2.3 CONTAMINANTS ASSESSMENT

2.3.1 INTRODUCTION

For purposes of evaluating contaminants within the Chesapeake Basin, two broad categories, *nutrients* and *chemicals*, have been formed for presentation of this section. Specific nutrients discussed include nitrogen and phosphorus. Pathogens, which often occur in unhealthy numbers in the presence of high nutrients in surface waters, will also be included in the discussion of nutrients.

Chemicals are divided into classes, which include petroleum, solvents, and organics, pesticides and herbicides, PCBs, heavy metals, and other inorganics. Contaminants may enter the environment from a variety of sources. These sources include large industries, small businesses, mobile sources, agricultural operations, residential areas, and biological sources, as well as through the air transport of contaminants from outside the Basin. As the Chesapeake Basin in Delaware represents the headwaters of the various individual watersheds, water transport of contaminants from outside the Basin is not expected, with the exception of those waterways influenced by tidal action, such as the Chesapeake and Delaware Canal, and the Nanticoke River.

Some data contained within this section describe *potential* sources of contamination that, if left unmanaged or in the event of an accidental release, could have serious impacts on the environment. Other sources exist that are defined as potential sources because the Department does not currently possess information that definitively links a source to observable contamination. These potential sources may be considered *possible* or *suspected* sources.

Existing contamination may be the result of either past or present human activities. Past practices, such as landfill operations (now closed) and Superfund sites, may still be contaminant sources. Contamination from current activities may occur routinely, as in a permitted discharge of a municipal wastewater treatment plant; or may occur as a result of a spill or leak, as in ground-water contamination from a leaking underground storage tank. Contamination may be transported or exchanged between various media, such as a contaminant that was land applied that is subsequently transported in ground- or surface water.

The contaminant assessment that follows describes the various nutrient and chemical contamination sources that the Department has identified as existing within the Chesapeake Basin. These sources are grouped and presented as *source types*. As an example, landfills are considered a source type. Therefore, all landfills within the Basin are discussed under one heading. Under each source type, additional information is presented for those individual sources where contamination levels are of concern.

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CONTAMINANTS ASSESSMENT

Separate maps for nutrient and chemical sources are also presented in this section. As several towns (Bridgeville, Delmar, Georgetown, Greenwood, Laurel, and Seaford) represent high concentration areas for chemical contaminant sources, a third map is provided that presents details of each of these areas. Trends and/or data gaps within a source type also are identified. In order for users of this section to readily obtain additional information, each source type section includes an appropriate Department contact.

A database, called the *Site Index Database,* has been developed for known and potential contaminant sources within the Basin. A copy of this database is included on the accompanying CD-ROM. This database is designed to be an easy-to-update, central registry of contaminant site summary data. It is not intended to be a replacement for more detailed program-developed databases such as the Site Investigation and Restoration Branch's Site Status Database, but rather to be an index to site data stored by the various programs in the Department. The database includes basic site identification information (name, ID number, XY location, basin), site type (e.g., underground storage tanks, spray irrigation sites, etc.), and a contact for more details about the site. Besides this basic information, the database also includes monitoring activity status and contamination potential ratings by media (soil, sediment, surface water, ground water) and contaminant class (nutrients, bacteria, petroleum, organics, pesticides, PCBs, metals, and inorganics) for each site. Database contents can be queried and displayed on-line through the database interface. Through the linking of the database with the GIS program Arcview, any number of sites can be plotted on a map. Using this database, it is possible to answer questions such as "Where are all the known PCB contamination sites in the state?" or, "Are there any contaminated sites near a proposed land acquisition area?" Chesapeake site data currently loaded in the database includes:

- Animal Operations;
- Combined Sewer Overflows;
- Dredge Spoils (Confined Disposal Facilities (CDFs));
- Hazardous Waste Generators;
- Landfills and Dumps;
- Large On-site Septic Systems;
- National Pollutant Discharge Elimination System (NPDES) Outfalls;
- Pesticide Loading, Mixing and Storage Facilities;
- Salvage Yards;
- State and Federal Superfund Sites (SIRB);
- Sludge Application Fields;
- Spray Irrigation Fields;
- Tire Piles;
- Toxics Release Inventory (TRI) Locations; and
- Underground Storage Tank (UST) Facilities.

In addition to these, the Department also has data/maps for houses with individual septic systems throughout the Basin and the state.

2.3.2 NUTRIENTS (NITROGEN AND PHOSPHORUS)

2.3.2.1 Category Definition and Characteristics

Nutrient enrichment of surface waters is a natural process, spanning thousands of years, resulting from natural erosion and the breakdown of organic material. However, activities linked to soil erosion, domestic waste disposal, and runoff can greatly increase the rate and amount of nutrients reaching waterways, accelerating the nutrient enrichment process (305(b), 1998). Nitrogen (N) and phosphorus (P) are the major nutrients that cause eutrophication of surface waters. *Eutrophication* is defined as an increase in the nutrient status of natural waters that causes accelerated growth of algae or water plants, depletion of dissolved oxygen, increased turbidity, and a general degradation of water quality. The enrichment of lakes, ponds, bays, and estuaries by N and P from surface runoff or ground-water discharge is known to be a contributing factor to eutrophication. According to the *1998 (305(b)) Watershed Assessment Report,* nutrients pose a serious threat to water quality, aquatic life, and human health. Most nutrients are transported to estuaries and lakes by rivers and ground water. Agricultural runoff, urban runoff, and municipal and industrial point source discharges are the primary sources of nutrients.

2.3.2.2 Nitrogen

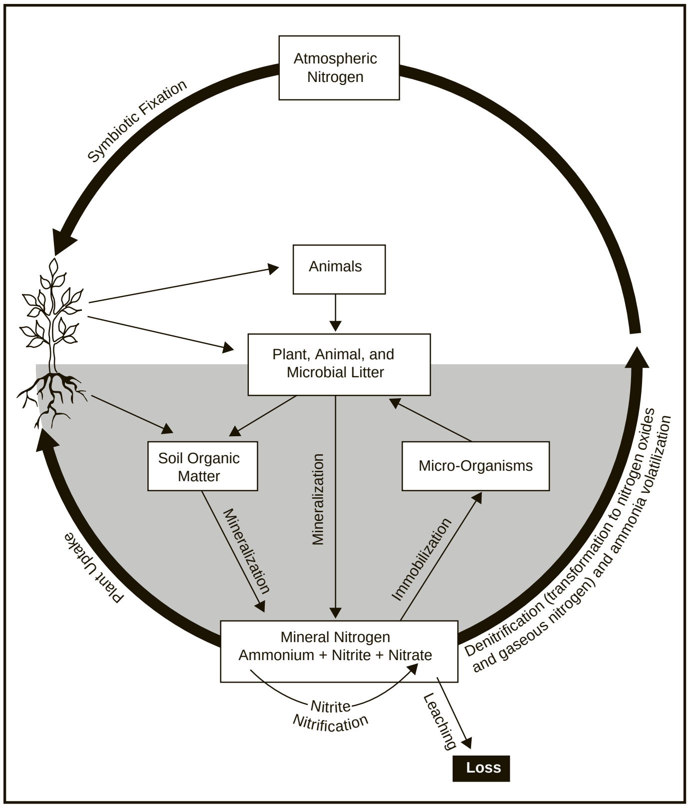
The soil nitrogen (N) cycle *(Figure 2.3-1 The Soil-Nitrogen Cycle)* is a conceptual summary of the interactions among the chemical and biological transformations undergone by N in the soil (Reeder, 1987). The key reactions for organic N sources include those that reflect the cycling of N between organic and inorganic forms (mineralization and immobilization); the gaseous losses (ammonia volatilization and denitrification); the losses associated with water movement (leaching and erosion); the symbiotic process of biological N fixation; and plant N uptake and subsequent removal in the harvested portion of crops. Many of these reactions are controlled by soil microorganisms which alter the form, oxidation states, and thus the fate of N, among N_2, N_2O (nitrous oxide), NH_3/NH_4^+ (ammonia/ammonium), NO_2^- (nitrite), and NO_3^- (nitrate). The relative importance of these reactions varies with soil and environmental conditions. Nitrate leaching is a major concern in humid regions (such as Delaware) where excessively well-drained soils overlie shallow-water tables (Sims, 1995).

Mineralization

Mineralization refers to the conversion of organic forms of N (proteins, amino sugars and nucleic acids) to ammonium-N (NH_4^+). Heterotrophic soil microorganisms that use the organic N as an energy source for their metabolism mediate the process. Once mineralized,

Figure 2.3-1

THE SOIL-NITROGEN CYCLE



NH_4^+-N can be nitrified, or converted, into nitrite (NO_2^-), and then nitrate (NO_3^-), by the actions of chemoautotrophic bacteria that are obligately aerobic, obtaining their carbon from CO_2 and their energy from the oxidation of NH_4^+ (ammonium). *Immobilization* represents the reverse reaction, and involves the assimilation of inorganic N (NH_3, NH_4^+, NO_2^-, NO_3^-) by soil microorganisms, and the transformation of these mineral forms of N into the organic compounds that constitute microbial biomass (Sims, 1995). The balance between these two biological reactions (mineralization and immobilization) determines the amount of plant-available inorganic N in the soil matrix.

Environmental factors controlling *mineralization*, *nitrification*, and *immobilization* reactions, as well as the soil itself, must be understood to ensure optimal quantities of available N when organic N sources are used as a fertilizer. As these processes are controlled by soil microorganisms, all parameters that affect biological activity (temperature, moisture, aeration, and soil pH) will influence the rate and extent of these three N transformations (Sims, 1995). "Optimum" conditions for these transformations have been broadly defined and vary slightly between mineralization-immobilization reactions and nitrification. For mineralization, optimum conditions are a temperature range of 40° – 60°C and a soil moisture content of 50 – 75 percent of soil water-holding capacity. For nitrification, optimum conditions occur when temperatures are 30° – 35°C, moisture content is 50 – 75 percent of soil water-holding capacity, and the pH value is between 6.0 and 8.0 (Sims, 1995).

Ammonia Volatilization

Ammonia volatilization refers to the loss of NH_3 from the soil as a gas and is normally associated with high free NH_3 concentrations in the soil solution and high soil pH. The most successful approach to reduce NH_3-N volatilization from organic wastes has repeatedly been shown to be rapid incorporation with the soil. For example, only 10 percent of the added NH_3-N was lost when poultry manure was incorporated immediately, as compared to a loss of 56 percent when it was incorporated after three days (Sims, 1995).

Denitrification

Denitrification is defined as the reduction of NO_3 to a gaseous form of N, by chemoautotrophic bacteria. As with all microbial reactions, denitrification is influenced by carbon (energy) availability, temperature, aeration/moisture, and soil pH. Amending soils with organic wastes generally increases the potential for denitrification losses of N (providing nitrification of organic N has occurred) because wastes provide available carbon and increase soil moisture-holding capacity.

Nitrogen can also be transported from organic waste-amended soils into ground water by leaching and to surface waters by erosion or runoff. Losses of N by leaching occur mainly as NO_3^- because of the low capacity of most soils to retain anions. In general, any downward movement of water through the soil profile causes leaching of NO_3^-, with the magnitude of loss being proportional to the concentration of NO_3^- in the soil solution and the volume of leaching water (Sims, 1995). Nitrate that leaches below the crop-rooting zone represents loss of a valuable plant nutrient, and hence an economic cost to agriculture. If the nitrate enters ground water, two major environmental problems can occur. The consumption by humans or animals of drinking water with high nitrate levels has been associated with several health problems, the most serious being methemoglobinemia (oxygen deficiency in blood) in infants. Additionally, ground water with high nitrate levels that discharge into sensitive surface waters can contribute to long-term eutrophication of these water bodies. The setting most conducive to NO_3^- (nitrate) leaching and ground-water pollution is a sandy, well-drained soil, with shallow water table, in an area that receives high rainfall and frequently applied fertilizers, manures, or other N source material (Sims, 1995). However, any situation involving overapplication of wastes and/or fertilizers, or intensive irrigation, has the potential to cause significant NO_3^- leaching, regardless of soil and climate (Sims, 1995).

According to Johnson (1976), ground water may contribute as much as 80 percent of the total flow in shallowly incised streams. Ground water also supplies most of the drinking water in Kent and Sussex counties. Chemical fertilizer, manure, and septic system leachate are major sources of ground-water nitrate contamination in Delaware. As evidence, researchers have noted a link between agricultural land activities and elevated ground-water nitrate levels (Ritter, 1984, 1992; Denver, 1989). Also, intense poultry production has been associated with elevated nitrate levels (Andres, 1992). Finally, septic tanks have been identified as a localized source of nitrate, especially when numerous systems are concentrated in an area (Denver, 1989). Provided a source of nitrate exists, a more critical factor is soil type and depth to water table (Ritter, 1984; Andres, 1991; Denver 1989; Bachman, 1984). Even if nitrate sources are extensive, areas with poorly drained soils do not tend to have high nitrate levels in ground water. Low oxygen conditions in poorly drained soils allow for greater denitrification so that nitrogen is lost to the atmosphere rather than leached into ground water.

Erosion

Erosion refers to the transport of soil from a field by water or wind. *Surface runoff* is the water lost from a field when the rate of precipitation exceeds the infiltration capacity of the soil. Both processes can transport soluble inorganic N and organic N to surface waters and contribute to the process of eutrophication or to drinking-water contamination. Several watershed studies have shown that most of the N lost by erosion or runoff is sediment-bound organic N (Sims, 1995). Although the solubility of NO_3^- favors its loss in runoff as opposed to sediment transport, total N losses from most watershed studies are usually several-fold greater than soluble N.

Surface applications of organic wastes are undesirable because they increase the likelihood of soluble and organic N losses by erosion and runoff. In agricultural operations, conservation practices designed to conserve soil by reducing tillage may involve applying manure to soil surfaces. Surface application of manure also occurs when farmers apply manure during winter months, when the soil is frozen and easily traversed by heavy equipment. The use of grassed waterways or filter strips that trap sediment and accumulate soluble N in plant biomass can help reduce N losses in these situations (Sims, 1995).

2.3.2.3 Phosphorus

Phosphorus (P) is an essential plant nutrient and vital for the successful production of agronomic crops. It is essential for most physiological processes in plants, such as photosynthesis, energy transfer, genetic regulation of cell division and growth, and the production of seeds and fruit (Sims, 1996). If soils are deficient in P, plants may become stunted, with poorly developed root systems. As a result, significant reductions in yield may occur. Studies show that long-term application of animal wastes to soils increases phosphorus levels well beyond the amount needed for effective crop production (Mozaffari and Sims, 1994). Phosphorus contributes to eutrophication by entering surface waters via erosion (sediment-bound P), runoff (soluble inorganic and organic P), or subsurface flow. Accordingly, accumulated levels of soil P must be reduced, and transport of soluble or sediment-bound P to sensitive water bodies needs to be inhibited.

Bioavailable phosphorus (BAP) (either dissolved or particulate form) in agricultural runoff can promote freshwater eutrophication (Sharpley et al., 1994). While dissolved phosphorus (DP) is immediately available for uptake by aquatic biota, a variable portion of particulate phosphorus (PP) represents a secondary and long-term source of BAP in lakes (Sharpley, 1993). Dissolved P in runoff originates from the release of P from a thin zone of surface soil and vegetative material. Particulate or sediment-bound P is associated with soil and vegetative material eroded during runoff. Bioavailable P includes DP and a portion of PP that is in equilibrium with DP and available for algal uptake.

Crop production systems are forced to continually use manure as fertilizer because of the lack of economically viable alternatives for manure disposal. As a result, these systems almost always build soil P levels well beyond ranges considered optimum for most agronomic crops. The unfavorable N:P ratio in most manures results in over-application of manure P relative to crop P needs. Consequently, soil test P has accumulated to levels that are of environmental rather than agronomic concern (Sharpley et al., 1996).

Phosphorus is retained in soils by several mechanisms, collectively referred to as “P fixation.” Phosphorus can also be immobilized in an organic form if the C:P ratio of an added organic material is high (normally greater than 300:1). The primary soil constituents involved in P retention are the hydrous oxides of iron (Fe) and aluminum (Al), the alumino-silicate minerals, soil carbonates, and soil organic matter. Amending soils with manures, litters, or other organic wastes has been shown to affect the adsorption-desorption process for P.

In animal wastes, phosphorus is found in both organic and inorganic forms (e.g. >50 percent of phosphorus in poultry litter can occur as inorganic phosphorus) (Goggin et al., 1997). Organic forms of phosphorus are slowly converted to soluble, inorganic forms (Mozaffari and Sims, 1996). In fact, phosphorus from animal waste is probably used by plants as efficiently as that provided in a broadcast, inorganic fertilizer. Most (>70 percent) of the phosphorus in

Delaware soils is fixed by aluminum or iron in forms that are only slowly available to plants (Mozaffari and Sims, 1996; Vadas, 1996).

In contrast to nitrogen, phosphorus levels are low in ground water, even in agriculturally affected ground water (Denver, 1989). Ground water is not considered a phosphorus-loading pathway. Phosphorus is lost from agricultural fields in either a soluble form dissolved in surface runoff and subsurface, laterally flowing water, or a particulate form bound to eroded soil particles or organic matter. Dissolved phosphorus can either leave a field in surface runoff; move through the soil and leave a field in subsurface, laterally flowing water; or percolate into the soil where it may eventually leave a field in water drained by tile drains or drainage ditches. 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 currently may be releasing phosphorus.

The Total Maximum Daily Load (TMDL) Regulation for the Nanticoke River and Broad Creek within the Chesapeake Basin call for nonpoint source nitrogen loads to be reduced by 30 percent and for nonpoint source phosphorus loads to be reduced by 50 percent from the 1992 baseline.

2.3.2.4 Bacteria (Pathogen Indicators)

As the name implies, *indicator bacteria* are indicators of pathogenic (disease-causing) bacteria and viruses. Sources of indicator bacteria (*enterococcus* and coliform) are widespread. Sources of most concern are those of human origin such as raw or inadequately treated sewage. Wildlife and animal operations such as feedlots can also be significant sources of indicator bacteria, although they represent less of a risk to human health compared to human wastes *(Watershed Assessment Report [305(b)],* 1998). High levels of bacteria pose an increased risk of illness to shellfish consumers, swimmers, and others who may come in contact with contaminated waters.

A quantitative measure of indicator bacteria in ambient water is performed semi-monthly at numerous sites within the Basin. Delaware uses a standard of 70 total coliform-n bacteria per 100 ml (running geometric mean); and fewer than 10 percent of samples may not exceed 330 total coliform per 100 ml.

Indicator bacteria are reflective of a concern for a variety of human enteric viruses, various other unclassified viruses, shellfish diseases, and bacterial pathogens.

At present, the *Total Maximum Daily Load* (TMDL) concept has been applied in Delaware only to marinas vis-̀a-vis indicator organisms. The concept is based on theoretical loading of bacteria that could indicate the presence of disease. The potential daily pathogen output from one person's untreated sewage could equal that of treated sewage from hundreds to possibly thousands of people (depending on the level of treatment). The boat/marina-related TMDL concept assumes zero fecal coliform background water, and establishes buffers around marinas based on the dilution volume required to reach the 70 total coliform per 100 ml standard. The dilution formula includes Delaware-specific loading factors, and is as follows:

$$\frac{\dfrac{2\, e^{9}\ fc \times 3.3\ \text{people/boat} \times .065\ \text{discharge rate}}{70\ \text{total coliforms per 100 ml}}}{\text{average depth}}$$

In addition, the Shellfish Program also tracks naturally occurring toxic phytoplankton. While the presence of these causative organisms is documented for the Chesapeake Basin, none have occurred at toxic levels.

All data from four stations in the Nanticoke Watershed are in excess of the 70 total coliform/100 ml shellfish harvest standard. Wading sample data collected from one station in the Trap Pond swimming area have led to swimming advisories for an average of 20 days per year. The geometric-mean swimming advisory criterion is 155 total enterococcus colony-forming units/100 ml. The single-sample standard is 360 units/100 ml.

Sampling for total coliform (a bacterial indicator of potential human illness/pathogens) commenced in March, 1991, in response to the illicit harvesting of freshwater clams (*Rangia cuneata*). Since then, none of the samples collected from Chesapeake Basin waterways have met the internationally mandated standard of 70 total coliform bacteria per 100 ml (running geometric mean), while more than 10 percent of the samples exceeded 330 total coliform per 100 ml. No sources have been directly linked to observable high bacteria counts. However, probable sources of contamination include combined sewer overflows, sewage treatment plants, suburban/urban runoff, agricultural runoff, and runoff from forested land. There is a statistical association between human illness and enteric indicator bacteria levels in ambient water. However, these bacteria are not specific to humans and may be associated with numerous warm-blooded animals. In addition, studies indicate that the bacteria are ubiquitous, possibly surviving in the environment, for example, in leaf litter. Additional studies provide supportive evidence that shows little or no association between indicator bacteria levels and human illness in areas not impacted by human sources or concentrations of domestic animals. As such, baseline data need to be established for bacteria (for example in forest or crop field situations). Bacteria levels in excess of background and associated with human or domestic animal sources — either by direct observation or DNA testing — is the basis for establishing TMDLs for bacteria. However, more studies are needed under extremely controlled conditions. In the absence of DNA testing, shoreline surveys such as sanitary assessments of pollution sources are used to identify the above sources. A comprehensive strategy should address all sources.

2.3.2.5 Inventory of Potential Sources

Source Type: Agriculture

According to the *1998 Delaware Agricultural Statistics Summary,* Delaware has 2,700 farms comprising 580,000 acres. The Chesapeake Basin is comprised of 488,792 total acres, with roughly half of this acreage used for agriculture. Agriculture is Delaware's number one industry, with poultry the primary agricultural product and largest animal based industry in the state.

Sussex County is the number-one broiler-producing county in the nation, with over 262 million broilers/roasters grown in 1995 (Delmarva Poultry Industry, Inc., 1996). Within Sussex County, the Indian River, Nanticoke River, and Broad Creek watersheds are meccas of poultry production (McDermott, 1995). For the Chesapeake Basin as a whole, a poultry inventory completed in 1997 indicates that there are 744 poultry farms in the Kent and Sussex County portions of the Basin.

The dairy industry is the second largest animal-based waste generator in Delaware (Goggin et al., 1997). Delaware Department of Agriculture records indicated approximately 100 registered dairy farms in Delaware. The animal inventory for 1987 lists 24 dairy operations in the Sussex and Kent County portions of the Basin. Overall, dairy farms are not increasing in number, although production reports indicate steady increases in total milk production by farm, as well as milk produced per cow.

Delaware's swine industry is currently undergoing major change. Delmarva is experiencing the arrival of integrated swine operations, similar to those seen in the poultry industry, and overtures have been made to establish contract-growing systems in Delaware. While producer numbers may decrease in Delaware, Delmarva may actually experience a net gain in the number of sows located in the region as the larger farms become more prevalent. Operating conditions in Delaware vary widely, with some hogs raised on dirt lots, and others raised in total confinement. (Goggin et al., 1997). Based on a 1987 animal inventory, 29 swine farms operate in the Sussex and Kent County portions of the Chesapeake Basin.

Environmental impact of dairy, swine, and beef manure may be of concern on a site-specific basis, but is of relatively less concern than the impact from poultry (McDermott, 1995). Dairy operations exist throughout the state. Beef cattle operations exist throughout the state, but the number of operations increase as one heads south. The swine industry is mostly in Sussex County, aggravating the existing problem of excessive nutrients in the county. The Broad Creek watershed has a high concentration of both swine and poultry operations (McDermott, 1995). A road survey of dairy, poultry, beef, and swine operations *(see Map 2.3-1 Known and Potential Nutrient Sources)* was accomplished in 1997 for Sussex County. Poultry operations, only, were inven-toried for Kent County using 1992 aerial photography. Progress is now under way to complete a comprehensive road survey (inventory) of all animal operations in Kent and Sussex counties and will include the number of animals for future usage.

Water-quality sampling and research from demonstration projects throughout Delaware indicate a strong need to be concerned about the fate and impact of nitrogen, phosphorus, and bacteria on surface and ground waters. According to the *Delaware Guidelines for Animal Agriculture* (1997), manure can be a valuable agricultural by-product if managed properly. Manure contains three major plant nutrients — nitrogen, phosphorus, and potassium, as well as essential elements like calcium, sulfur, boron, magnesium, manganese, copper, and zinc. Applying manure to fields provides valuable plant nutrients, improves soil tilth, aeration, and water-holding capacity, decreases soil erosion potential, and promotes the growth of beneficial soil organisms. Many manure application systems fail to fully utilize these nutrients. For example, applying manure in excess, or at the wrong time, or improperly handling it, may release nutrients into the air or water. Instead of only nourishing crops, the nutrients become pollutants. The major concern is that excess nitrogen may leach through the soil and into the ground water. Accordingly, nutrient management in areas dominated by animal-based agriculture is a major nonpoint source pollution issue. The *Nonpoint Source Program Assessment Report* (1995) calculated a statewide nutrient budget *(Table 2.3-1)* showing nutrient excess of 15,288 tons of nitrogen/year and 10,079 tons of phosphorus/year. According to McDermott (1995), chemical fertilizers alone are applied at rates greater than the calculated crop acreage requirements. When combined with chemical excesses, organic fertilizers, especially manures, become part of the overall problem. McDermott (1995) suggests that chemical fertilizers are less of a concern than manures because the former are more evenly distributed throughout the state. Manures, on the other hand, are not evenly distributed. Manure does not lend itself to inexpensive, easy transport due to its bulk, and thus has a tendency to be land applied in close proximity to the animal operation. The animal production industry, in particular the poultry industry, is not spread out, but rather, is concentrated in specific areas. Transport of manures away from these areas is limited and cost-prohibitive if transport distance is greater than 15 miles (McDermott, 1995).

Another management conflict arises when considering the N and P ratio in poultry manure. Applying poultry manure at rates that meet crop nitrogen requirements results in over-application of phosphorus. Land application of animal waste can add more P to soils than is removed in harvested crops, resulting in a long-term accumulation of soil P (Sims, 1997). Phosphorus buildup in Delaware soils has been documented by the University of Delaware's Soil Testing Laboratory (Cooperative Bulletin No. 45, 1993). A summary of 37 years of soil data at the laboratory shows that soil phosphorus levels have been steadily increasing in many areas. In 1994, 72 percent of all commercial crop soil samples received had a "high" or "excessive" level of plant-available phosphorus (no phosphorus fertilizer recommended). Twenty percent of all commercial crop soil samples from Sussex County had double the optimal level of phosphorus. Previous research in other Mid-Atlantic states indicates that it can take from 10 to 20 years, with no additional application of P, for normal cropping practices to deplete soil P from excessive to optimum levels (McCollum, 1991).

The University of Delaware does not recommend P application for fields that have high or excessive levels of plant-available phosphorus. At most, a minor starter application of P in the spring is recommended because soils do not release phosphorus fast enough for seedlings in the spring (McDermott, 1995). In addition, Sims (1995) notes that roughly half of the 290,000 acres of non-pasture cropland in Sussex County is in soybeans. Soybean production requires no nitrogen fertilizer and often only starter amounts of phosphorus. Sims (1995) suggests that, provided manure is not applied to soybean fields**,** poultry manure alone could meet all crop nutrient needs in Sussex County. McDermott (1995) suggests that any solution to phosphorus surface-water contamination must reconcile excessive phosphorus delivery with farmers' concerns for adequate crop fertilization.

In 1993, the Nonpoint Source Program, in conjunction with the Sussex Conservation District, initiated an intensive Watershed Implementation Project for the Nanticoke Watershed. The main goal of the project is to complete comprehensive resource conservation plans and provide follow-up on farms in the Broad Creek subwatershed. In 1994, a surface-water monitoring program was initiated to evaluate the effect of Best Management Practices (BMPs) on water quality. All surface-water monitoring samples were analyzed for ammonia, nitrates, kjeldahl nitrogen, ortho phosphorus, and total phosphorus. Grab samples were collected at all sites twice a month from July 1994 to September 1997. Results of this monitoring are available through the Nonpoint Source Program. In addition, *Table 2.3-2* summarizes other conservation planning initiatives that have taken place in the entire Chesapeake Basin since 1985.

The Nanticoke River Watershed is also a high-priority area for determining TMDLs for nutrients. In order to develop TMDLs, the Nonpoint Source Program funded development of a nitrogen and phosphorus budget for all major subwatersheds in the Nanticoke Watershed. The subwatersheds of the Nanticoke for which nutrient budgets were developed include Broad Creek, Deep Creek, Marshyhope River, Gum Branch, Nanticoke River, and Gravelly Branch.

Table 2.3-1

ESTIMATED AGRICULTURAL
NUTRIENT BUDGET FOR DELAWARE

NUTRIENT CONTRIBUTION BY SOURCE	TONS NITROGEN/YR (% OF TOTAL)	TONS PHOSPHORUS/YR (% OF TOTAL)
Chemical Fertilizer	22,127 (66%)	7,858 (59%)
Poultry	8,651 (25%)	3,845 (29%)
Cattle	2,175 (7%)	1,215 (9%)
Swine	365 (1%)	285 (2%)
Sludge	183 (.5%)	110 (1%)
Wastewater	3 (–)	< .1 (–)
Total Nutrient	**33,504**	**13,313**
Nutrients Required	18,216	3,234
Nutrient Excess	**15,288**	**10,079**

Source: *1995 Nonpoint Source Assessment Report* (McDermott, 1995).

Nutrient loads were calculated for different land uses, point sources, and nonpoint sources. Nonpoint source nutrient loads were calculated for wet, normal, and dry years. Point source loads were obtained from flow data and chemical analysis data obtained from the Department. In all six subwatersheds, the major source of nitrogen was cropland, which contributed N ranging from 45 to 79 percent of the total N (Ritter, 1995). The only significant point source for N is the DuPont nylon plant in Seaford (Nanticoke River subwatershed). In the Nanticoke River subwatershed, for a normal year, 45 percent of the N load is from cropland, and 39 percent from point sources. The Nanticoke River subwatershed is the only watershed that has a significant N point source load. In the other subwatersheds, the only significant point source for N is the Laurel sewage treatment plant in the Broad Creek subwatershed.

According to Ritter (1995), nitrogen from septic tanks ranges from 3 percent in three of the subwatersheds to 6 percent in Gravelly Creek. After cropland, forestland is the next largest contributor to nonpoint source nitrogen load. Nitrogen loads from forestland ranged from 6 percent for Nanticoke River to 30 percent for Gravelly Creek. Phosphorus load contributions for forestland ranged from 8 percent for Nanticoke River to 36 percent for Gravelly Creek.

The Broad Creek subwatershed has the greatest density of poultry per acre than any other subwatershed in the state. Approximately 50 percent of the land use is cropland while 44 percent is classified as forestland. Broad Creek and Nanticoke River have the largest number of poultry houses. These two subwatersheds also have the largest area of cropland. There are approximately 500 poultry and swine operations in the Broad Creek sub-watershed. Assuming 450 poultry growers in this sub-watershed raise 40,000 birds/flock with 5.75 flocks per year, the total manure production for the watershed would be over 100,000 tons/yr. Based upon the nitrogen content of broiler manure reported by Malone et al. (1992), the nitrogen application rate to cropland would be 175 lb/ac/yr. At these potential application rates, manure becomes a serious disposal problem that can create surface and ground-water quality problems. Both Broad Creek and Nanticoke River subwatersheds have a surplus of manure that ideally should be transported to other parts of the watershed for land application. The Nanticoke River and Broad Creek are both rated very high in susceptibility to nonpoint source water pollution, and are two of the highest priority watersheds in Sussex County *(1995 Nonpoint Source Assessment Report).*

According to Ritter (1995), cropland is the largest source of phosphorus in all six subwatersheds. Phosphorus loads from cropland ranged from 50 percent in the Nanticoke River subwatershed to 78 percent in the Marshyhope Creek subwatershed. The only significant source of point source phosphorus loads occurred in the Nanticoke River subwatershed. Approximately 35 percent of the phosphorus load originated from point sources, with the DuPont nylon plant being the largest contributor. Phosphorus loads from forestland varied from 8 percent in the Nanticoke River subwatershed to 36 percent in the Gravelly Creek subwatershed. Septic tanks contributed <4 percent of the phosphorus load in all six subwatersheds. Ritter (1995) suggests significant reductions in nitrogen and phosphorus loads could be achieved in the Nanticoke River subwatershed by reducing the nutrients in the point source loads.

On a final note, the rate of loss of farms and acreage in farms in Delaware has slowed in the last decade (Delaware Agricultural Statistics, 1996). Still, Delaware converts on the average a little over one percent of its farmland to other uses each year. While the beef cattle, dairy, and swine industries are not growing significantly, the poultry

Table 2.3-2

CHESAPEAKE BAY DRAINAGE AREA CONSERVATION ACTIVITIES

PRACTICE	CODE	UNIT	PLANNED NOT APPLIED	APPLIED
Waste Management System	312	Number	187	244
Waste Storage Facility	313	Number	126	244
Composter	317	Number	64	193
Nutrient Management	590	Acres	33,429	40,717
Pest Management	595	Acres	32,777	40,065
Filter Strip	393	Acres	288	30
Cover Crop	340	Acres	7,401	2,513
Residue Management	344	Acres	27,226	15,971
Grassed Waterway	412	Acres	5	5
Conservation Plans (Systems)	108	Acres	106,657	30,072
Soil Erosion Reduced	–	Tons/Ac/Year	–	43,612

Notes:

1. Information reflects only that data entered into the NRCS FOCS system. Other practices installed without NRCS or Conservation District Assistance are not included.
2. Resource Concern Data other than Soil Erosion Reduced not included.
3. FSA records indicate $2,224,800 spent on conservation through ACP Program from 1980 – 1996. Pro-rated for Chesapeake Bay Watershed — $735,000.
4. Program started in FY 97 (for five-year period) targets up to $2.6 million dollars in cost share in the Upper Nanticoke Watershed.

industry continues to increase its production (McDermott, 1995). This continued growth will require cropland for nutrient utilization. However, alternative markets for poultry litter (such as the horticulture industry or an energy source) must also be considered. On the peninsula, the poultry industry has developed the infrastructure necessary to perpetuate itself and grow. Here, the farmers grow the feed, poultry producers raise the birds, and the poultry integrator companies process them. Waste management and alternative uses for poultry litter must grow with the industry as well (McDermott, 1995).

Specific implementation/management recommendations that address agriculture as a contaminant source can be found in Section 3.1. For more information on nutrients and agricultural impacts, contact the Nonpoint Source Program.

Source Type: Pesticide and Fertilizer Mixing, Loading, and Storage Areas

These sites serve as areas to store, mix, and load pesticide products and/or liquid and solid fertilizer products. Products are generally stored in large bulk quantities. Products may be stored in individual packages in a warehouse or in large mixing tanks, drums, or mini-bulk containers.

The potential exists for a product to be released during mixing or loading of the product onto transporter vehicles or application equipment. The potential also exists for storage container failure. While some sites have modern containment systems, including dikes, berms, and product recovery systems, many do not.

Currently, the design of these facilities is not regulated, and no monitoring data exist for these sites. However, the U.S. EPA is developing draft regulations that address this shortcoming. Refer to *Map 2.3-1 Known and Potential Nutrient Sources* for the location of known sites. For more information, contact the Delaware Department of Agriculture, Pesticides Section.

Source Type: On-Site Septic Systems

Septic systems are the main method for treatment of domestic wastewater used in the rural or unsewered areas of the Chesapeake Basin. In portions of unsewered sections, especially rural homesteads and older subdivisions, cesspools are still being used. Most are undocumented. A cesspool is usually a large, open-bottomed tank, which drains both liquid and solid wastes directly underground. A septic system is a more engineered waste disposal system compared to a cesspool, and is usually comprised of a septic tank for solids and a distribution box and drainage field for liquids. The drainage field may be either gravity-fed or pressure-dosed.

Although domestic wastewater can contain a wide range of substances, its chemical composition is relatively simple compared to municipal wastewaters, which obtain liquid wastes from a variety of sources including housing, commercial, and industrial activities. Potential contaminants in domestic wastewater include dissolved organic matter, heavy metals, biological oxygen demand (BOD), pathogenic microorganisms, and soil nutrients such as nitrogen and phosphorus.

New Castle, Kent, and Sussex counties, and municipalities have governing authority over sewered areas and their locations. Currently, none of the counties has a central sewer district within the Basin. However, the municipalities of Georgetown, Greenwood, Bridgeville, Seaford, and Laurel have jurisdiction over sewer systems and sewer districts.

The 1990 census of population and housing provides percentages of central sewer systems vs. on-site septic systems. In the Chesapeake Basin, 82.4 percent of households had on-site septic systems, while 17.6 percent were centrally sewered. By comparison, statewide, 65 percent of households had central sewer, and 35 percent had on-site septic systems.

In 1985, the Department conducted site evaluations statewide and ceased usage of the archaic percolation test. Since 1985, a total of 15,500 site evaluations have been conducted in the Chesapeake Basin. This count includes lots evaluated prior to subdividing, possibly suggesting a lower number of sites than that actually permitted. Based upon septic records, 18,000 permits have been issued in the Chesapeake Basin since 1985.

The Chesapeake Basin has one of the highest percentages (95 percent of land area served by septic systems as compared to other basins in the state. Many of the parcels are strip developments along rural roadways. Due to moderate-to-poorly drained soil conditions, moderate limitations for on-site septic disposal exist. Systems that are suitable for this area range from gravity-fed systems to engineered, pressured systems.

Ritter and Scarborough (1995) estimated the nitrogen loading rate from septic disposal systems to ground water within the Nanticoke watershed to be approximately 14.1 to 28.2 pounds per acre per year. This loading rate is considerably higher than the 0.7 pound per acre per year nitrogen load in the Piedmont Basin. The higher rate is due to more permeable sandy soils and higher water table. For nitrogen loads, septic tank N content ranged from 2.9 percent in Marshyhope Creek and Nanticoke Creek to 5.5 percent in Gravelly Creek. Phosphorus loads for septic tanks ranged from <1.0 percent in Marshyhope Creek to 3.5 percent in Deep Creek (Ritter, 1995). These data suggest that septic tanks are not a major contributor to nonpoint source loads of nitrogen and phosphorus. However, this study only evaluated loading rates for functioning systems and did not calculate loads based on a percentage of inoperable or failing septic tanks.

Installing a septic system in Delaware involves three steps. The first step requires a site evaluation. Site evaluations consist of investigating, evaluating, and reporting basic soil and site conditions. 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 results of the hydraulic conductivity test conducted; easements; and underground and overhead utilities in the evaluated area. This siting procedure ensures that septic systems are properly located utilizing the following soil properties: permeability, texture, structure, consistency, redoximorphic features, slope, and depth to rock.

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 Ground Water Discharges Section. The final step after the permit is approved involves hiring a licensed system contractor to construct the system under supervision of the section.

In spite of this permitting process, there are approximately 80 septic system complaints filed with the Department on a yearly basis statewide in regards to malfunctioning on-site septic systems. On average, during a given year, the Department issues 2,200 on-site septic permits per year. Approximately 25 percent of these permits are for replacing existing disposal systems or components, with the remaining 75 percent of the septic permits issued for new home construction on individual lots. For further information, contact the Ground Water Discharges Section.

Source Type: Large On-Site Community Disposal Systems

Large community septic systems are on-site wastewater disposal systems which serve more than one lot or parcel or more than one dwelling unit of a planned development or industrial use. The projected daily wastewater flow in these types of systems is greater than 2,500 gallons. A large community system is a more complex waste disposal system, usually comprised of holding tanks for solids, and a pressure dosed distribution system. Similar to domestic wastewater from smaller on-site septic systems, community systems contain a wide range of substances: dissolved organic matter, heavy metals, pathogenic microorganisms, and nutrients such as nitrogen and phosphorus.

In the Chesapeake Basin, there are 13 permitted large on-site wastewater treatment and disposal systems. These systems are regulated under *The Regulations Governing the Design, Installation, and Operation of On-Site Wastewater Treatment and Disposal Systems*. These systems have a projected daily flow of wastewater ranging from 2,500 gpd to 24,300 gpd. All projects with estimated flows exceeding 2,500 gpd must be accompanied by a preliminary ground-water assessment, which is then reviewed by the Department's Ground Water Protection Branch. Eighty-five percent of the large on-site community systems fall under the state's criteria for requiring a site to have a licensed operator to maintain the system to ensure proper maintenance and operation. Seventy-seven percent of the large community system owners are required to monitor ground water on the project site for the following parameters: Depth to Water Table, Temperature, pH, Specific Conductance, Total Nitrogen, Ammonia as Nitrogen, Nitrate (NO_3) as Nitrogen, Coliform Bacteria (Total & Fecal), and Total Dissolved Solids. These monitoring parameters enable the Department to detect contaminants entering the ground water from on-site disposal systems. Such monitoring also helps the Department to discover/prevent ground-water contamination from crossing the property boundary of the site.

Source Type: Land Application of Wastes

Land application of wastewater, biosolids, and other residual wastes in a soil system is a viable alternative for the treatment, disposal, and beneficial reuse of municipal and some industrial wastes. Land treatment of wastewater and other wastes provides one of the most environmentally sound methods of managing wastewater and other residuals. The constituents (nutrients) in the wastewater are taken up by selected plants (farming), fixed in soluble forms (metal, phosphorus) in the soil, evolve as gases (ammonia), or leach into the ground water (nitrate and nitrite) where they are diluted. Land application of wastewater and other wastes provides ground-water recharge and enables governmental agencies the power to create incentives to maintain farmland or green spaces. The basic criteria for land treatment are:

- Quality standards for ground water and surface waters are not exceeded;
- Land application of wastes does not present a significant health problem; and
- The soil is not degraded so as to prevent future use for agriculture, forestry, or other planned development.

Current land treatment facilities are designed for a 25- to 50-year site life based on wastewater flow, nutrient loading, and metal loading. During the operation of systems, nutrient and metal content of the wastewater is monitored yearly to track the actual site life of these facilities over the long term. Generally, long-term effects of land treatment have shown decreased nutrient loading (compared with conventional farming fertilization practices); nutrient (nitrate) reduction in ground-water recharges; stream discharge decreases due to required conservation planning; and agricultural lands preservation.

In the Chesapeake Basin, there are six spray-irrigation land treatment facilities *(see Map 2.3-1 Known and*

Potential Nutrient Sources), ranging from food processing and textile finishing to domestic wastewater treatment and disposal. These systems have a projected daily flow of wastewater ranging from 3,200 to 452,000 gpd. All permitted land treatment systems undergo a comprehensive design review process. The review covers soil and hydrologic investigative work, and treatment and waste-loading calculations. After the permit review process is completed, land treatment systems are constructed based on plans and specifications submitted to the Department, and done so under the supervision of licensed operators. These licensed operators, in turn, properly operate and maintain the systems.

Two of the six permitted spray irrigation facilities in the Chesapeake Basin have recently ceased operations. The other four facilities continue to monitor the ground water for the following parameters: depth to water table, temperature, pH, specific conductance, total nitrogen, ammonia as nitrogen, nitrate as nitrogen, phosphorus, sodium, chloride, total dissolved solids, and coliform bacteria (domestic waste facilities only). These monitoring requirements enable the Department to detect contaminants entering the ground water from the land treatment systems. This will also the help Department prevent ground-water contamination from crossing adjacent property boundaries of the site. There are no permitted biosolid land application sites in the Chesapeake Basin. For further information, contact the Ground-Water Discharges Section.

Source Type: National Pollutant Discharge Elimination (NPDES) Reporting Facilities

Municipal and industrial sites that discharge wastewater to surface waters are subject to limitations, monitoring requirements, and other terms and conditions identified in the individual NPDES permit issued to each site. Individual permittees must report monitoring results monthly, using the Discharge Monitoring Report (DMR) form developed specifically for each facility. The DMR lists parameters in the discharge that have a reasonable potential to cause or contribute to water-quality problems in receiving waters. Example parameters are temperature, dissolved oxygen, pH, copper, oil and grease, benzene, and PCBs. Although the DMRs are submitted monthly, actual monitoring frequency ranges from “continuously” to “once per year,” depending on the discharge’s characteristics and its volume relative to the receiving waters.

Industrial sites that discharge only storm water may be permitted under an NPDES General Permit, which is a single permit that applies to a group of similar dischargers, e.g., trucking operations. Monitoring for storm-water discharges is typically less frequent, for example, three times in five years. *Table 2.3-3* lists the point source discharges for the Nanticoke Watershed.

Source Type: Landfills

Decomposition of organic waste such as household garbage or food processing by-products disposed of in landfills and dumps can be a source of unwanted nutrients to ground water and surface water. The decomposition process in landfills produces soluble nitrogen-rich decay products such as ammonia, nitrate, and complex organic compounds. Rainwater seeping through the waste transports these soluble nitrogen-rich compounds into ground water that ultimately discharges into streams. To produce significant quantities of nutrients, a landfill must contain large quantities of organic waste.

To be considered a potential nutrient source for the purposes of this assessment, a landfill or dump has to be at least 5 acres in size and contain household garbage or food processing by-products. Six landfills in the Chesapeake Basin meet these criteria facilities *(see Map 2.3-1 Known and Potential Nutrient Sources)*. Two are operating municipal solid waste landfills owned by the Delaware Solid Waste Authority. These landfills receive all municipal waste generated in Kent and Sussex counties, and are regulated by the Department’s Solid Waste Management Branch. The other four sites are closed landfills under the jurisdiction of the Site Investigation and Restoration Branch of the Department. Routine ground-water and surface-water monitoring of these sites indicates there have been no significant nutrient releases to date. For more information about these landfills contact the Solid Waste Management Branch or the Site Investigation and Restoration Branch.

Source Type: Toxics Release Inventory (TRI) Facilities

Manufacturing facilities report annually under the Toxics Release Inventory (TRI) on any reportable toxic chemical that is manufactured, processed, or otherwise used above certain thresholds. The reportable list includes 576 individual chemicals and 28 chemical categories. Reports contain data on releases of the specific chemical to air, water, and land, as well as information on chemicals in waste tranported off-site or managed on-site.

There are 14 facilities within the Basin that have reported under TRI since reporting began in 1988 (refer to *Table 2.3-4* and *Map 2.3-1 Known and Potential Nutrient Sources)*. For the most recent reporting year (1998), 12 facilities within the Basin (all located within the Nanticoke watershed) submitted 49 reports for 32 different chemicals. All reported on-site releases, for 1998, were to the air except for the release by DuPont Seaford of nitrates to the Nanticoke River.

For more information about the TRI database, contact the Emergency Planning and Community Right-to-Know (EPCRA) Reporting Program.

Table 2.3-3

POINT SOURCE DISCHARGES
FOR THE NANTICOKE WATERSHED
Individual NPDES Permittees in the Chesapeake Basin

PERMIT NO.	FACILITY	MAJOR OR MINOR?	INDUSTRIAL OR MUNICIPAL?
DE 0020249	Bridgeville WWTF	Major	Mun.
DE 0000035	DuPont Seaford	Major	Ind.
DE 0020125	Laurel WWTF	Minor	Mun.
DE 0050725	Mobile Gardens Trailer Park	Minor	Mun.
DE 0020265	Seaford WWTF	Major	Mun.
DE 0050971	S. C. Johnson and Son, Inc.	Minor	Ind.

Source Type: Combined Sewer Overflow (CSO)

Combined sewers are designed to carry both sanitary sewage (wastewater from domestic, commercial, or industrial sources) and urban storm-water runoff and to convey the "combined" sewage and storm-water flow to the treatment facility.

Combined sewer overflows occur during wet weather events when the combined sewerage and storm-water flows exceed the hydraulic capacity of the sewer system. CSOs are designed to relieve the sewer system of the excess flow and discharge it directly to a tributary or stream channel.

2.3.3 CHEMICALS

2.3.3.1 Category Definition and Characteristics

Contaminant sources located within the Delaware portion of the Chesapeake Basin consist of a variety of chemical contaminants, including heavy metals, solvents and organics, polychlorinated biphenyls (PCBs), pesticides and herbicides, and petroleum. Chemical contamination may adversely impact human health or the environment through various toxic effects that different chemicals pose.

Chemical contaminants have been grouped into the following classes:

- Heavy Metals — Includes iron, arsenic, cadmium, chromium, manganese, nickel, lead, barium, and zinc. Some metals are carcinogenic or poisonous to humans and/or other organisms. In high concentrations, metals such as iron or manganese can render water unsuitable for drinking due to taste and staining, even though they might not cause specific health problems.
- Solvents and Other Organic Compounds — Includes organic chemicals such as chlorinated solvents, degreasers, paint thinners, alcohols, and certain chemical feedstocks. Many of these chemicals are carcinogenic or poisonous to humans and/or other organisms.
- PCBs — A class of organic compounds formerly used in electrical transformers and switches. These compounds are generally insoluble in water and break down very slowly under normal environmental conditions. They can accumulate in stream sediments where they can be directly or indirectly ingested by fish. Most forms of PCBs are considered carcinogenic.
- Pesticides and Herbicides — Are carcinogenic and/or poisonous to humans and other organisms. Many pesticides or herbicides have the potential of being biologically concentrated in the highest part of the food chain.
- Petroleum — Includes but is not limited to gasoline, heating oil, diesel fuel, kerosene, and waste oil. Certain compounds contained within each product, such as benzene, are carcinogenic or poisonous to humans and/or other organisms.
- Other Inorganic Compounds — Includes chemicals such as chlorides, sulfates, and Total Dissolved Solids (TDS).

Contaminant sources located within the Chesapeake Basin containing the above chemical groups are discussed in more detail under the different source types discussed below. Source locations are provided on *Map 2.3-2 Known and Potential Chemical Sources,* with *Map 2.3-3 Known and Potential Chemical Sources – City Details* showing close-ups for the cities and towns in the Basin.

2.3.3.2 Inventory of Potential Sources

Source Type: Agriculture

In addition to the nonpoint source nutrients discussed above, many agricultural practices also apply non-nutrient chemicals, such as lime or pesticides, to large areas of land in the Basin. If care is not taken, this can be a significant source of chemical contamination.

Source Type: Pesticide and Fertilizer Mixing, Loading, and Storage Areas

These sites store, mix, and load pesticide products and liquid and solid fertilizers. The products are usually purchased in large bulk quantities, and stored in individual packages in a warehouse, or in large mixing tanks, drums, or mini-bulk containers.

Product may potentially be released during mixing or loading into transporter or application equipment. The product storage containers may also fail. While some sites have modern containment systems, including dikes, berms, and product recovery systems, others do not.

Currently, the design of such facilities is not regulated. Consequently, no data are available on pesticide/fertilizer releases from mixing, loading, or storage areas.

Source Type: Landfills

Waste disposed of in landfills and dumps can be a source of a wide variety of contaminants. Rainwater seeping through a landfill dissolves or leaches out contaminants present in the waste. The resulting leachate, if not properly managed and contained, may contaminate nearby ground water and surface water. The composition and concentration of the leachate depends on the type and volume of waste in the landfill. Landfills and dumps in the Chesapeake Basin primarily contain:

- Municipal waste — trash from households, offices, and stores with significant amounts of putrescible food waste;
- Miscellaneous non-putrescible waste — waste from road clean-up activities, construction and demolition activities, old appliances, etc.; and/or
- Coal ash — from combustion of coal to generate electric power and steam.

Table 2.3-4

TRI FACILITIES REPORTING WITHIN THE CHESAPEAKE BASIN (1987 – 1998)

FACILITY NAME	YEARS	CHEMICALS REPORTED
Allen Petroleum	1998	Benzene, Ethylbenzene, N-Hexane, MTBE, Toluene, 1,2,4-Trimethylbenzene, Xylene, Zinc Compounds
Allen's Milling	1995 – 1998	Arsenic Compounds, Copper Compounds, Manganese Compounds, Zinc Compounds
American Original Foods	1987 – 1989	Phosphoric Acid, Sodium Hydroxide
Agrilink Foods	1989 – 1998	Ammonia, Chlorine
DuPont – Seaford	1987 – 1998	Antimony Compounds, Barium Compounds, Biphenyl, Chlorine, Chromium Compounds, Formaldehyde, Hydrochloric Acid, Methanol, Nitrate Compounds, Phosphoric Acid, Sodium Hydroxide, Sodium Sulfate, Sulfuric Acid, Tetrachloroethylene
Gardner Asphalt	1988 – 1993, 1996 – 1998	Anthracene, Asbestos (friable), Dibenzofuran, Polycyclic Aromatic Compounds
Lebanon Chemical	1989 – 1990	Manganese Compounds, Phosphoric Acid
Marble Works	1991 – 1998	Acetone, Styrene
Nanticoke Homes	1991 – 1998	Dichloromethane, Ethylene Glycol, Methylene bis(phenylisocyanate), Toluene, Xylene
Orient Chemical	1992 – 1998	Aniline, Chromium Compounds, Hydrochloric Acid, Nitrobenzene
Peninsula Oil – Blades	1998	Benzene, Ethylbenzene, N-Hexane, MTBE, Toluene, 1,2,4-Trimethylbenzene, Xylene
Perdue – Bridgeville	1988 – 1998	Copper Compounds, Manganese Compounds, Zinc Compounds
Rite Off	1993 – 1998	1,1-Dichloro-1-fluoroethane, Dichloromethane, Glycol Ethers, N-Hexane, Tetrachloroethylene, 1,1,1-Trichloroethane, Trichloroethylene
S. C. Johnson & Sons	1993 – 1998	Ammonia, Butyl Acrylate, Ethyl Acrylate, Glycol Ethers, Hydrochloric Acid, Methyl Methacrylate, Styrene

Leachate from municipal waste landfills is typically high in complex organic degradation compounds, ammonia, chlorides, alkalinity, chemical and biological oxygen demand (COD and BOD), iron, and sulfate. It may also have smaller amounts of volatile organic compounds and heavy metals. Besides leachate, municipal waste landfills also generate large amounts of methane gas.

Leachate from miscellaneous non-putrescible waste landfills is typically high in alkalinity, iron, and sulfate, but lacks the organic decay products and ammonia typical of municipal waste leachates. It may also contain smaller amounts of volatile organic compounds and heavy metals. Miscellaneous non-putrescible waste landfills can generate methane gas if they contain wood waste and hydrogen sulfide gas if they contain gypsum wallboard.

Leachate from coal-ash landfills is typically high in sulfate and iron and often contains a variety of heavy metals, including arsenic. These landfills do not generate gases.

Excluding the landfills covered under the Site Investigation and Restoration Branch (SIRB), there are nine landfills and dumps documented in the Chesapeake Basin *(Map 2.3-2 Known and Potential Chemical Sources)*. Two of these landfills are major municipal waste landfills operated by the Delaware Solid Waste Authority. These two landfills, each covering 60 to 70 acres, receive all municipal waste generated in Kent and Sussex counties. Liners to protect ground water and surface water from contamination underlie each landfill. They also include leachate and methane collection systems. Monitoring results from these two landfills indicate that they are significantly impacting the environment.

There are five miscellaneous non-putrescible waste landfills and dumps in the Chesapeake Basin. All are less than 6 acres in size, and the waste is generally only a few feet thick. None of these landfills is operating today.

There is one coal-ash landfill and one coal-ash settling pond complex in the Chesapeake Basin. Both are located at the DuPont Seaford plant. Monitoring results indicate that these coal ash areas may be causing sulfate and arsenic contamination of local ground water. This site is currently under investigation.

For more information about these landfills, contact the Solid Waste Management Branch.

Source Type: Tire Piles

There are five large waste tire piles in the Chesapeake Basin. The piles contain 3,000 to 50,000 tires (see *Map 2.3-2 Known and Potential Chemical Sources)*. Other than serving as a breeding ground for mosquitoes, these tire piles are causing no apparent environmental problems. However, these piles do present a significant environmental risk if they catch on fire. Tire pile fires are very difficult to put out. Large tire piles may burn for weeks before being extinguished. Tire pile fires generate large amounts of noxious smoke that may necessitate evacuation of downwind residents. The fires also generate organic liquids that can contaminate ground water and surface water.

For more information about these tire piles, contact the Solid Waste Management Branch.

Source Type: Hazardous Waste Facilities

The Hazardous Waste Management Branch regulates facilities that generate, accumulate, transport, treat, store, or dispose of hazardous waste. Many manufacturing processes commonly generate hazardous waste. If released, hazardous waste can cause notable harm to human health and the environment. Hazardous waste can be of two types:

- Listed hazardous waste. Listed hazardous wastes are specifically identified in the *Delaware Regulations Governing Hazardous Waste*. Currently, there are more than 400 such wastes listed. The wastes are listed as hazardous because they are known to be harmful to human health and the environment.
- Characteristic hazardous waste. Even if a waste is not listed, it may still be regulated as hazardous if a *characteristic* of hazardous waste is exhibited. Charac-teristics of a hazardous waste include ignitabilty, corrosivity, reactivity, and toxicity.

Within the Chesapeake Basin, 83 facilities are identified as hazardous waste generators. Of the 83, ten facilities have been identified as large quantity generators (LGQ), generating greater than 2,200 pounds of hazardous waste per month. Twenty-nine facilities have been identified as small-quantity generators (SQG), generating between 220 pounds and 2,200 pounds of hazardous waste per month. Forty-four facilities have been identified as conditionally exempt small-quantity generators (CESQG), generating less than 220 pounds per month. The Site Index Database contains a list of these sites, along with the types of hazardous waste generated at each site.

Although all facilities regulated by the Hazardous Waste Management Branch have the potential to release contaminants to the environment, most facilities manage their wastes in a responsible manner and, thereby, minimize the possibility of a release occurring. Furthermore, the proactive regulatory stance adopted by the Hazardous Waste Management Branch has increased companies' awareness and usage of proper hazardous waste management practices. For further information about hazardous waste generators in the Chesapeake Basin, please contact the Hazardous Waste Management Branch.

Source Type: Hazardous Chemical Inventory Reporting Facilities

Facilities report under the Hazardous Chemical Inventory for each hazardous chemical (as defined by OSHA) or extremely hazardous substance (EHS) present above threshold quantities. The basic threshold is 55 gallons or 500 pounds, whichever is lower, based on the maximum amount present on site at any time during the calendar year. Certain EHSs have a lower threshold. For each chemical or mixture, facilities report the identity of the substance, the amount present, and storage location information. This information has three primary purposes. Local Emergency Planning Committees (LEPCs) use it to develop plans to prepare for and respond to chemical emergencies in their districts. The 911 Fire Dispatch centers access the chemical information during emergencies at facilities and provide this information to local fire fighters and other emergency personnel responding to the site. The information is also available to the public to promote public participation in managing chemical risks in the community.

Approximately 1,200 facilities statewide report chemicals each year to the Hazardous Chemical Inventory, with an estimated 300 of these facilities located in the Chesapeake Basin. The data are made available to users through the Computer-Aided Management of Emergency Operations, or CAMEO, data system. The CAMEO system contains basic facility information such as facility name and street address, as well as the chemical-specific inventory information. CAMEO also contains a variety of other data modules used for emergency planning and response.

CAMEO runs in conjunction with a basic GIS mapping system named *MARPLOT*. While New Castle County is presently the only county to use MARPLOT, efforts are under way in Sussex County to map reporting facilities. Mapping will be performed by the Sussex County LEPC. Similar mapping for Kent County has yet to be planned. MARPLOT layers should be easily transferred to the Department's GIS system for inclusion in watershed assessments. While these facilities report only the presence of chemicals and not releases to the environment, a geospatial representation of these facilities would contribute greatly to the Department's overall knowledge of potential sources of chemical contamination.

Therefore, the Chesapeake Basin Team recommends that the Department encourage and support the efforts of the LEPCs to map the facilities in their districts and to periodically update information. If efforts by the LEPCs do not meet the needs of the Department, the Team recommends that funding be sought to have this mapping performed either by the LEPCs or the Department.

The Hazardous Chemical Inventory reporting and CAMEO data systems are managed by the Emergency Planning and Community Right-to-Know (EPCRA) Reporting Program and can be contacted.

Source Type: Toxics Release Inventory (TRI) Reporting Facilities

Manufacturing facilities report annually under the Toxics Release Inventory (TRI) on any reportable toxic chemical that is manufactured, processed, or otherwise used above certain thresholds. The reportable list includes 576 individual chemicals and 28 chemical categories. Reports contain data on releases of the specific chemical to air, water, and land, as well as information on chemicals in waste tranported off-site or managed on-site.

There are 14 facilities within the Basin that have reported under TRI since reporting began in 1988 (refer to *Table 2.3-4, Map 2.3-2 Known and Potential Chemical Sources,* and *Map 2.3-3 Known and Potential Chemical Sources – City Details)*. For the most recent reporting year (1998), 12 facilities within the Basin (all located within the Nanticoke Watershed) submitted 49 reports for 32 different chemicals. All reported on-site releases, for 1998, were to the air except for the release by DuPont Seaford of nitrates to the Nanticoke River.

For more information about the TRI database, contact the Emergency Planning and Community Right-to-Know (EPCRA) Reporting Program.

Source Type: Superfund Sites

The investigation and remediation of this country's most serious hazardous waste sites are performed through the Federal Superfund Program, which established a National Priority List (NPL). In 1990, Delaware enacted the Hazardous Substance Cleanup Act (HSCA), administered by the Site Investigation and Restoration Branch (SIRB), to deal with other potentially harmful sites not addressed through the Federal Program. In 1993, the SIRB Branch initiated the Voluntary Cleanup Program (VCP), which is administered under the Hazardous Substance Cleanup Act. The VCP is primarily designed to address the properties that are being evaluated for transaction or redevelopment and properties where no immediate threat to human health or the environment exists.

A total of 34 SIRB sites, either under state or federal jurisdiction, are located in the Chesapeake Basin. The Sussex County Landfill #5 and the Harvey & Knott Drum Site, are on the NPL while the Seaford Arbutus well is currently under EPA Operation & Maintenance (O&M).

The 37.5-acre Sussex County Landfill #5 operated from 1970 until 1979, and accepted mixed municipal and industrial wastes. After closure, monitoring wells were installed at the site, and a ground-water plume, comprised of organics and select metals, was found extending 400 to 500 yards from the site. Subsequent monitoring has shown that the plume has ceased to increase in size. Ground water on-site is being monitored semi-annually and is being evaluated under the EPA Five-Year Reviews during O&M phase.

The 3-acre Harvey and Knott Drum Site was an operating open dump and burning area between 1963 and 1969.

The facility accepted sanitary, municipal, and industrial wastes, some of which may have been comprised of sludges, paints, pigments, and solvents. Volatile organic compounds and metals were detected in ground water at the site. Prior EPA activities at the site included a large-scale drum and soil removal, capping of lead-contaminated soils, and removal and disposal of water contained in a pond located in the drum disposal area. On-site ground water is currently being monitored semi-annually during the EPA O&M Phase. It appears that ground-water contamination is localized, and that any contaminated ground water-to-surface water discharge is being successfully filtered within the adjacent wetlands.

Contamination in the Seaford Arbutus well was initially discovered through odor complaints from residents. An ensuing Site Inspection discovered high concentrations of tetrachloroethylene (PCE) and lesser concentrations of trichloroethylene (TCE) in the ground water. The EPA Removal Branch issued an Administrative Order for Removal Response Action to the responsible parties. Currently, a granular activated-carbon absorption system is in place at the well, and the EPA continues to monitor the ground water at the site.

Fourteen sites are listed under the authority of HSCA: eight are considered 'Low Priority' (there is no immediate known threat to human health or the environment), one needs no further action (following a series of investigations), and three are undergoing investigation and review. Additionally, four other sites in the Chesapeake Basin are under the authority of the VCP.

Additional information regarding the sites mentioned in this section may be obtained from the accompanying Site Index Database, from the SIRB Web Site (http://www.sirb.awm.dnrec.state.de.us), or from the Site Investigation and Restoration Branch directly.

Source Type: Underground Storage Tank Sites

Leaking underground storage tank (UST) sites have been the source of over 2,000 reported releases of chemical contaminants into Delaware's environment for the past 20 years. Contaminant releases often result from:

- Corrosion, breaks, ruptures or other types of structural damage in the tank or associated piping, dispensers, or other tank system components;
- Loose fittings in the tank system piping, associated dispensers, or other tank system components; or
- Spills and overfills that routinely occur during tank filling and dispensing operations.

Except for spills and overfills, contaminants are released below ground, and no release may be suspected by the tank owner or operator as many tank leak rates are often very low compared to the amount of fuel dispensed. Unless the tank is equipped with properly functioning leak detection equipment, and unless the operator is trained to use such equipment properly, leaks can continue unnoticed for many years. Such leaks continued undetected until a sensitive receptor, such as a water well (i.e., drinking water), utility line, or a building basement (explosive situation) has been impacted. By that time, the area that was impacted may have been severely environmentally damaged, and resulting site remediation costs escalated to several million dollars.

Released contaminants (including petroleum products) migrate downward through backfill, soils, and sediments surrounding the tank to the water table. Most products stored in USTs have a specific gravity that is less than one. As a result, any free-phase product that makes it to the water table not only floats on ground water but will migrate in the direction of ground-water flow. Because the water table in the Delaware portion of the Chesapeake Basin is often within 10 feet of the ground surface, a very small release from an UST may be sufficient to contaminate ground water. Once ground water becomes contaminated, the potential to impact domestic or public drinking-water wells increases, especially if these wells are screened in the water table aquifer. Surface-water bodies such as rivers, ponds, or lakes also can be impacted by a release from an UST facility.

UST site releases have become a growing concern in Delaware, including the Chesapeake Basin, over the past 20 years, especially because water wells and other sensitive receptors have been impacted.

Most UST systems in Delaware store petroleum products which include, but are by no means limited to: gasoline, kerosene, jet fuels, diesel fuel, heating oil, and used oils. USTs also may contain a variety of hazardous substances, such as chlorinated solvents.

Petroleum products can contain more than 100 different hydrocarbon compounds, many of which have been shown to be toxic to humans and wildlife. For example, benzene, a common constituent of gasoline, has been shown from epidemiological studies to be a human carcinogen. Benzo(a)anthracene and benzo(a)pyrene, which are common constituents of heating fuels, are probable human carcinogens.

Chemical compounds are commonly added to petroleum products to make these products burn more efficiently, and to reduce emission of toxic chemical compounds into the air. For example, the requirements of the Federal Clean Air Act Amendments of 1990 require that gasoline dispensed in Delaware contain up to 15 percent methyl tertiary butyl ether (MTBE). Unlike benzene and other hydrocarbon compounds present in petroleum, MTBE does not significantly biodegrade in the natural environment and dissolves into ground water much more easily, thus making remediation more difficult. Dissolved MTBE molecules migrate through ground water much more rapidly than other hydrocarbon compounds. As a result, MTBE is usually one of the first chemicals from a release to impact drinking-water supplies. The EPA is currently conducting studies to determine if MTBE is a carcinogen. MTBE contamination is of great concern to the UST Branch because it has been documented in an increasingly greater number of new and existing leaking UST sites over the past few years.

There are currently 422 registered UST facilities and 235 identified leaking UST sites in the Chesapeake Basin. Seventy-two leaking UST sites are active, with the remainder closed or de-activated by the Department. Essentially, closed or inactive leaking UST sites are those sites where site investigation and remedial actions have been completed, and apparent threats to human health, safety, or the environment have been eliminated. Thus, the UST Branch requires no further action at closed or inactivated sites.

Although no data exist on the number of active sites in the Basin prior to 1997, it is likely that trends for the Delaware portion of the Chesapeake Basin are similar to those of the entire state. That is, available data show that the number of active sites statewide increased rapidly from 1983 through 1990, and then leveled off at about 550 sites. It is likely that the number of active sites will slowly decrease over the next several years.

Any UST site in the Basin, even one where no known release has occurred, is a potential source of contamination. Concern for releases is genuine, as even a small release can impact and degrade ground water due to occurrence of the water table so close to the ground surface. As a result, all registered UST sites in the Chesa-peake Basin are included in the accompanying Site Index Database. Each registered UST site is also shown on *Map 2.3-2 Known and Potential Chemical Sources,* and *Map 2.3-3 Known and Potential Chemical Sources – City Details.*

It is important to note that not every UST in the Chesapeake Basin is registered with the Department. This includes UST facilities that are “exempt,” under current regulations, from registering with the Department. Most of the “exempt” USTs are heating oil tanks with capacities of 1,100 gallons or less for which no leaks or releases have occurred. Once a release has occurred, an “exempt” UST *becomes regulated* and the release must be cleaned up to levels that are not a threat to human health, safety, or the environment (as required at any leaking UST site). The Department has documented many cases of releases that have occurred in previously “exempt” tanks, and where stringent site remediation was required. Therefore, any currently “exempt” tank also has release potential.

Releases from “exempt” tanks are more difficult to detect and track because the Department does not regulate them. Detection occurs only during property transfer proceedings or after a sensitive receptor such as a water well is impacted. Thus, it is likely many releases have occurred from “exempt” tanks that the Department is not aware of, whereas those from regulated tanks under similar circumstances would likely be known. The relative lack of release data for “exempt tanks” represents a major data gap at UST sites.

Ground-water contamination has been documented in 56 leaking UST sites in the Chesapeake Basin. Severe ground-water contamination, including the presence of free-phase hydrocarbons, has been documented for 22 of these sites. Off-site contaminant migration has been observed at six sites.

Current UST regulations require that any UST installed after 1985 must comply with “new” tank standards, including protection against corrosion, and be equipped with spill and overfill protection and leak detection equipment. New tank systems cannot be put into operation until they pass a precision tank test (which is used to determine if a tank is leaking). Those tanks installed before the regulations went into effect in 1986 must have been either upgraded to comply with new tank standards before 1991 (except for corrosion protection) or be removed from the ground. Existing tanks still not equipped with adequate corrosion protection by 1998 must be either upgraded to comply with new tank corrosion protection requirements or be removed. Inventory control, recordkeeping, precision tank testing, as well as monitoring of leak detection equipment (including vapor and observation wells) and corrosion protection equipment, are required by owners and operators of all regulated USTs.

One of the major challenges of the Underground Storage Tank Branch is to (1) ensure that tank owners and operators bring their tanks into compliance with the regulations; (2) report any releases; and (3) effectively remediate contamination released at UST sites.

UST facility and leaking UST site records are available to the public through the Freedom of Information Act (FOIA) process. Anyone who wishes to review information regarding a specific UST site or has any questions regarding current UST regulations or UST Branch policies and guidelines should contact the UST Branch.

Source Type: Large On-Site Community Disposal Systems

Large community septic systems are a potential source of chemical contamination. The typical contamination is consumable salts, especially chloride (Cl). However these systems can also act as rapid pathways for various household chemicals (degreasers, cleansers, etc.) to the subsurface.

Source Type: Land Application of Wastes

Land application sites can vary in regard to their chemical constituent concentrations. The main chemicals of concern in the Chesapeake Basin for industrial facilities are sodium and chloride. Chloride is also a potential contaminant from domestic wastewater facilities. Although many treatment systems receive other chemicals from domestic wastewater, the treatment process generally removes any chemical contaminants through aeration, volatilization, and chemical breakdown prior to land application.

Source Type: Dredge Spoil Areas

Chesapeake and Delaware (C&D) Canal. The C&D Canal is a navigational waterway to the Port of Baltimore maintained by the U.S. Army Corps of Engineers. The canal system provides a continuous sea-level channel connecting the Port of Baltimore to the northern ports of Wilmington, Philadelphia, and northern trade routes.

The federal government owns nearly 9,000 acres along the Chesapeake and Delaware Canal, and leases roughly 180 acres. The leased federal land is used for agricultural (39 acres) and disposal purposes, as well as for habitat and recreational purposes. Most of the unleased federal land (5,426 acres) along the canal is used for disposal of material resulting from maintenance dredging performed to sustain the authorized channel dimensions. *Map 2.3-2 Known and Potential Chemical Sources* shows locations of the dredge disposal areas.

Man-made embankments along the canal are the result of years of disposal activity and maintenance to authorized canal depths. Through a series of agreements, the states of Delaware and Maryland manage approximately 7,500 acres of property for recreation and wildlife management. These areas encompass historically filled disposal areas as well as many active (diked) disposal areas.

Nineteen upland disposal sites have been actively used by the federal government over the last 25 years for maintenance dredging of the Chesapeake and Delaware Canal. A 10-year monitoring program was initiated in 1987 to monitor heavy metal concentrations in vegetation, surface water, and ground water. DNREC and the Maryland Department of Natural Resources conduct soil, groundwater, and surface-water sampling on a regular basis. To date, results show the sampled media is not an environmental concern.

Nanticoke River. Dredging operations within the Nanticoke River Basin are conducted by the U.S. Army Corps of Engineers and confined to the main stem of the Nanticoke River between its mouth at Tangier Sound/ Chesapeake Bay, Maryland, and the Route 13-A bridge at Seaford and Blades, Delaware. In addition, two Nanticoke tributaries, Marshyhope Creek and Broad Creek, have been dredged. With the exception of Broad Creek, the Corps has continued to maintain navigable depths in these waterways because of the vital role they play in economic development and growth.

During the 1980s, the Corps implemented two maintenance-dredging projects to alleviate shoaling conditions hindering commercial shipping activities in the river. In 1983, one such project involved removal of 30,000 cubic yards of material from the Hawks Nest Shoal area of the main channel and from the section between Turtle Creek and the Seaford Harbor. Another project initiated in 1989 – 90 dredged over 50,000 cubic yards of material between Turtle Creek and the Harbor.

Sussex County provided confined disposal facilities to retain the dredge material from the above two projects. In 1983, the County secured a 6-acre tract of upland near the Delaware-Maryland State Line, and, in 1989, secured a 25-acre tract of upland on property owned by the DuPont Company. *Map 2.3-2 Known and Potential Chemical Sources* shows locations of these disposal facilities. Records of areas used for disposal before 1980 are not readily available, but there is speculation that Prickly Pear Island was created as a result of dredging activities in the downstream portion of the Nanticoke River.

Source Type: Salvage Yards

Automobile salvage yard and scrap metal recycling facilities provide a valuable service by recovering and recycling usable materials from discarded vehicles and equipment. While salvage operations are beneficial, the associated products and generated wastes have the potential to harm human health and the environment. Products and wastes from salvage operations include used oil, antifreeze, spent solvents, refrigerants, petroleum fuels, lead-containing wastes (e.g., batteries), tires, automobile fluff, and other solid wastes. Mismanagement of these products and wastes contributes to soil, water, and air pollution. Additionally, data linking the mismanagement of salvage materials containing polychlorinated biphenyls (PCBs) to the degradation and contamination of water systems exist. PCB contamination is responsible for the continued fish advisory precautions placed on numerous water bodies throughout Delaware. The Site Index Database contains information about the automobile salvage yards identified in the Chesapeake Basin. For more information regarding automobile salvage yards, contact the Hazardous Waste Management Branch.

Source Type: National Pollutant Discharge Elimination System (NPDES) Reporting Facilities

Municipal and industrial sites that discharge wastewater to surface waters are subject to limitations, monitoring requirements, and other terms and conditions identified in the individual NPDES permit issued to each site. Individual permittees must report monitoring results monthly, using the Discharge Monitoring Report (DMR) form developed specifically for each facility. The DMR lists parameters in the discharge that have a reasonable potential to cause or contribute to water-quality problems in receiving waters. Example parameters are temperature, dissolved oxygen, pH, copper, oil and grease, benzene, and PCBs. Although the DMRs are submitted monthly, actual monitoring frequency ranges from “continuously” to “once per year,” depending on the discharge’s characteristics and its volume relative to the receiving waters. *Table 2.3-3* shows the list of currently active sites.

Industrial sites that discharge only storm water may be permitted under an NPDES General Permit, which is a single permit that applies to a group of similar dischargers, e.g., trucking operations. Monitoring for storm-water discharges is typically less frequent, for example, three times in five years.

Source Type: Combined Sewer Overflow (CSO)

Combined sewers are designed to carry both sanitary sewage (wastewater from domestic, commercial, or industrial sources) and urban storm-water runoff and to convey the “combined” sewage and storm-water flow to the treatment facility.

Combined sewer overflows occur during wet weather events when the combined sewerage and storm-water flows exceed the hydraulic capacity of the sewer system. CSOs are designed to relieve the sewer system of the excess flow and discharge it directly to a tributary or stream channel.

Source Type: On-Site Septic Systems

Septic systems are the main method for treatment of domestic wastewater used in the rural or unsewered areas of the Chesapeake Basin. In portions of unsewered sections, especially rural homesteads and older subdivisions, cesspools are still being used. Most are undocumented. A cesspool is usually a large, open-bottomed tank, which drains both liquid and solid wastes directly underground. A septic system is a more engineered waste disposal system compared to a cesspool and is usually comprised of a septic tank for solids and a distribution box and drainage field for liquids. The drainage field may be either gravity-fed or pressure-dosed.

Although domestic wastewater can contain a wide range of substances, its chemical composition is relatively simple compared to municipal wastewaters, which obtain liquid wastes from a variety of sources including housing, commercial, and industrial activities. Potential contaminants in domestic wastewater include dissolved organic matter, heavy metals, biological oxygen demand (BOD), pathogenic microorganisms, and soil nutrients such as nitrogen and phosphorus.

2.3.4 OVERALL CONTAMINANT FINDINGS

2.3.4.1 Nutrients

Research in the Nanticoke watershed indicates that a notable amount of nitrogen loading (14.1 – 28.2 lbs/acre/yr) may be originating from septic systems. As the soil types and water table depths in the Nanticoke watershed are similar to the rest of the Chesapeake Basin, similar nutrient loads can be expected throughout the Basin. Overall, large community septic systems do not appear to be a significant problem. The majority of these systems are maintained and monitored by licensed operators. This requirement enables the Department to detect contaminant contribution to ground water and subsequently correct the related operational problems.

Monitoring data from land application of wastes from municipal and industrial sources indicate a decrease in nutrient over-application vs. conventional farming fertilization practices; nitrate reduction in ground-water recharges; and decreased nitrate in stream discharges.

Of the two operating municipal solid waste landfills owned by the Delaware Solid Waste Authority, routine ground-water and surface-water monitoring shows no significant nutrient releases.

Based on assessment data, the DuPont Seaford Nylon Plant is identified as a large point source for nitrogen and the largest point source for phosphorus. The TRI reports that, in 1998, DuPont Seaford released 669,000 pounds of nitrates from its on-site wastewater treatment plant, down from the 1,090,000 pounds reported in 1995. No earlier data are available from the facility to further define trends.

A major source of nutrient loading in the Chesapeake Basin is agriculture, the poultry industry, in particular. The recently completed poultry house inventory shows that there are approximately 750 poultry farms in the Basin. These farms are concentrated in specific areas (rather than spread out across the Basin). A resulting problem is that manure, too expensive to transport due to its bulk, is also concentrated in these areas.

The Broad Creek subwatershed has the state’s highest density of poultry activity per acre, as well as largest area of cropland. Total manure distribution for this subwatershed alone is estimated at 100,000 tons/year. Based on Broad Creek’s cropland acreage (40,886 acres), the manure application rate would be 2.4 tons per acre, which would appear to pose no environmental problems since the State of Delaware nutrient management recommendations allow for up to 4 tons per acre. This is assuming that this 40,886 acres of available cropland is grown in corn with recommended crop nitrogen needs of 175 lbs/ac/yr. In this scenario, the nitrogen application rate would be 175 lbs/ac/yr, and the phosphorus application rate would be 212 lbs/ac/yr. The recommended crop needs for phosphorus are only 40 – 45 lbs. This excess phosphorus is leaving the cycle in some fashion — either entering surface waters attached to sediment particles or leaching into the ground waters through phosphorus-laden soils.

The above scenario is not realistic because not all available crop acreage is grown in corn in this subwatershed. This scenario also does not take commercial fertilizer applications into consideration or that many times nitrogen from poultry manure is not credited as part of the overall crop needs. This means that someone may be applying the recommended 175 lbs of nitrogen per acre of commercial nitrogen, while also applying 4 tons of manure. Another factor to take into consideration is that crops such as soybeans and small grains that are grown in the Broad Creek subwatershed do not require the same high nitrogen inputs as corn.

In summary, the inability of crops to utilize all available nitrogen, combined with the predominance of sandy soils, leads to nitrogen loss through leaching or through volatilization as ammonia gas. Phosphorus is a serious issue that needs to be looked at closely in nutrient management planning and should be considered a limiting factor for determining overall manure application rates.

2.3.4.2 Chemicals

A large number of chemical contaminants are present in the Chesapeake Basin. They include the following:

- ◆ Heavy metals, such as iron, arsenic, cadmium, chromium, manganese, nickel, lead, barium, and zinc;
- ◆ PCBs;
- ◆ Solvents, degreasers, and paint thinners;
- ◆ Petroleum products such as gasoline and heating fuels;
- ◆ Pesticides and herbicides; and
- ◆ Other inorganic compounds such as chlorides and sulfates.

Contaminant source types present in the Chesapeake Basin include the following:

- ◆ Agricultural (pesticide mixing, loading, and storage locations);
- ◆ Landfills;
- ◆ Tire piles;
- ◆ Hazardous waste generators;
- ◆ Hazardous chemical inventory sites;
- ◆ TRI reporting facilities;
- ◆ Superfund sites;
- ◆ Leaking underground storage tank (UST) sites;
- ◆ Large on-site community septic systems;
- ◆ Spray irrigation sites;
- ◆ Dredge spoil areas;
- ◆ Salvage yards;
- ◆ NPDES point source dischargers.
- ◆ Combined sewer overflows, and
- ◆ Small on-site septic systems.

Not all sources have had actual releases, but are listed nonetheless because they have the potential to do so.

Chemical releases in the Chesapeake Basin have been documented at landfills, some hazardous waste generators, TRI facilities, Superfund Sites, UST sites, and salvage yards. These sites are under various stages of investigation/remediation, including:

- ◆ Undergoing corrective action;
- ◆ Contained and controlled;
- ◆ Monitored;
- ◆ Currently on hold but still active (because they are low-priority sites), or
- ◆ Inactive due to cleanup or because contamination remaining does not pose a threat to human health or the environment.

Many sources listed above have the potential to release chemicals into the environment. For some of these potential sources, engineering measures have been taken to minimize or prevent releases. Other potential sources have installed monitoring devices to provide early detection and cleanup of releases before they impact human health or the environment.

Some contaminant sources, such as pesticide mixing and loading facilities, have no data currently available. Part of the reason for this is that these sites are not currently regulated, either by the state or by EPA. Such data gaps make it difficult, if not impossible, to determine whether releases to the environment have occurred at these sites.

2.3.5 DATA GAPS AND RECOMMENDATIONS

2.3.5.1 Nutrients

1. Continue to promote and financially support conservation planning in the Chesapeake Basin and use COMPAS GIS technology to document implementation of Best Management Practices.
2. Promote expansion of the state cost-share program, State Revolving Fund (SRF) and federal cost-share programs to cover innovative Best Management Practices and technologies for improved nutrient management in the state and in priority watersheds. For example, provide cost-sharing on poultry litter movement from areas of high concentration to areas where it can be utilized to meet crop needs, or offer low-interest loans to poultry companies to retrofit feed mills for nutrient reduction in poultry litter.
3. Targeted ground-water monitoring should be incorporated more frequently into projects. If possible, monitoring plans should be developed to discern short-term effects and predict long-term trends to provide a better indication of implementation impact.

4. Implement a cover-crop program throughout the Chesapeake Basin that includes educating farmers on the water-quality benefits of cover crops. Provide technical assistance and financial assistance through the state cost-share program.

5. Implement the Conservation Reserve Enhancement Program (CREP) in the Chesapeake Basin on 2,000 to 3,000 acres by the year 2002 for the following Best Management Practices (BMPs): filter strips, riparian buffers, wildlife habitat restoration, and shallow wildlife areas.

6. Evaluate current management practices used for agricultural drainage ditches. Data have shown that sediments in ditches represent an immediate source of particulate P and, as climatic conditions become favorable (i.e., warm and anoxic), a source of soluble P.

7. Consider how soil conservation and water management practices together affect the potential for P transport. For example, maintaining water levels in the ditches (and thus the adjacent fields) increases the potential for P losses in erosion and runoff by decreasing the infiltration capacity of soils. High water tables in soils also promote desorption and transport of subsoil P, and can cause reducing conditions that may induce the release of Fe-bound P from soils and sediments. We need to carefully re-evaluate how we now manage drainage to avoid creating water-quality problems based solely on water-quantity issues.

8. Promote new phosphorus management strategies (such as the "Phosphorus Index") that consider both agricultural profitability and environmental quality. The Phosphorus Index evaluates eight characteristics to obtain an overall rating for a site. Each characteristic is assigned an interpretive rating based on the relationship between the characteristic and the potential for P loss from a site. The site characteristics are soil erosion; irrigation erosion; soil runoff class; soil test P value; P fertilizer application rate; P fertilizer application method; organic P source application rate: and organic P source application method.

9. Implement a phosphorus-based and nitrogen-based nutrient management system. Phosphorus-based nutrient management plans should be used for fields that have excessive soil-test phosphorus levels and a strong potential for phosphorus loss based on the Phosphorus Index.

10. Minimize nonpoint source pollution of surface waters by P from agricultural cropland using management practices that control both the supply *and* transport of soil P. The basic objective of environmentally sound P management is to maintain soil P fertility levels in a range that is optimum, but not excessive, for crop growth, while reducing the loss of particulate and soluble P by processes such as erosion, runoff, and drainage. Determination of the Phosphorus Index for soils that are near sensitive surface waters is the first step in this strategy, because this prioritizes the efforts needed to reduce P losses. Once this has been done, management options that are appropriate for soils with different P Index ratings can be implemented.

11. Focus nutrient management plans for intensive animal-based agriculture on farm-scale nutrient balance rather than exclusively on field-scale crop response to nutrients applied in animal wastes. Nutrient management plans that balance farm-scale nutrient inputs and outputs avoid on-farm nutrient accumulations, minimize the impact of off-farm nutrient losses, and optimize economic returns. When nutrient inputs to a farm exceed nutrient outputs, either inputs must be reduced or outputs must be increased to obtain a nutrient balance. For poultry-grain agriculture in Delaware, reducing inputs may include decreasing nutrient supplements in feed (e.g., using supplemental phytase or low-phytate corn feed); maximizing feed efficiency to reduce waste; and eliminating unnecessary fertilizer applications to fields. Increasing outputs may include developing off-farm uses of poultry litter as alternatives to land application (e.g., value-added products, bio-energy, poultry manure composting or pelleting, or the use of poultry litter in synthetic topsoils). Even when inputs and outputs can be balanced, efficient on-farm use of nutrients is still needed to prevent nonpoint losses of nutrients to the environment.

12. The Department should closely monitor Maryland's *Pfiesteria* Action Plan as it contains proposed land-based solutions to the overall nutrient-loading problem. Governor Glendening's Citizens *Pfiesteria* Action Commission has the following recommendations for agriculture:

    a. The Commission recommends that Maryland adopt a phosphorus-based and nitrogen-based nutrient management system. Phosphorus-based nutrient management plans should be used for fields that have excessive soil-test phosphorus levels and a strong potential for phosphorus losses based on a phosphorus index.

    b. The Commission recommends that Maryland enroll all farmers in nutrient management plans by the year 2000. These nutrient management plans should be fully and demonstrably implemented by 2002, contingent upon the Maryland supplying the appropriate level of education, outreach, technical support and financial resources necessary to meet these goals.

    c. The Commission recommends that the Governor convene an oversight committee consisting, at a minimum, of the Secretaries of the Departments of Agriculture, Natural Resources and the Environment, a member of the Senate of Maryland, and a member of the House of Delegates to oversee the development and implementation of appropriate nutrient management programs and Best Management Practices.

d. The Commission stresses the importance of developing alternative uses for manure in conjunction with the movement to nitrogen-based and phosphorus-based nutrient management planning.

e. In order to make immediate progress in the redistribution of manure, the Commission recommends the establishment of a pilot program aimed at transporting chicken manure from the lower Eastern Shore.

f. The Commission believes that copies of all nutrient management plans be submitted to the Departments and to the Cooperative Extension Service in its role as a scientific and education agency, in a manner that protects the privacy of the individual farmer. The Commission also believes that nutrient planning standards and guidelines developed by the University of Maryland be utilized by all Cooperative Extension Service planners and private sector planners.

g. The Commission strongly recommends that phytase be added to feed supply as soon as possible. The Commission encourages the industry, Maryland, surrounding states, and the federal government to work together to implement the necessary technology as soon as possible.

h. The Commission recommends that Maryland (and surrounding states) establish a cost-sharing program to assist in the conversion of feed mills.

i. The Commission recommends that the MACS Program (cost-share) be expanded to allow non-animal growers who store and apply manure to be eligible to receive state assistance for the construction of manure storage sheds. Maryland need not invest money in such structures if the land on the requesting farm does not need additional phosphorus (as determined by the recommended phosphorus-based nutrient management plan).

j. The Commission encourages industry and the University System of Maryland to develop and, when appropriate, implement the use of litter treatments that will stabilize manure phosphorus into environmentally inactive forms.

k. The Commission recognizes that the use of low-phytic acid corn may be a viable and important part of the effort to reduce the phosphorus content of manure.

l. The Commission encourages expedited research into composting, post-composting processing, and the market potential of a composted product. The Commission urges industry, Maryland, and the private sector to collaborate on these solutions.

m. The Commission is encouraged by the prospect of burning the manure and encourages further research and demonstration on this issue. Fuel needs can likely be met on a large scale, as it is being explored by the Maryland Environmental Service and the Department for the Eastern Correctional Institute, or on smaller scales, as evidenced by the demonstration project examining the use of poultry litter as a fuel source for heating broiler houses. Burning litter disposes of the manure and leaves a certain amount of ash that can be used to either make artificial soils, serve as a component of a fertilizer mix, or serve as a poultry feed additive.

n. The Commission encourages the University of Maryland and the Department of Agriculture to work with the agricultural community to evaluate the effectiveness of current agronomic practices (such as no-till) to balance the techniques for minimizing soil erosion, surface-water runoff, and leaching of nutrients from agricultural land.

o. The Commission is encouraged by federal and Maryland's efforts to increase resources for the Conservation Reserve Enhancement Program (CREP). This program will provide increased payments to farmers who treat certain environmentally sensitive land in order to voluntarily restore wetlands, establish stream buffers, and retire highly erodible land from production.

p. The Commission urges Maryland to aggressively market CREP and to sponsor outreach and educational programs designed to maximize farmer participation. The Commission encourages all interested Marylanders to participate in publicizing this voluntary opportunity.

q. The Commission encourages the University of Maryland to work with the agricultural community to establish demonstration projects and to conduct expedited research into drainage ditches. In soils where soluble phosphate is reaching drainage ditches, it is theoretically possible to chemically precipitate the phosphorus out of the water by using crushed limestone. The cost associated with this technique should be minimal, but the chemical dynamics of the procedure need to be better understood before its use can become widespread.

r. The Commission encourages the University of Maryland and the Department of Agriculture to continue research and demonstration projects in the area of tillage as a site-specific technique for reducing phosphorus levels in the upper layers of soil. Tillage would "turn over" the soil, burying the phosphorus below the soil surface, but within the root zone of the crop. In order for this technique to work, the subsurface soils must have lower phosphorus content than the surface soil and the subsurface soil must be conducive to supporting crop production.

s. The Commission strongly encourages the regular use of cover crops as a Best Management Practice. Research has shown that nitrate-leaching losses occur even when all crop-yield goals are met and all Best Management Practices and a nutrient management plan are implemented. It is estimated that the utilization of a cereal grain cover crop following a corn or soybean crop can reduce nitrate-leaching losses by 50 percent.

t. The Commission strongly recommends that Maryland implement a continuing cover-crop program designed specifically to limit nitrate leaching and to prevent nutrients from entering the bay and its tributaries. The Commission encourages the federal government to provide support for Maryland's cover crop program, possibly through the Environmental Quality Incentive Program.

u. The Commission believes that participation in MACS cost-sharing programs in place for manure sheds, dead bird composters, and CREP improvements, as well as programs addressing cover crops and nutrient management planning, can be enhanced by increased outreach and technical assistance. The Commission encourages Maryland to provide an appropriate and meaningful level of support to the Department of Agriculture and the Cooperative Extension Service in order to increase the use of existing Best Management Practices and to otherwise implement the recommendations of this Commission.

13. With the widespread nutrient inputs throughout the Basin, it is important to locate all of the various sources accurately so that local action can be taken. In particular, as population increases in rural areas, septic systems are installed to dispose of the waste. The regional density of these systems and their proximity to the sensitive resources are important pieces of the nutrient management puzzle. Therefore, all septic systems in the Basin (state) should be mapped using aerial photography. This information, when placed in GIS format, should be used to answer more specific questions about system placement and density.
14. Recommend use of septic mapping data in the development of Pollution Control Strategies (PCSs).
15. Recommend that the state develop Animal Feeding Operations (AFO) strategies (permits, BMPs, etc.).
16. Identify the areas where a significant amount of ground water is being consumed and the Department has little or no water-quality data.
17. Develop and implement pollution control strategies to meet established TMDLs for Nanticoke and Broad Creek.
18. Begin development of TMDLs for remainder of Basin.
19. Develop and implement storm-water monitoring plan.
20. Eliminate all Combined Sewer Overflows in Basin.
21. NPDES permit synchronization in watersheds/basins.
22. Review of septic regulations considering TMDL/PCS issues.
23. Work with counties and local governments to coordinate septic regulations for greater (average) open space for unsewered areas.
24. Amend the septic regulation to provide for more appropriately located large community septic systems.
25. Recommend that the Department deny the placement of new (non-replacement) alternative septic systems outside of investment areas and restrict their placement in investment areas to reduce impacts to wetlands and important habitats.
26. Assess septic system failure rate for the Chesapeake Basin through remote sensing and verification by grounding survey.
27. Support and develop certification for (required) inspection of septic during property transfer.
28. Obtain grants to repair, or replace, malfunctioning septic systems in environmentally sensitive areas. Incorporate innovative technologies where appropriate.
29. Continue to research and demonstrate alternative systems, such as gray-water separation, or the placement of sawdust under tile drainage fields.
30. As the state moves to implement TMDLs and Pollution Control Strategies, it is very important that the lands the government owns or controls be managed properly. Therefore, all lands owned by state and federal governments should be assessed and have comprehensive conservation plans developed for them. These plans should then be incorporated into the land lease agreements and daily management practices.
31. Review analytical site data from all site types for any available nutrient information.

2.3.5.2 Chemicals

Based on a chemical contamination study of sediments for the Nanticoke River conducted by Greene (1997), several recommendations were made which would help characterize chemical contamination within the Basin:

1. The Department should coordinate with the U.S. EPA and the City of Seaford in the review of influent and effluent data generated in conjunction with the City's Industrial Pretreatment Program for its wastewater treatment plant. The effluent data should be used to estimate mass loadings of toxics to the Nanticoke River from the treatment plant.

2. The Department should work with the DuPont Company to better characterize metals releases from the DuPont Seaford Nylon Plant to the river. Water and sediment samples should be collected downstream of the fly-ash polishing pond and analyzed for selected metals. These samples should be collected above the dam on DuPont's property and below the dam within DuPont Gut. The magnitude, duration, and frequency of coal-pile runoff should also be assessed.
3. The Department should continue to work with the City of Seaford to ensure that the city's Combined Sewer Overflows (CSOs) are eliminated in a timely manner.
4. The results of the Chesapeake Bay Fall Line Toxics Monitoring Program for the Bridgeville USGS gauge location suggest existence of sources for pesticides and metals entering the Nanticoke River above the Bridgeville gauge. The Chesapeake Whole Basin Team should review and map out available pollutant source data for that area of the watershed above the Bridgeville gauge. The relative importance of these sources in comparison to sources in the Seaford area should be considered within an overall mass balance context.
5. An assessment should be made of the potential for silver iodide to enter the Nanticoke River from agricultural supply operations.
6. Delaware should contact the Army Corps of Engineers and request a summary of the nature and extent of shipping activity on the Nanticoke. Information that would be of use includes the annual volume and type of products transported to and from the Seaford area; a description of off-loading practices used at the various docking facilities; a summary of spill reports and cleanup response; a description of past dredging activities; and a schedule for future dredging activities.
7. The Department should evaluate the extent to which Best Management Practices are being implemented for bulk chemical transfer and storage along the Seaford waterfront.
8. Educate the public regarding the proper disposal of motor oil and household chemicals. Continue to support the efforts of the Delaware Solid Waste Authority in its household hazardous waste collection program.
9. Place EPCRA Tier II facilities on the chemical contaminants map and also populate the Site Index Database with these sites.
10. The extent to which metals contamination of the sediment is also a problem in the water column is not well characterized. Historical water column metals data should be compiled and assessed in conjunction with the Preliminary Assessment Report.
11. Provide technical assistance to the city of Seaford for the installation of "urban BMPs" such as sand filters and other passive storm-water pollutant reduction devices.
12. Implement a storm-drain stenciling program to raise the awareness of the public concerning the relationship between storm-water runoff and river quality.
13. Aboveground storage tanks are currently unregulated; develop regulations for operation, spill/overfill protection, leak detection, tank testing requirements, and corrosion protection.
14. A sediment "Triad" study should be conducted in the reach of the Nanticoke River below Seaford to confirm or refute whether sediments are actually toxic to benthic organisms.
15. Deep (e.g., 3' – 5') sediment cores should be obtained and analyzed at discrete depth intervals in an effort to determine the historical input and sedimentation rate of PCBs and heavy metals in the Nanticoke below Seaford.
16. Develop education process for owners of exempt Underground Storage Tanks about proper maintenance and leak detection to avoid becoming a regulated LUST.
17. Explore options for acquiring the needed support to produce comprehensive periodic inventories of greenhouse gases.

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