices soared and chemicals became expensive, efficient use was promoted. Growth curves that show the fertilizer application rate at which yields level off, and historical yield information helped farmers improve net income by avoiding the expense of unnecessary inputs. Scouting methods have been developed so that pesticide inputs can be reduced to application only when necessary rather than automatic preventative application.

Development and implementation of these practices have reduced water-quality impacts coincidentally. Reducing total chemical input and carefully timing applications to meet crop needs automatically reduces leaching and runoff of excesses to ground- and surface waters. Reducing erosion in the field reduces sediment delivery to surface waters. As the knowledge of water-quality impacts from agriculture has increased, though, maintaining water quality has become a goal of farmers and agricultural agencies rather than a side benefit.

Raising the priority level of water-quality management has two particular benefits: (1) documentation of improved agricultural practices can be kept in a way that allows for correlation between those practices and water quality;

(2) management practices can be geared more effectively toward high agricultural productivity as well as reducing water-quality impacts.

In the Piedmont Basin, the Natural Resources Conservation Districts in Chester County, Pennsylvania, and New Castle County, Delaware, work with farmers to develop conservation plans. Farmers agree through conservation plans to manage farming operations in a way that minimizes nutrients, pesticides, and sediment loading to ground- and surface waters.

The two districts and the Brandywine Conservancy have signed an agreement to target the Red and White Clay creeks with concentrated conservation efforts to achieve water-quality improvements. The Watershed Plan and Environmental Assessment developed by those agencies addresses the treatment of nonpoint source pollution to restore water quality and aquatic habitat. Listed in the document are recommendations to establish agricultural waste management systems, cropland resource management systems, and riparian area treatment systems. Benefits anticipated from this effort include a 28% reduction in sediment loading, 27% reduction in nutrient loading, reduced water treatment costs, 85% of the cropland protected from erosion, 3,000 acres using improved nutrient management, and 5,000 acres using improved pesticide management.

Pennsylvania has passed legislation requiring animal production operations to have nutrient management plans. The regulations required to carry out that legislation are under review. Ratification is anticipated in 1997.

The Natural Resources Conservation Districts in New Castle County, Delaware, and Chester County, Pennsylvania, are in the process of mapping agricultural lands and the locations of existing installed management practices. This information will be used to model pollution loading from agriculture and to prioritize sub-watersheds for implementation.

Silviculture. Forestland, outside of parks and preserves, has been generally reduced to areas along stream and river banks. These areas, though localized, may pose greater environmental risk if harvested because of their immediate proximity to surface water. Very little clear-cutting occurs in New Castle County other than clearing acreage for development. Select cutting is the dominant practice (Julie Klapperoth, personal communication). Since select cutting disturbs the land less, it is preferred over clear cutting. See Table 68.

Table 68

PERCENT WOODED LAND BY WATERSHED
(Delaware Portion Only)

WATERSHED	PERCENT
Shellpot Creek	10%
Naamans Creek	12%
Christina River	24%
White Clay Creek	26%
Brandywine Creek	27%
Red Clay Creek	29%

Resource Extraction. Sand and gravel are the only materials mined in Delaware. The sites, known as borrow pits, are located throughout the state. Borrow pits vary in size. A relatively small pit may be opened to supply sand for poultry-house floors. Large sites may supply sand and gravel for road construction. Active pits are a concern because (1) the groundwater table may be lowered, potentially affecting local wells; (2) sloughing of the perimeter may cause unintended expansion into adjacent properties; and (3) ground- and surface waters could be con-taminated by fuel and other industry-related materials.

Although statewide extractive-use regulations have been proposed, they have not been promulgated. The three counties have individual strategies for dealing with borrow pits. New Castle County has rigorous regulations. A proposed site must go through rezoning specifically for borrow pit activity. Applications for a permit must include an erosion and sediment control plan and a restoration and stabilization plan. Groundwater monitoring and semi-annual reporting are required. The work-face area is limited to 25 acres. New Castle County has four active borrow pits, one suspended site, and one application in-house for a new operation. Their regulations are comprehensive and effectively inhibit small operations.

Hydromodification. Hydromodification involves waterway modification (ditching, dredging, stream-bank stabilization) to manage flooding, improve navigation, improve drainage, and minimize stream-bank erosion. This category also includes flow alteration by installation of dams and water-control structures. Although not a direct waterway modification, a substantial change in flow has occurred in the Piedmont Basin as a result of development in general. Increased impervious surface, drainage swales, French drains, and detention ponds all change drainage patterns in a watershed.

Flood control and stream-bank stabilization resulting from historic development as well as construction and future maintenance of sediment and stormwater detention ponds in new developments are the major concerns of municipal public works departments and the New Castle County Natural Resources Conservation District. The larger part of their work is fixing erosion and stormwater

problems in neighborhoods that were built before stormwater regulations and floodplain ordinances existed. Also, older downstream developments are affected by more recent upstream developments.

In-stream flood control typically involves excavation of deposited sediments, clearance of obstructions such as brush, and widening of engineered structures such as culverts. Stream-bank stabilization typically involves use of hard surfaces, rip rap, and soil bioengineering as required by stream-flow energy. Within neighborhoods and developments, stormwater flow may be modified using swales, storm drains, and detention ponds. While these activities do not occur in-stream, redistribution of hydraulic energy will ultimately affect streams.

In-stream modification may result in temporary or permanent degradation of riparian and subaqueous habitat. Fixing a problem upstream can transfer problems downstream, in some cases requiring additional in-stream engineering. Improving or returning flow may increase sediment and pollutant transport and deposition downstream and alter hydraulic energy so that erosion, scouring, and flooding may occur farther downstream.

Efforts are made to minimize environmental impacts and anticipate downstream effects when planning flood-, stormwater-, and erosion-control projects. However, not all impacts can be avoided.

As noted earlier in the Sediment section, the extent of impervious surface (pavement, roofs) in a watershed increases stormwater runoff and increases hydraulic energy delivery to surface waterways. Somehow the streams and rivers must adjust to increased energy. The streambed will widen as stormwater scours out banks. The scoured-out sediments will be deposited downstream, which will eventually result in flooding. When properties exist along those adjustment areas, the properties are adversely affected and protection measures must be installed. If the hydraulic energy is not reduced, the stream will respond to those protection measures elsewhere.

At some point, a stream's natural characteristics are irreparably degraded. While the chemical water quality may be adequate, the stream will be devoid of life. Public works departments are then destined to maintain and repair streams in their altered condition so long as property is maintained along the stream. The public pays for these services through taxes.

Dredging and Excavation. For the purposes of this report, dredging is delineated from excavation by intent and equipment used. Dredging typically refers to removal of bottom sediments to enhance navigation. Typically, though not exclusively, hydraulic equipment is used. Excavation is removal of sediments for flood control or drainage, using mechanical equipment. The terms are often used interchangeably, however. Concerns with both activities are disturbance of habitat, temporary increases in turbidity, the potential for removed and resuspended sediments to be contaminated, clearance of riparian habitat for access, and disturbance of fish spawning areas.

Dredging is not common in the Piedmont Basin. Wilmington Harbor is dredged regularly to maintain commercial traffic. The project is sponsored by the U.S. Army Corps of Engineers. Approximately 550,000 cubic yards are removed along 6,300 linear feet between Lobdell Canal and the Delaware River about every nine months. Dredging has occurred as far as 9 miles from the Delaware River to approximately where Route 41 crosses the Christina River. The source of sediments is generally felt to be from erosion in the Christina River tributaries. Further information on dredging projects in Piedmont Basin ponds can be found in the Sediment section of this document.

Dredging projects require permits from the U.S. Army Corps of Engineers and from DNREC. Before permits are issued, applicants must verify consistency with the policies and requirements of the Delaware Coastal Management Program, the U.S. Department of Fish and Wildlife, and the National Marine Fisheries Service within the National Oceanic and Atmospheric Administration (NOAA).

Excavation is sometimes necessary to remove sediments that fill in streams and ponds in the Piedmont Basin. Little Mill Creek (off the Christina River) and Red Clay Creek near its confluence with White Clay Creek are currently being evaluated as possible excavation projects to reduce flooding.

Dams and Water-Control Structures. There are about 20 dams in the Piedmont Basin, ranging in height from 6 feet to 127 feet at Hoopes Reservoir. Rockland Dam and the Brandywine Creek Dam in Wilmington were built as far back as 1800. Many others were built in the early 1900s. The primary concern with dams is to maintain adequate pass-by flow during low-flow conditions. Failure to do so could result in fish kills from low-oxygen conditions downstream of dams. No incidences have been documented.

Water-control structures, which include weirs, sluice gates, and flap or tide gates, are not common in the Piedmont Basin. A tide gate controls tidal flow on the Shellpot River. One-way tide gates are considered detrimental to wetlands.

Tide gates, used to control flow in tidal tributaries draining to the Delaware River and Bay, were originally installed by colonists and have not changed much in design until only recently. The traditional "one-way" structure would allow water to drain from tributaries, but prevent water from flowing back in from the river during high tide. This type of management causes degradation of wetland habitat quality because it inhibits the necessary flushing and

oxygenation of surface waters. New structures that allow flow both ways currently are being studied for environmental impact. If managed properly, mosquitoes and *Phragmites* can be controlled, fish populations can be diversified, and hard pans from salt deposition can be avoided.

Stream-Bank Stabilization and Restoration. As noted, stream banks may be stabilized to reduce sediment loading from scouring and to reduce property loss from stream encroachment. Typically riprap (loose stone) is placed on stream banks and is effective, where placed, at stopping scouring. However, the hydraulic energy is not diminished by this practice, and further damage may occur downstream. Also, stream-bank habitat, though already degraded by scouring, is further degraded. The Conservation District promotes maintenance of vegetative cover along the higher portions of the stream bank to reduce shade and habitat loss.

The City of Newark, in conjunction with the Conservation District, initiated a stream-bank restoration demonstration project on a section of the upper Christina River. Soil bioengineering measures were installed to stabilize degraded stream banks in a heavily used city-owned park. A similar project was implemented in the Brandywine Creek near the Wilmington Zoo. Results are currently being monitored. Such innovative techniques have not been as fully explored in Delaware as they have been in surrounding states, particularly in areas funded by the Chesapeake Bay Program. However, bioengineering efforts may be constrained by the level of shade along Piedmont Basin stream banks.

County Hydromodification Management. The Delaware Department of Transportation constructs and maintains drainage systems associated with roads. The New Castle County Public Works Department "is responsible for providing open and free-flowing conditions in public non-tidal waterways and maintaining all county-constructed drainage infrastructure" according to the Drainage Maintenance Section Program narrative. This service is "provided on a complaints or 'as called' basis."

The Public Works Department also maintains 33 stormwater management basins owned by the county and inspects all stormwater basins in public trust (managed by neighborhood maintenance associations, for instance) that were built after July 1991. The county is concerned with who will be required to maintain "public trust" basins should neighborhoods fail to maintain them. Cost of maintaining stormwater ponds is estimated at $1000/acre/year.

The Public Works Department is interested in combining, where possible, detention requirements for several developments into one basin instead of having individual basins for each development. Though compelling, actually accomplishing "co-brokering" is difficult.

In 1991, New Castle County adopted an ordinance that protects public water-supply resources. Included are the Cockeysville Formation areas, wellhead areas, surface-water areas, and recharge areas. The surface-water areas include floodplains, erosion-prone slopes, and public surface-water-supply intakes. Several county departments in conjunction with the Water Resources Agency for New Castle County are currently formulating an ordinance regarding riparian zones with habitat and water-quality protection in mind.

Both the Department of Transportation and the county Department of Public Works have been delegated authority to carry out state-level stormwater management requirements. Additionally, the county and the Department of Transportation have applied jointly to DNREC for a "Phase II" stormwater permit under the National Pollution Discharge Elimination System Program. The application process actually stipulates conditions that will be included in the permit. Included in the application are discussions regarding new development concerns, inclusion of water-quality analysis in flood studies, and participation by the county and the Department of Transportation in basin projects.

A key frustration voiced by the chief of Drainage Operations, and mirrored by other agencies and the public, is the difficulty in determining how surface waters are delineated from one environmental program or agency to the next. Workshops have been held with the county to clarify those delineations. However, delineations may still be elusive when trying to comply with regulations on a day-to-day basis. Not only are legal delineations difficult, but understanding how a project affects different environmental goals may be confusing, and perhaps contradictory, as well. For many, understanding why a project may be acceptable according to state subaqueous regulations but not to federal Army Corps of Engineers regulations, or why the project will not cause concern to the Division of Fish and Wildlife but will be harmful according to the Wetlands and Subaqueous Lands Section, is a challenge. That frustration and confusion may inhibit our ability to establish cooperative relationships with other agencies.

As noted in the program description, waterway clearance efforts are made upon request. The county has a backlog of requested projects. This system of response to requests does not allow resources for holistic watershed planning. While some watersheds in the Christina basin are developed so extensively that proactive measures are not possible, some watersheds may benefit from comprehensive hydraulic modeling and subsequent planning. Resources do not currently exist for such efforts.

On-Site Waste Disposal Systems. Septic systems are the main method for treating domestic wastewater in the unsewered areas of the Piedmont Basin. In portions of unsewered sections, cesspools are still being used; however, most are undocumented. As sewer systems are

developed in areas where septic systems and cesspools are used, the latter are slowly being decommissioned.

A cesspool is usually a large, open-bottomed tank that drains both liquid and solid wastes directly to the subsurface. A septic system is a more engineered waste disposal system, usually composed of a holding tank for solids and a distribution box and drainage field for liquids. The drainage field may be either gravity-fed or pressure-dosed.

The New Castle County Department of Public Works has the governing authority over central sewer and its location. Information regarding central sewer locations has not yet been provided by New Castle County; however, both the 1980 and 1990 census provide percentages of central sewer systems versus on-site disposal systems. Although breakdown of central sewer versus on-site systems per county was obtained from the 1980 census (percentage profile provided by DNREC, 1987; and Delaware Economic Development Office), a per-county breakdown was not available for the 1990 census.

During 1980 in New Castle County, 137,359 households (92.5 %) were centrally sewered, while 10,529 households (7.1 %) had on-site disposal systems. Per the 1990 census, 212,793 households statewide had central sewer while 74,541 households had on-site systems.

In 1986, New Castle County allowed DNREC to conduct site evaluations in the county. Since then, 1,763 site evaluations have been conducted in the Piedmont Basin. This count includes lots evaluated prior to subdivision, possibly suggesting a lower number of sites than that actually permitted. Based upon septic records, 1,559 septic permits have been issued since DNREC took over the permitting program in April 1991; until then, New Castle County approved septic system installations. Within the Piedmont Basin, five failing septic systems have been reported to Environmental Enforcement since January 1996. Complaints were directed to the Groundwater Discharge Branch for compliance follow-ups. Seven holding tank permits have been issued within the Piedmont Basin.

White Clay Creek Watershed. As shown on Map 27, 26% of the developed residential area of this watershed is served by on-site disposal systems. A significant portion of the dwellings are served by cesspools. In recent years, however, the number of cesspools has diminished. Most of the land that is developed with septic systems has a slope greater than 10%. New Castle County has restricted any development on slopes that are greater than 15% and prohibits development on slopes greater than 25%. This slope-restriction ordinance has effectively reduced slope development in this watershed. Generally, the White Clay Creek watershed has moderate to severe limitations for on-site waste disposal due to the presence of slopes in excess of 15%, poorly drained soils, and isolation-distance requirements to watercourses. A significant portion of this watershed is sewered by New Castle County. Septic systems presently range from gravity-fed systems to engineered, pressurized systems on the steeper slopes and in wetter soils. Only a few holding tanks have been allowed in the Piedmont Basin.

To evaluate impacts from on-site waste management practices, Nizeyimana et al. (1996) studied nitrogen loading to groundwater from septic systems in Pennsylvania. They developed a methodology to compute nitrogen loading using a Geographical Information System, 1990 census data, and the state soil geographic data base. The White Clay Creek watershed was one of 14 watersheds in Pennsylvania that had very high nitrogen-loading rates from septic systems. The investigators estimated the loading rate to be about one pound per acre per year of nitrogen and concluded that nitrogen loads correlate with population density. This study demonstrated that a significant amount of nitrogen loading to ground- and surface waters may originate from septic systems. Much of the nutrient loading to the White Clay Creek watershed could originate from outside Delaware's border from developments with on-site septic systems.

Red Clay Creek Watershed. The Red Clay Creek watershed (see Map 27) has a slightly greater number of *residences* (34%) served by septic systems, but actually has fewer *individuals* on septic systems. A significant portion of the dwellings are still served by cesspools. Most of the developable land has a slope greater than 10%. Slopes tend to be steeper than those found in the White Clay Creek watershed. Most of the septic systems in this watershed are gravity systems. Where slopes are greater than 10%, the systems are engineered and often pressurized to compensate for slope.

Nizeyimana et al. (1996) calculated a loading rate to groundwater of approximately one pound per acre per year of nitrogen for the Red Clay Creek watershed, similar to that estimated for the White Clay Creek watershed. This watershed was also one of 14 watersheds in Pennsylvania with high nitrogen-loading rates from septic systems. Similar to the White Clay Creek, much of the nutrient loading may originate from outside Delaware. A significant portion of this watershed is served by the New Castle County sewer system.

Brandywine Creek Watershed. Brandywine Creek watershed has one of the highest percentages (60%) of land area served by septic systems although this watershed has the fewest septic systems per acre in the Piedmont Basin. Many of the developed parcels tend

to be larger than 5 acres. Many older dwellings in the Chateau area of the watershed are still served by cesspools. Brandywine Creek watershed has some of the steepest and rockiest slopes in the Piedmont Basin. The Neshaminy-Aldino-Watchung and the Neshaminy-Talleyville-Urban Land Associations tend to be less suited for septic systems due to their low permeability and poor drainage. These areas are served by the New Castle County sewer system.

Nizeyimana et al. (1996) estimated the nitrogen-loading rate to groundwater to be approximately 0.7 pound per acre per year. This loading rate is lower than that in the Red Clay Creek or White Clay Creek watersheds, but is still considered a high rate. Brandywine Creek watershed has the only commercial spray irrigation facility within the Piedmont Basin. This spray facility was recently permitted for a dairy operation near the Pennsylvania state line.

Shellpot Creek Watershed. Most of this watershed is urban and is served by the New Castle County sewer system. Only 646 acres of the total residential area (7,367 acres) are not sewered.

Naamans Creek Watershed. Most of this watershed is urbanized and sewered by New Castle County. Only 6 acres of the residential area (2,995 acres) are not sewered.

Christina River Watershed . The Christina River watershed has the largest area of residential development in the Piedmont Basin. Approximately 60% of the area is served by septic systems. Most of these developments are relatively recent. Some of the earliest subdivisions within the watershed were developed with cesspools on soil that was unsuitable for residential development. The Christina River watershed has some of the least sloping ground in the Piedmont Basin. Overall, this watershed has moderate to severe limitations for on-site waste disposal due to slopes greater than 15%, poorly drained soils, and isolation distance requirements to watercourses. Systems that are suitable for this area range from gravity-fed systems to engineered pressurized systems.

Extrapolating from the Nizeyimana et al. (1996) study, the nitrogen-loading rate of the Christina River watershed ranges from 0.7 to 1.0 pound per acre per year. The Chris-tina River basin has a high percentage of septic systems and, unlike the Red Clay Creek or White Clay Creek and Brandywine watersheds, most of the nitrogen nutrient load is likely attributed to septic systems located within Delaware. New Castle County has already eliminated the use of many septic systems in areas of high failures, unsuitable soils, and sewer-system availability. Many older subdivisions are now proposed for septic elimination.

Another source of contamination appeared during the winter of 1995. A single mushroom farm in Pennsylvania stockpiled its composted horse manure. Seepage from the piles eventually discharged into Mill Creek, affecting turbidity and ammonia levels. Elevated ammonia, nitrogen, and total coliform concentrations were detected at levels toxic to aquatic life. This scenario could occur throughout the basin if compost-handling best management practices are not employed.

Program Descriptions

Nonpoint Source Pollution Program. Delaware's Nonpoint Source Pollution Program (319 Program) seeks to address nonpoint source pollution through coordination with other agencies and by funding projects through a competitive grant process. To utilize resources efficiently, the 319 Program is required by law and by guidance to assess the extent and causes of nonpoint source pollution and to direct control and mitigation.

The two guiding documents of the Nonpoint Source Program are the Assessment Report and the Management Plan. The Assessment Report identifies waters that require work to attain or maintain water-quality standards, identifies nonpoint sources that contribute significant pollution to those waters, and describes measures that will reduce nonpoint sources. Watersheds and issues are prioritized for efficient use of grant funds. The White Clay Creek and the Christina River are priority watersheds for the Nonpoint Source Program. The Management Plan identifies management practices that will reduce pollutant loadings and programs that can implement those management practices, and establishes a schedule containing annual milestones for implementation.

As a prioritized watershed, the Christina River and its tributaries have been targeted for resource allocation by the Nonpoint Source Program. Over the next several years, the Christina basin project will be the most comprehensive project that the Delaware Nonpoint Source Program has participated in to date. Many agencies are involved:

- Chester County Conservation District
- Chester County Water Resources Authority
- City of Newark, Delaware
- Delaware Department of Natural Resources and Environmental Control, Nonpoint Source Program and Watershed Assessment Branch
- Delaware Geological Survey
- New Castle Conservation District
- Pennsylvania Department of Environmental Resources, Nonpoint Source Program
- U.S. Geological Survey
- Water Resources Agency for New Castle County

Begun as a "Total Maximum Daily Load" (TMDL) process for the Christina River, a core work group, composed mainly of point-source experts and hosted by the Delaware River Basin Commission, met in 1994 in West Chester, Pennsylvania, to determine a plan of action. Because the basin has strong point and nonpoint components, a sub-work group was formed to develop a nonpoint source strategy that would be compatible with the ongoing process.

A model was chosen as a vehicle to quantify nonpoint-source pollutant loads and integrate those quantifications with point-source pollutant load quantifications. Over the next several years, existing information will be gathered, additional necessary data will be collected, the basin will be modeled, sub-watersheds will be prioritized for targeting action, and a comprehensive watershed management plan will be created. Throughout the process, educational and demonstration projects will be implemented.

Underground Discharge Branch. Building a septic system in Delaware is a three-step process. The Groundwater Discharges Branch is responsible for ensuring that the process meets Title 7, *Delaware Code*, Chapter 60. The first step requires a site evaluation, which consists of investigating, evaluating, and reporting the basic soil and site conditions that are used to design on-site systems. Each report describes specific site conditions or limitations including, but not limited to, isolation and separation distances, slopes, existing wells, cuts and fills, and unstable landforms. Each report also contains information about zoning verification; the type of on-site disposal system that must be constructed in the acceptable on-site disposal area; the hydraulic conductivity test conducted; easements, and underground and overhead utilities in the evaluated area.

This siting procedure ensures that septic systems are located based on soil properties: permeability, texture, structure, consistence, redoximorphic features, slope, and depth to rock. New Castle County has restricted any development on slopes that are greater than 15% and prohibits development on slopes greater than 25%.

The second step requires hiring a licensed system designer to design the septic system required by the approved site evaluation and obtaining design approval by the Underground Discharge Branch. After the permit is approved, a licensed system contractor is hired to construct the system under the branch's supervision.

Direct Surface-Water Discharge Program. Pursuant to both state and federal law and regulations, any discharge of a "pollutant" from a "point source" to state waters is unlawful unless such discharge is sanctioned by a permit. Such permits are issued and administered in accordance with the National Pollutant Discharge Elimination System (NPDES). Every NPDES permit issued must include conditions that reflect the application of either the "best available technology economically achievable" or the "best conventional pollutant control technology", as defined by the administrator of the EPA. More stringent limitations or conditions may be imposed when deemed necessary to meet any applicable surface-water-quality standards and to protect the designated uses of the receiving waters.

While it is obvious that industrial, municipal, and agricultural wastes discharged into water are considered "pollutants," the term is broadly defined as any material or substance that adversely changes the chemical, physical, biological or radiological properties or characteristics of water. Whether or not a substance is actually a pollutant, then, depends upon the amount or concentration discharged and the effect it has on the receiving waters.

A "point source" is generally a pipe, ditch, channel, or other discrete conveyance from which pollutants are discharged. Point-source discharges can be linked to a specific source and location. They typically include discharges from municipal wastewater treatment plants and industrial facilities. Discharges of urban runoff, stormwater "associated with industrial activities," cooling water, and combined sewer overflows may also be regulated as "point source discharges of pollutants."

Although an NPDES permit legally sanctions the discharge of substances that may be considered pollutants, it is designed to effectively limit the discharge of those substances such that the discharge would not, or would not be expected to, adversely affect the quality of the receiving waters or interfere with the designated uses of those waters.

The Surface Water Discharges Section within the Division of Water Resources is responsible for administering the NPDES program in Delaware. The public is notified whenever the division makes a tentative determination on a given NPDES permit application (e.g., a decision to issue, re-issue, or deny the application; or if a permit is to be issued, the conditions to be included in the permit and the basis for those conditions). The public is given an opportunity to comment on the draft permit and have a voice in reaching a final decision. See Table 69.

While the NPDES Program relies on the discharger to generate and report the information needed to demonstrate that the discharge meets the objectives of the permit (i.e., each NPDES permit issued includes provisions that require the discharger to collect representative samples of the discharge, analyze specified parameters, and report the results), Surface Water Discharges Section staff review the data submitted, conduct their own surveillance and monitoring program, and provide whatever assistance is deemed necessary to assure permitted facilities regain or maintain compliance.

Table 69

DELAWARE INDIVIDUAL NPDES PERMITS

PERMIT NO.	COMPANY	MINO AJO	IND / MUNIC	BIO-MONIT.	RECEIVING WATERS	BASIN	RIVER	TRIBUTARY	DISCHARGE DESCRIPTION
DE 00004	Ciba-Geigy Corp.	Minor	Ind.	A	Delaware Riv	Christina River			Contam. Stormwater
DE 00217	Winterthur	Minor	Mun.		Delaware Riv	Christina River	Brandywine Riv	Clenney Run	Small STP
DE 00509	AMTRAK	Minor	Ind.		Delaware Riv	Christina River	Brandywine Riv	B'wine (001), Shellpot Creek	Contam. Stormwater
DE 00000	DuPont Exp. Sta.	Minor	Ind.		Delaware Riv	Christina River	Brandywine Riv		Stormwater &Cooling
DE 00005	DuPont Chestnut Run	Minor	Ind.	C	Delaware Riv	Christina River	Little Mill Creek	Chestnut Run & Willow R	Cooling Water
DE 00005	Gen. Motors Assembly	Minor	Ind.	A	Delaware Riv	Christina River	Little Mill Creek		Storm & Groundwater
DE 00510	Boeing	Minor	Ind.	A	Delaware Riv	Christina River	Nonesuch Creek		Contam. Stormwater
DE 00217	Greenville Country Club	Minor	Mun.		Delaware Riv	Christina River	Red Clay Creek	Tributary	Small STP
DE 00500	Center for Creative Arts	Minor	Mun.		Delaware Riv	Christina River	Red Clay Creek	Tributary	Small STP
DE 00002	Hercules, Inc.	Minor	Ind.		Delaware Riv	Christina River	Red Clay Creek		Cooling Water
DE 00004	NVF, Yorklyn	Minor	Ind.	C	Delaware Riv	Christina River	Red Clay Creek		Cooling & Processing
DE 00001	FMC Corp.	Minor	Ind.	A	Delaware Riv	Christina River	White Clay Creek	Cool Run	Cooling Water
DE 00201	Dragon Run Terrace MH	Minor	Mun.		Delaware Riv	Dragon Run			Small STP
ELIMINATED NPDES DISCHARGES									
DE 00003	Airco Industrial Gases	Minor	Ind.		Delaware Riv	Naamans Creek			Cooling Water
DE 00002	Ametek-Haveg Div.	Minor	Ind.	A	Delaware Riv	Christina River	Red Clay Creek		Cooling Water
DE 00507	Artesian Water Co.	Minor	Ind.		Delaware Riv	All N.C.C. Streams			Water Tank Rinse
DE 00216	Brandywine Raceway	Minor	Mun.		Delaware Riv	Christina River	Brandywine Riv	Br. of Beaver Creek.	Small STP
DE 00003	DuPont Stine-Haskell	Minor	Ind.		Delaware Riv	Christina River	West Branch		Cooling Water
DE 00218	Eleutherian Mills Lib	Minor	Mun.		Delaware Riv	Christina River	Brandywine Riv		Small STP
DE 00218	Hagley Museum	Minor	Mun.		Delaware Riv	Christina River	Brandywine Riv		Small STP
DE 00005	MEDAL, Willow Bank	Minor	Ind.		Delaware Riv	Christina River			Cooling Water
DE 00004	NVF Newark	Minor	Ind.		Delaware Riv	Christina River	White Clay Creek		Cooling Water
DE 00505	Q-C, Inc.	Minor	Mun.		Delaware Riv	Christina River	Red Clay Creek (Tributary of)		
DE 00508	Shellhorn & Hill	Minor	Ind.		Delaware Riv	Christina River			
DE 00002	Wilming. Finishing Co.	Minor	Ind.		Delaware Riv	Christina River	Brandywine Riv		Cooling Water