SOILS

The following description of soils is provided by the U.S. Department of Agriculture's Soil Conservation Service (subsequently renamed Natural Resources Conservation Service):

> Soils are the collection of natural bodies in the Earth's surface, in places modified or even made by man of earthy materials, containing living matter or capable of supporting plants out-of-doors. Its upper limit is air or shallow water. At its margin, it grades to deep water or to barren areas of rock or ice. Its lower limit to the "not-soil" beneath is perhaps the most difficult to define. Soil includes the horizons near the soil surface that differ from the underlying rock material as the result of interactions, through time, of climate, living organisms, parent materials, and relief. In the few places where it contains thin cemented horizons that are impermeable to roots, soil is as deep as in the deepest horizon. More commonly, soil grades at its lower margin to hard rock or to earthy materials virtually devoid of roots, or marks of other biological activity, which generally coincides with common rooting depth of native perennial plants. . . . The lower limit of soil, therefore, is normally the lower limit of biological activity, which generally coincides with common rooting depth of native perennial plants (USDA, 1975, 1993).

In Delaware's Piedmont Basin, soil depth approaches the limits of this definition in the form of weathered, micaceous crystalline rock (saprolite). The rock margin of saprolites grade from tidal marsh to deep water near the terminus of the Christina River. Certain areas in and around Wilmington have soils consisting entirely of man's earthy materials; in other areas, the parent material of the soils consist primarily of sands, silts, and clays.

Topography, or "relief," controls or modifies soil formation. Relief affects the landscape distribution of soils and moisture, affects erosion and alleviation patterns, affects temperatures that are influenced by aspect (the compass direction the slope faces), and affects the combined temperature and rainfall effects that result from elevation differences (Fanning and Fanning, 1989). Soil temperatures are 2° F to 5°F warmer on the south-facing slopes compared to the north-facing slopes (Fanning and Fanning, 1989). The physical and chemical characteristics of Piedmont Basin soils are significantly affected by the slope, aspect, and rock content. Soil depth is usually shallow on the steeper slopes and increases as the slopes become flatter. Soil rock content is dependent on aspect; warmer, south-facing slopes face the sun and are usually rockier than the north-facing, cooler slopes.

Relief reduces the portion of water available to infiltrate into the soil. Although those soils in the Piedmont Basin that have formed from crystalline rock are more permeable than some soils from the Potomac Formation — the formation characteristic of the Atlantic Coastal Plain portion of the basin — most of the rainfall on the steeper Piedmont Basin slopes drains directly from the soil surface into nearby watercourses. Movement of that water which does infiltrate is affected by the elevation at which, and the material (formation) through which, it flows. Surface-water runoff either collects in depressions or flows in watercourses, whereas infiltrated water discharges into depressions or into sloping seep areas. These depression and seep areas contain many of the nontidal wetlands in the Piedmont Basin.

Tidal wetlands are found in the floodplains of the Christina River and along the lower portions of Red and White Clay, Brandywine, Naamans, and Shellpot creeks. All these creek and river areas are urbanized and have lost many of their associated wetlands. Some of the wetlands within the basin have been flooded by reservoirs or ponds; this storage of surface waters commonly has negative effects on the downstream riparian wetlands. Road construction also has significant effects on wetlands. Because roadbeds serve as a dam to water movement, wetlands that have no surface-water inlets or outlets and which thereby interact only with groundwater can be significantly affected by road construction. Landscape changes caused by paving portions of the watershed, channelization of the stream, or cutting-and-filling slopes within a watershed to accommodate urban growth can significantly alter flow volumes. Stream channeling can do likewise. Both practices can affect wetland hydrology — either by reducing the water supply available to the wetland or by increasing the speed in which the water flows through the wetland. In addition, these practices tend both to increase sediment loads to streams due to bank scouring and increase water velocities, allowing streams to transport those sediments longer and farther.

Perhaps the most important factor affecting the hydrology of the Piedmont Basin is the draw-down of groundwater by wells. Groundwater is not plentiful in this basin; thus removal of groundwater through wells reduces the water available to the wetlands by redirecting groundwater flow away from the wetland and toward the pumping well.

Interpreting soils for the purposes of determining suitable land use tends to be difficult in the portion of the basin that rests in the Piedmont geologic province. Saprolite color is often inherited from the rocks from which it was formed, and this saprolitic parent material often lacks indicators (redoximorphic features) of seasonally high water tables. In certain areas of the White Clay Creek watershed, for example, inherited colors mask evidence of seasonal wetness. "Dips" in the tightly folded rocks range from nearly vertical

to steeply dipping and serve as a conduit through which water flows to produce springs at the base of topographic lows. Usually, such conduits are not evident until the soils have been cut or graded; as a result, many basements become wet after these conduits are intercepted during home construction. Many land parcels also have numerous springs and seeps that affect septic system performance, the placement of encumbrances, or landscaping.

Characteristics

Four major soil associations make up the Piedmont Basin (see Map 17). These associations reflect the geologic formations from which they have been born. The Glenelg-Manor-Chester association — located in the northern and northwestern parts of the region — comprises about 30% of the region. These are nearly level to steep, well-drained, medium-textured soils formed over micaceous crystalline rocks on uplands. The Glenelg soils make up approximately 43% of the association; the Manor, 23%; and the Chester, 14%. The Glenelg and Chester soils are moderately erodible, while the Manor soils are highly erodible. Limitations for suitability of human land use are generally due to the severity of the slopes.

The Sassafras-Fallsington-Matapeake association (18% of the basin) consists of level to gently rolling, well-drained and poorly-drained soils on uplands (see Map 18). These soils have formed from Coastal Plain sediments, and their textures are generally moderately coarse to medium. The eastern portion of the river basin is comprised mainly of the Neshaminy-Talleyville-Urban Land association (12% of the basin), which consists of level to moderately sloping, well-drained, medium-textured soils that are relatively undisturbed to severely disturbed. These soils are formed over dark-colored gabbroic rocks. Also included is the Neshaminy-Aldino-Watchung association (6.5% of the basin), which consists of level to steep, well-drained to poorly-drained, medium-textured soils formed over dark-colored gabbroic rocks. Urban Land-Soil Complexes and other minor soils make up the remaining 24%.

A significant portion of the soils found in the basin are poorly to very poorly drained. Some of these soils would be considered hydric. *Hydric soil* is defined by the U.S. Department of Agriculture's Soil Conservation Service (1982) as a soil that is either (1) saturated at or near the soil surface with water that is lacking free oxygen for significant periods during the growing season, or (2) flooded frequently for long periods during the growing season.

The following soils have the potential to be considered hydric: Bayboro, Calvert, Elkton, Fallsington, Hatboro, Johnston, Kinkora, Mixed Alluvial Land, Othello, Pocomoke, Tidal Marsh, and Watchung. Areas are considered to be wetlands when composed of hydrophytic plants, hydric soils, and hydrology indicative of periods of continuous soil saturation during the growing season. Many such soils are associated with the floodplains of the creeks and rivers, and floodplain soils comprise 9.5% of the Piedmont Basin.

White Clay Creek Watershed

The Glenelg-Manor-Chester association (see Map 17) makes up the majority (approximately 55%) of the soils in the White Clay Creek watershed and is generally found in the northern and northwestern portions of the watershed. These are nearly level to steep, well-drained, medium-textured soils formed over micaceous crystalline rocks on uplands. The Chester soils make up approximately 65% of the association; the Manor, 20%, and the Glenelg, 8%. Floodplain soils constitute 10% of the Delaware portion of the White Clay Creek watershed.

Most of the soils within White Clay Creek watershed are highly erodible (see Map 19). The inherent erodibility of a soil — its "K factor" — is influenced by its infiltration capacity, soil, and structural stability. The K factor is a relative value that ranges from near 0 to nearly 0.6. Soils with low erodibility tend to be sandy and have K factors below 0.2. Soils with intermediate infiltration capacities and moderate soil stability have K factors of 0.2 to 0.3. And soils that are easily eroded have K factors greater than 0.3; such soils tend to have low infiltration capacities.

The Glenelg and Chester soils are moderately erodible while the Manor soils are highly erodible. With the high inherent erodibility of the soils in this watershed, coupled with steep slopes associated with Glenelg-Manor-Chester soils, erosion can be a significant factor affecting surface water quality. As stated previously, the cutting and grading associated with the initiation of new residential and commercial development projects make these soils highly erodible. Despite existing state erosion-control regulations that require areas not to be worked for at least two weeks to be stabilized, Delaware's rainfall pattern can allow considerable erosion even where control measures are employed. During the development of those erosion-control regulations, DNREC had estimated that exposed Piedmont soils could erode at a rate of 100 tons/acre/year.

The soils of the southern portion of the watershed, near its juncture with the Christina River, are predominantly from the Elsinboro-Delanco-Urban association (14% of the watershed) and the Sassafras-Fallsington-Matapeake association (6% of the watershed in Delaware). The Elsinboro-Delanco-Urban soils are formed from old alluvium on stream terraces associated with White Clay Creek. These associations tend to be more erodible than, and tend to have wetter soils than, the Glenelg-Manor-Chester association. Consequently, construction work is generally hindered by the presence of

residual boulders in the saprolite of the Elsinboro-Delanco-Urban soil. Throughout the Piedmont, slope failures along bedding planes and joints can be a hazard during excavation. Minor soils constitute the remaining 15% of the watershed.

Red Clay Creek Watershed

The majority of the Red Clay Creek watershed (77% of Delaware's portion of the watershed, primarily the northern portion) is comprised of the Glenelg-Manor-Chester association (see Map 17). These soils vary from nearly level to steep and are well-drained (see Map 18), medium-textured soils formed over micaceous crystalline rocks on uplands. The Glenelg soils make up approximately 43% of the association; the Manor, 23%; and the Chester, 14%. The Glenelg and Chester soils are moderately erodible, while the Manor soils are highly erodible (see Map 19). Usage limitations for parcels with such soils are generally attributable to slope severity or to soil wetness where the soils are associated with floodplains. Suitability for septic systems on land parcels with such soils ranges from gravity-fed systems to engineered, pressurized systems on the steeper slopes and the wetter soils.

The southern portion of the watershed is composed mainly of the Elsinboro-Delanco-Urban association (8% of Delaware's portion of the watershed), consisting of level to moderately sloping, well-drained, medium-textured soils ranging from relatively undisturbed to severely disturbed. This association tends to be more erodible than the Glenelg-Manor-Chester association because of its location adjacent to the creek. The floodplain soils comprise 8.6% of Delaware's portion of the Red Clay Creek watershed, and minor soils constitute the remaining 6.4% of the watershed.

Brandywine Creek Watershed

The Glenelg-Manor-Chester soil association (40% of Delaware's portion of the watershed) occupies the upper reaches of the watershed; the Neshaminy-Aldino-Watchung association (20%) is located centrally; and the Neshaminy-Talleyville-Urban Land association (26.5%) is located in the southern portion of the Brandywine Creek watershed (see Map 17). Wilmington and the surrounding areas (4% of the watershed) are extensively "Made Land" (i.e., urban). These "Made Land" soils are composed of severely cut and graded or artificially filled soils. Often, this Made Land is very poorly drained. As stated previously, most of these soils are highly erodible (see Map 19). A considerable portion of the lower section of the watershed is covered by impervious surface materials that promote rapid runoff. Flood-plain soils comprise 7.5% of the Delaware portion of the Brandywine Creek watershed, and minor soils constitute the remaining 2.0%.

Shellpot Creek Watershed

Neshaminy-Talleyville-Urban Land soil (62%) and the Neshaminy-Aldino-Watchung association (13%) predominate the Shellpot Creek watershed (see Map 17). Toward the mouth of Shellpot Creek, soils grade into the Aldino-Keyport-Mattapex-Urban association 6% of the watershed). These soils are much less well-drained than the Neshaminy-Talleyville-Urban Land soil association, very little agriculture occurs in this watershed, and a considerable portion of the watershed is covered by impervious surface materials that promote rapid runoff. Floodplain soils comprise 16% of Delaware's portion of the Shellpot Creek watershed, and minor soils make up the remaining 3%.

Naamans Creek Watershed

The Neshaminy-Aldino-Watchung association (23% of the watershed) and the Neshaminy-Talleyville-Urban Land soil associations (59% of the watershed) predominate in this watershed (see Map 17). Most of these soils are highly erodible (see Map 19) and tend to have slow permeabilities due to moderately fine and fine-textured subsoils. The Aldino-Keyport-Mattapex-Urban association comprises 9% of the watershed. Neshaminy-Aldino-Watchung and Neshaminy-Talleyville-Urban Land associations tend to be less suited for septic systems due to slow permeability and soil wetness. Floodplain soils comprise 7% of the Naamans Creek watershed, and minor soils constitute only 2.0%.

Christina River Watershed

The Christina River watershed has some of the most diversified soils in the Piedmont Basin because part of the watershed is located in the Atlantic Coastal Plain. Most of the northern portion of the Christina River watershed (9% of the watershed) is comprised of the Glenelg-Manor-Chester association (See Map 17). These soils are nearly level to steep, well-drained, medium-textured soils formed over micaceous crystalline rocks on uplands. Two Piedmont province outliers occur in the southern portion of the watershed; these outliers (i.e., Chestnut Hill and Iron Hill) are just south of Newark and — although completely surrounded by Coastal Plain sediments which isolate them from the Piedmont proper — are included in Delaware's Piedmont Basin (see Map 3). The Glenelg soils make up approximately 43% of the association; the Manor, 23%; and the Chester, 14%.

The southern portion of the Christina River watershed (northern Coastal Plain) is composed of five major soil associations (see Map 17). The Sassafras-Fallsington-Matapeake association (44% of the watershed) consists of level to gently rolling, well-drained, and poorly drained soils on uplands. These soils have formed from Coastal Plain sediments, and their textures are generally moderately coarse to medium. The Matapeake-Sassafras association is comprised of nearly level to steep, well-drained, medium-textured and moderately coarse-textured soils on uplands. A small area (9% of the watershed) is comprised of the Matapeake-Sassafras-Urban Land association. The Aldino-

Keyport-Mattapex-Urban Land association (3% of the watershed) makes up the area around New Castle, Newport, and northeastern Wilmington. The Tidal Marsh association (3% of the watershed) traverses the Delaware River and short tidal streams. Extensive areas in and around Wilmington (11% of the watershed) are Made Land. Floodplain soils comprise 9% of the Christina River watershed, and minor soils make up only 10%.

The southern portion (see Map 19) of the watershed has some of the most erodible soils in the Piedmont Basin. Soil infiltration capacities tend to be slower due to the amount of silt and clay in the Matapeake, Elkton, and Keyport soils. Elkton soils occupy 5% of the watershed. Many of the other soils in the southern portion of the basin have very silty surface horizons, which make them more susceptible to erosion.

Trends

Development will only continue within the Piedmont Basin. It is expected that the number of septic systems will initially increase, but with time, more of the basin will become sewered and the number of septic systems will decrease. It may not be possible to provide central sewer to all unsewered communities and locations. The Wetlands/Soil Assessment Branch developed an evaluation criteria at the request of the Wastewater Facilities Advisory Councils to determine relative need and feasibility for central sewer. The evaluation criteria considered water-quality issues, other environmental issues, soils suitability for septic systems, septic system siting limitations, distance to existing sewers, cost-effectiveness of providing central sewer, and community well-being. These criteria were used to identify the unsewered communities with the highest, medium, or lowest needs for central sewer. The Centerville area was the only community evaluated within the basin. Based on the evaluation criteria, Centerville had very low need for central sewer when compared to the 59 other communities statewide included in the feasibility assessment.

Sources of Impact

Soils tend to become a wastebasket for anthropogenic activities. They are used to renovate wastewater from residences, to serve as landfills for our garbage, depositories for unwanted and often hazardous wastes, sources of earthy fills, and storage areas for automobiles and other items. Buried wastes produce methane and other natural gases, which can explode and contaminate groundwater. Storage tanks often leak due to corrosion effects from groundwater and soil acidity. The Piedmont Basin has its share of wastebaskets and depositories. A tremendous amount of development has taken place within the basin. Major soils areas within the basin have been modified to accommodate human progress.

Unfortunately, when new development projects (residential or commercial) are initiated, most of the soils are cut and graded, which makes them highly susceptible to erosion. Delaware's erosion-control regulations require that areas that will not be worked for at least two weeks are to be stabilized. With Delaware's rainfall pattern, considerable amount of erosion can occur even with control measures. During development of erosion-control regulations, DNREC estimated that exposed Piedmont soils could erode at a rate of 100 tons/acre/year. The acceptable soil erosion loss that will maintain soils for crop production is only *two tons/acre/year*. The erosion-control regulations allow 50 times this rate.

Septic systems are the main method for treatment of domestic wastewater in the unsewered areas of the basin. In some areas of the unsewered sections, cesspools are still being used; most are undocumented. However, as sewer systems are developed in areas where septic systems and cesspools are used, they are slowly being decommissioned.

Positive Initiatives

Before construction or replacement of septic systems in Delaware, a site evaluation must be conducted. Performed by a private site evaluator, site evaluations consist of investigating, evaluating, and reporting the basic soil and site conditions, which are used to define on-site system design. 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 appropriate hydraulic conductivity test conducted in configuration encumbrances, easements, and underground and overhead utilities in the evaluated area. The site plans show reference points such as a utility pole number, telephone or electrical box, building(s), and/or a fixed survey marker.

This procedure ensures that septic systems are sited based on soil properties [permeability, texture, structure, consistence, redoximorphic features (seasonal high water-table indicators), slope and depth to rock] which limit or hinder septic system performance. A siting system based on these parameters, as well as those listed above, ensures that the system type is designed to minimize the soil's limiting factors, which in turn improves system performance and reduces loading rates to water sources. New Castle County has restricted any development on slopes that are greater than 15% and prohibits development on slopes greater than 25%. This slope restriction ordinance effectively reduced the proposal of developments on sloping lands. Also, the New Castle County Zoning and Subdivision Code limits septic systems to a minimum density of two acres per dwelling in Water Resource Protection Areas and one acre per dwelling elsewhere.