SOME ENVIRONMENTAL GEOLOGY CONSIDERATIONS IN MONTGOMERY COUNTY, MARYLAND

The Montgomery County folio is intended for use by planners, engineers, hydrologists, and citizens interested in evaluating geologic and hydrologic conditions that may be limiting factors to certain types of land use. The scale of the maps, 1:62,500 (1 inch = approx. 1 mile, contour interval 20 ft), permits only a regional overview, or guide, on a county basis. The maps and accompanying tables and texts provide source and supplementary information to facilitate preliminary area evaluations for some uses, but the data are considered to be reliable only at the published scale. The maps are not intended for enlargement, nor are they, or the engineering data, intended to replace site investigations by qualified technical personnel. Local details at any given site may be quite different from the generalities portrayed on these county maps. These local details must also be considered in planning for a specific land use, although remedial actions and treatments can commonly be engineered at reasonable cost so that otherwise limiting factors can be overcome.

The folio consists of a series of derivative maps that provide a perspective of the surface and shallow subsurface of Montgomery County not readily apparent from published geologic, soils, and ground-water studies on which they are primarily based. Engineering properties of rock and overburden are provided in generalized tabular summaries. The maps are designed as multipurpose products to be used independently and in combination with other maps or data published or available elsewhere, such as soils, ground-water, flood-prone areas, slope, vegetation, population, zoning, land use, or geophysical maps. By combining the maps in a variety of ways depending on the relevent limiting factors for any given land use, a series of maps can be derived by the user that focuses on specific problems. For example, the user will be able to evaluate several given areas for a sanitary landfill considering a group of factors using certain map combinations, then be able to assess the limitations or advantages of the same areas for park land or urban development by using other factors and other map combinations. By selecting criteria or guidelines, unique single-purpose derivative maps can be made. Once the essential guidelines to a specific problem are established, other secondary criteria can be modified by trading off or moderating conflicting uses. Current problems, such as evaluating sites for sanitary landfills, sewage-treatment and disposal plants, evaluating areas with limitations for heavy construction, locating transportation or utility corridors, siting septic-tank leaching fields, extracting mineral resources, assessing ground-water resources, determining limitations for surface disposal of treated waste water, selecting areas for park land or rural open space, and many other urban area problems can be more rationally assessed from these maps, at least on a regional basis. Potential uses and possible derivative products from other combinations are discussed in the texts accompanying each map.

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TABLE 2.—Selected engineering properties of a hypothetical column of surface materials over typical schistose gneiss

[Modified from table 7, Soil properties for design, Musser and others, 1967. PCF, pounds per cubic foot; KSF, kips per square foot; kip, a unit of weight equal to 1000 pounds—used to express a deadweight load; TSF, tons per square foot; ksi, kips per square inch; BPF, number of blows of 200–350 lb hammer falling 18 in. needed to drive 2½ in. casing 1 ft]

Map unit and symbol	Special conditions	Total unit weight, PCF	Shear strength, cohesion, KSF[1]	Effective friction angle	Allowable bearing pressure, TSF	Penetration rate, BPF
ARTIFICIAL FILL 1	Local overburden mixed with rock	130	No data	30°	1.5–2.0 (needs special study)	10–20
ALLUVIUM 2	Organic clay	120	0.3	23°	0.75	5–10
	Silty sand	130	No data	30°	2–2.5	No data
UPLAND GRAVEL DEPOSITS 3	Clay and silt	130	1–2	25°	1–2	5–30
	Sand and gravel	130	No data	30°–36°	2–4	10–200
COASTAL PLAIN STRATA 4	Plastic clay	130	2.5–5	23°	2.5–4	25–40
	Sandy clay	130	4–6	30°	3–4.5	30–100
	Silty to gravelly sand	130–135	No data	32°–36°	4–6	30–100+
SAPROLITE (decomposed rock) 5D	Near surface, micaceous, unstructured.	140	do.	30°	3–4	50
	Undisturbed, compact, relaxed rock structure.	140	do.	36°	5	100
	Highly jointed, weathered schistose gneiss	170	0.5–5 ksi	45°	10	No penetration
BEDROCK (data for gneiss only) 6	Moderately jointed second gneiss	170	5.0–15.0 ksi	No data	30–60	do.

[1]Where shear strength in KSF is listed, the material is expected to perform as a cohesive soil. Where no shear strength is listed, the material is expected to perform as a cohesionless soil.

FIGURE 1.—Block diagram of hypothetical area in Montgomery County showing some common examples of surface materials overlying bedrock. The land surface is shown as it would appear on the surface materials map.

TABLE 3.—Engineering properties of saprolite (decomposed rock) derived from schist and gneiss (similar data not available from other units)

[Modified from table 7, Soil properties for design, Musser and others, 1967]

Engineering tests of saprolite		Chlorite schist (3 samples)	Schistose gneiss (4 samples)	Quartz gneiss (4 samples)
Depth range		35.8 –55.6 ft	10.9 –25.5 ft	15.6 –35.8 ft
Average natural water content		17.2 –24.5%	20.9 –31.2%	16.5 –42.3%
Direct shear tests	Normal stress (TSF)	0.18– 2.51	0.51– 3.01	0.51– 2.0
	Shear stress (TSF)	0.79– 2.22	0.47– 2.74	0.56– 1.51
Triaxial and unconfined compression tests	Deviator stress (TSF)	0.67– 1.67	0.96– 3.87	0.48– 1.79
	Confining tests	0.0 – 2.0	0.0 – 2.0	1.47
Consolidation tests	Existing overburden stress (TSF)	3.2	1.1	1.4
	Estimated pre-consolidation stress (TSF)	11.7	10	13
	Swelling index	0.009–0.056	0.04	0.115
	Compression index	0.0174	0.55	0.520

[1] TSF, Tons per square foot.

SURFACE MATERIALS MAP OF MONTGOMERY COUNTY, MARYLAND

INTRODUCTION

The one artificial deposit and four naturally occurring unconsolidated and partly consolidated deposits (overburden) which can generally be moved by power equipment are differentiated from areas of shallow bedrock on the map. The naturally occurring deposits underlie soils and blanket most of the hard bedrock. They comprise alluvium of the stream valleys, colluvium and upland gravels, Coastal Plain strata, and saprolite; in addition, artificial fill, man-made and disturbed ground, and areas of shallow bedrock (fig. 1) are delineated.

MAP UNITS

Artificial fill (unit 1) and man-made ground.—Consist mainly of locally derived, heterogeneous mixtures of soil, saprolite, gravel, rock, and sand which have been moved a short distance from artificial cuts and borrow pits made during construction. In a few fills, however, limestone from Frederick County and marble from Baltimore County have been used for riprap. No two fills have the same bulk composition, thus each filled area requires special study to determine significant engineering properties. In general, artificial fill is less stable and has less bearing strength than the undisturbed parent material. It is readily eroded and provides a major source of sediment of streams until stabilized by vegetation and riprap. General engineering characteristics are summarized in table 2.

Alluvium (unit 2).—Consists of transported sand, silt, clay, gravel, and boulders in flood plains. The angular and subangular gravel and boulders of streams which drain the Piedmont were derived principally from nearby crystalline bedrock outcrops, and the ubiquitous and abundant subangular pebbles are predominantly quartz. The sand, silt, and clay fractions are fairly well to poorly sorted and commonly very micaceous.

Streams which drain the Coastal Plain and the upland gravel areas on Triassic sedimentary rocks deposit alluvium with abundant reworked well-rounded pebbles and cobbles of quartz, quartzite, and chert with rare crystalline rock fragments. The sand, silt, and clay fractions are commonly fairly well-sorted and contain organic material in some areas.

Thickness ranges from a feather edge at the headwaters of small tributaries to as much as 33 ft (10 m) along the Potomac River. Some engineering characteristics of organic clay and silty sand types of alluvium are compared in table 2.

Upland gravel deposits (unit 3).—Occur in two widely separated areas—in extreme eastern Montgomery County and in the southwestern part of the county bordering the Potomac River. Colluvium, or slope wash, was not mapped, as it is rare and deposits are mainly at the foot of steep slopes on quartzite in extreme western Montgomery County. Upland gravel deposits contain abundant interstitial sand, silt, and clay, as well as rounded pebbles, cobbles, and boulders of quartz, quartzite, chert, and rare crystalline rock fragments. Selected physical properties are described in table 1, and some engineering characteristics of upland gravel deposits are summarized in table 2.

The upland gravel deposits of southwestern Montgomery County occur at altitudes of 300 to 500 ft (91–152 m) more than 200 feet (60 m) above the present Potomac River; they overlie mainly Triassic sedimentary rocks but locally overlie crystalline rocks. Many of the pebbles and cobbles were apparently derived locally by reworking of Triassic conglomerate. The upland gravels also contain a clay-rich, reddish-brown, silty matrix derived from fine-grained Triassic materials.

The upland gravels of eastern Montgomery County mainly overlie Coastal Plain sedimentary rocks, but locally straddle the contact and extend onto crystalline rocks. They are light gray, contain minor amounts of interstitial clay and silt, and are well sorted. They are probably derived principally by reworking of Coastal Plain deposits with additional fluvial material, mainly quartz, transported from residuum on the adjacent Piedmont upland to the west.

The upland deposits have been dug as a source of gravel and sand in both areas; however, these deposits require washing and grading. Thickness ranges from zero to possibly as much as 100 ft (30 m) where deposits fill channels, but probably averages 33 ft (10 m) thick.

Coastal Plain strata (unit 4).—Unconsolidated and partly consolidated Cretaceous sediments (Potomac Group) occur mainly on interfluvial ridges overlying saprolite formed on much older Piedmont crystalline rocks and underlying younger upland gravels. They rest on a truncated surface which slopes east-southeast from 60 to 100 ft per mile (11 to 19 m per km). The wedge of sediments thickens eastward from a feather edge at the Fall Line along Highway 29 to more than 100 ft (30 m) on uplands along the Prince Georges County line. The unit consists of an interbedded sequence of coarse gravel, fine to coarse sand, silt and clay in beds a few inches to 33 ft (a few centimeters to 10 m) thick. The gravel occurs in lenticular beds as much as 17 ft (5 m) thick consisting mainly of well rounded and polished pebbles and cobbles as much as 6 in. (15 cm) in diameter of quartz, quartzite, and chert, in a matrix of fine to coarse sand. Sand also occurs in fairly well-sorted crossbedded, locally pebbly, lenticular beds as much as 17 ft (5 m) thick and is mainly very quartzose; it also occurs as fairly well to poorly sorted sand which is locally micaceous, clay rich, ferruginous, and silty. Silt and clay occur in beds as much as 33 ft (10 m) thick and is mainly gray where fresh, and variegated, brightly colored, pink, greenish, and mottled where weathered. Some zones are very iron rich and iron was mined for local use a few miles to the east in Prince Georges County. Sand and gravel have been extensively dug and a few pits were operative in 1972. The sand and gravel beds are commonly porous and permeable, and produce ground water down dip to the southeast. Much of the outcrop belt in Montgomery County may be part of the aquifer recharge area, and hence may warrant protection from surface pollutants. Selected physical properties are described in table 1, and some engineering properties of Coastal Plain strata are summarized in table 2.

Saprolite (units 5A–5G).—The most widely distributed surficial material in the county is mapped only where inferred to be more than 20 ft (6 m) thick. Saprolite is a residual deposit of soft, red-brown to gray, earthy, untransported, porous material derived from decomposed crystalline rock in which the constituent minerals other than quartz have been altered to clays. The upper part is generally a few feet thick, massive, and grades upward into soil; the massive material grades downward into structured saprolite, as much as 160 ft (50 m) thick, which retains the structural characteristics of the unweathered bedrock into which it grades. The density of saprolite is commonly less than half that of the unweathered bedrock from which it is derived. The thickness and physical and chemical characteristics of saprolite are chiefly related to clay mineralogy, which in turn is a function of topographic position, parent material, drainage, and the physical-chemical environment in which it formed.

The term "saprolite" is used for the in-place weathered mantle overlying all types of crystalline rocks in the Maryland Piedmont; however, because the physical and chemical characteristics of this material commonly vary greatly, it may be helpful to delineate different saprolites based on different parent materials. Saprolite is therefore subdivided into six units based on parent rock and derived soil (5A–5G). Selected physical properties are described in table 1, and some engineering characteristics of massive and structured saprolite are compared in tables 2 and 3. The clay mineralogy of a few saprolite samples in the Beltsville quadrangle of northeastern Montgomery County is given in Withington and Froelich (1974a).

POSSIBLE USES OF THE MAP

The map can be used to delineate the distribution and general physical characteristics of the unconsolidated and partly consolidated deposits (overburden) which underlie the soil zone and which overlie hard bedrock. When used in conjunction with the thickness of overburden map (Froelich, 1975c), the volume of surficial material as well as its physical properties can be defined. When used in conjunction with the contour map of the base of saprolite and the bedrock map (Froelich, 1975a,b), some conclusions bearing on erodibility, and relative rates of infiltration, percolation, absorption, and ground-water movement can be deduced.

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TABLE 1.—Selected properties of surface units (unconsolidated and partly consolidated) in Montgomery County, Maryland

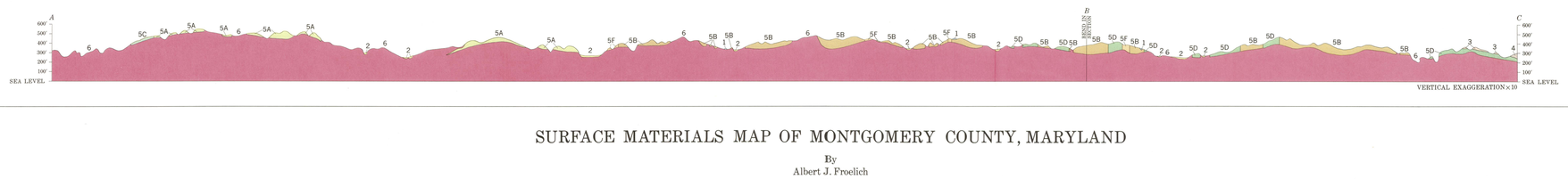
[Based in part on table 1, Engineering properties of map units in the Beltsville quadrangle (Withington and Froelich, 1974b)]

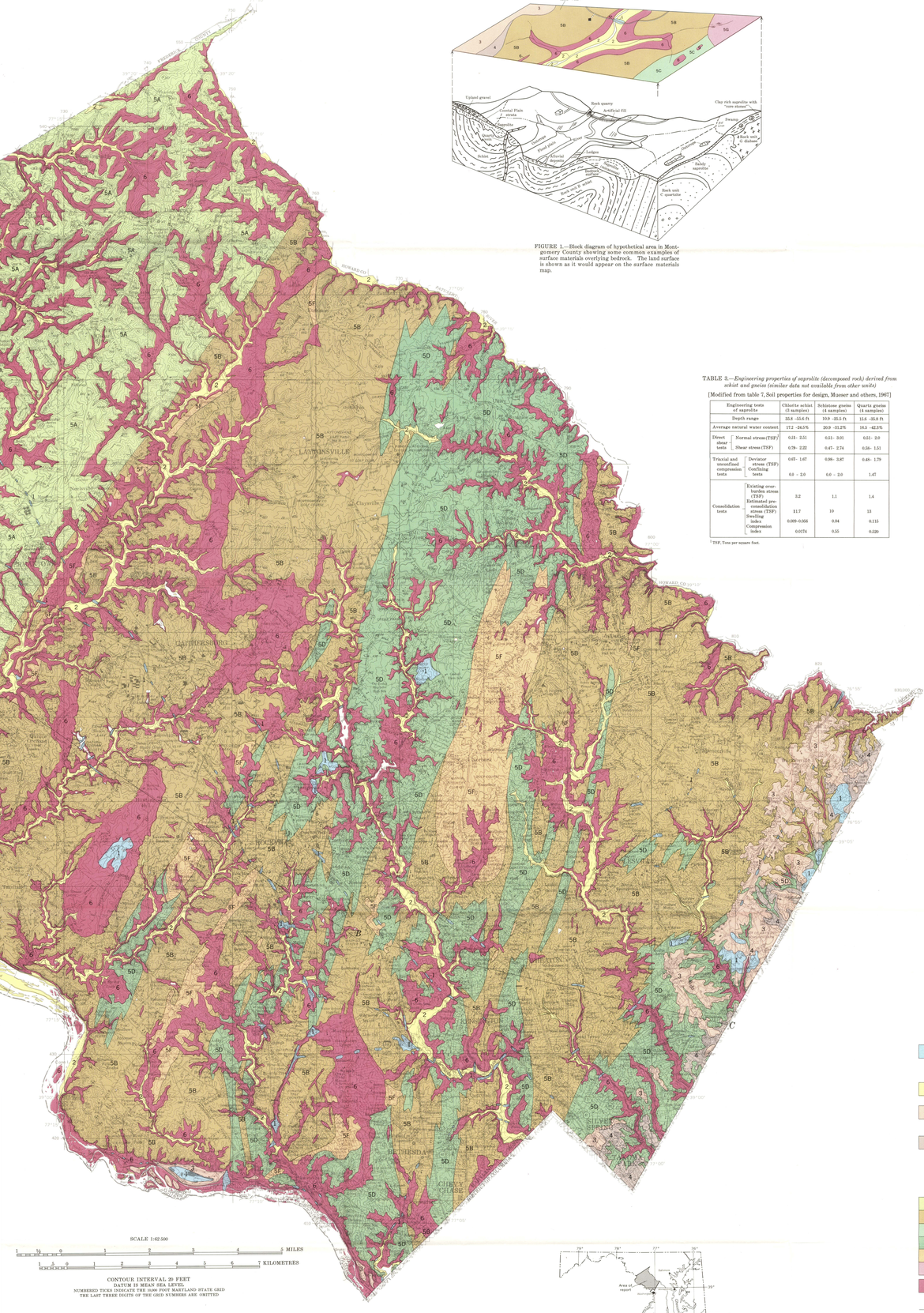
Map unit and symbol	Thickness (in ft (m))	Description and physical character	Topographic form and occurrence	Workability: Excavation	Workability: Compaction (in percent of maximum density)	Surface drainage and erodability	Ground-water characteristics	Limitations for waste disposal: Septic systems	Limitations for waste disposal: Sanitary landfill	Stability: Foundation[1]	Stability: Slope[2]	Known, reported, and possible uses	Remarks
ARTIFICIAL FILL 1	5–20 (1.5–6)	Heterogeneous mixture of local material (soil, saprolite, sand, gravel, clay, rock, etc.) from borrow pits or adjacent cuts.	Variable; engineered to specific use.	Easy with light power equipment, except moderately difficult where clay or saprolite form the fill.	To 95 or more	Gravel and sand fill drain well; clay and saprolite fill drain poorly. Erosion susceptibility moderate to high; should be stabilized and covered quickly with vegetation.	Not applicable.	Many limitations.	Many limitations.	Good for light two-storied structures if compacted to 95% of maximum density.	Stable on slopes of 1½:1; steeper slopes should be shored against slumping. Effective friction angle 30°.	Clay and silt in sediment pond fill used locally in brick manufacture and as impervious cores of earth dams (Withington, 1967).	Commonly constructed where roads and railroads cross streams and low points. Most highways and railroads over alluvium are on fill. Includes man-made and disturbed ground and sediment pond fill in gravel pits. Each fill needs special study.
ALLUVIUM 2	5–30 (1.5–9)	Gravel, sand, silt, and clay: Piedmont areas mainly fairly well sorted, subangular, micaceous, and silty; some areas contain sticky silty micaceous clay; locally rock masses to several tons. Coastal Plain areas of gravel mainly rounded quartz, quartzite, and friable sandstone. Some iron-cemented gravel and sandstone; minor sandy clay.	Flat (stream valleys).	Easy to moderate with light power equipment.	do.	Drainage poor to fair; subject to recurrent flooding; some swampy areas. Erosion susceptibility variable. Sandy areas high, clay and rock areas low.	Close to surface; water may be useful for industry if iron content not a factor. Iron may exceed 0.3 mg/l (milligrams per liter), the maximum recommended for domestic use.	Many limitations. Will not drain well—water table near surface.	Many limitations. Effluent likely to contaminate surface water.	Gravel and sand alluvium good for heavy structures with bearing strength 2 to 4 tons/sq ft. Clay areas poor for light structures; bearing strength ½ to 1½ tons/sq ft.	Temporary cuts stable on slopes of 1:1. Steeper slopes should be shored against slumping. Permanent slopes should be 1½:1 or gentler. Effective friction angle 23°–30°.	Sand and gravel dug locally for aggregate and concrete sand.	Some silty clays locally rich in plant material. Flood plains in common use as parks and recreation areas. Heavily vegetated. Thickest deposits along Potomac River west of Seneca.
UPLAND GRAVEL DEPOSITS 3	5–100 (1.5–30)	Gravel, sand, silt, and clay; southwestern deposits mainly poorly sorted gravel and sand in clay-rich, red-brown silty matrix derived from Triassic materials. Pebbles and cobbles mainly quartz, quartzite, and chert. Eastern deposits mainly well-sorted gravel and sand with minor amounts of light-gray interstitial silt and clay and minor clay and silt lenses.	Nearly flat to gently rolling hill tops and adjacent slopes; in southwest and east part of county.	Easy with light power equipment.	95–99	Drainage good to excellent except near base; water-laden by clay. Erosion susceptibility moderate to high.	Unit commonly above water table; good recharge area. Iron content average 0.7 mg/l. Springs common at top of clay lenses and at contact with underlying saprolite or bedrock.	Few limitations; septic tank fields will generally drain well except in areas of fragipan soils on gravels or in clay areas.	Many limitations due to high permeability of gravel and sand layers. High ent for pollluting ground water.	Generally good for heavy structures; bearing strength, 2 to 5 tons/sq ft; clay and silt areas fair to poor; bearing strength 1–2 tons/sq ft.	Cut slopes stable at 1½:1 or flatter; steeper cuts, slopes deeper than 4 ft (1.2 m) require shoring to avoid slumps, especially when material is saturated. Effective friction angle 25°–36°.	Source of fill, highway subgrade, and base course, concrete sand and aggregate. Locally abundant, friable sandstone makes gravel undesirable for aggregate.	As gravel and sand deposits are limited, extraction and multiple reclamation plans may warrant consideration. Upland gravel deposits in east part of county extensively urbanized. Deposits in southwestern part of county contain abundant red-brown clay and silt matrix and are poorly sorted; require washing and grading.
COASTAL PLAIN STRATA 4	5–100 (1.5–30)	Gravel, sand, silt, and clay, interbedded; gravel in lenses as much as 17 ft (5 m) thick, consisting of well rounded pebbles and cobbles of quartz, quartzite, and chert in a matrix of sand. Sand also occurs in fairly well sorted, crossbedded quartzose lenses as much as 20 ft (6 m) thick, and as poorly sorted micaceous clay-rich, silty and ferruginous sand. Silt and clay, mainly gray, variegated; lenses as much as 30 ft (9 m) thick.	Rolling hills in east part of county. Mainly in interfluvial ridges overlying saprolite and underlying upland gravel.	Easy to moderately difficult with heavy power equipment.	To 90–96	Drainage good, except poor in areas underlain by clay. Erosion susceptibility moderate to high.	Recharge area for important aquifers used to the east. Iron content commonly high where producing wells average 40 gpm. Iron content averages 0.7 mg/l. Springs common at top of clay lenses and at contact with underlying saprolite or bedrock.	Some limitations; septic tank fields will generally drain well but may contaminate aquifers in special situations.	do.	Good to excellent for heavy structures. Bearing strength 3–6 tons/sq ft for gravel and sand, 2.5–4.5 tons/sq ft on silty clay.	Permanent cut slopes stable at 1½:1; temporary slopes should be no more deep; will stand at 1½:1, but require shoring as they may slide when sand is saturated. Sand locally free running. Effective friction angle 25°–36°.	Excellent source of sand and gravel and for aggregate. Sand contains low mica content for glass manufacture. Clay and silt in lenses locally used for brick. Clay makes poor fill material; sand and gravel are good fill.	As gravel and sand deposits are limited in areal extent and volume, extraction of resources followed by reclamation and multiple use of excess may warrant consideration. Outcrop area currently being urbanized.
SAPROLITE 5A, phyllite 5B, schist 5C, quartzite 5D, gneiss 5F, mafic 5G, dolmaw	10–160 (3–49)	Clay, silt, sand, angular quartz and rock fragments; residual deposit of soft, red-brown to gray, earthy, porous material derived from decomposed crystalline rock in which constituent minerals other than quartz have been altered to clay. Retains structure of original rock. Montmorillonite, kaolinite, illite, sepiolite, and mixed layer clays.	Rolling, hilly upland surfaces.	Easy with light power equipment near surface, becoming moderately difficult with heavy power equipment below 20 ft (6 m).	To 90–95	Drainage generally good, ranging from poor to excessive; directionally permeable, best parallel to fractures and foliation, poor perpendicular to orientation of mica and clay flakes; poor near surface where swelling clays present. Erosion susceptibility low to moderate except where disturbed.	Most ground water stored in saprolite which contributes to fractures in unweathered bedrock. Quality usually good. Wells average 10 gpm but range from 1 to 100 gpm depending on aquifer mark type, thickness of saprolite, fractures, and configuration of bedrock surface.	Few limitations on thick saprolite formed on schist (5B) and gneiss (5D), many limitations on saprolite formed on mafic rocks (5F), diabase (5G), phyllite (5A), and quartzite (5C).	Some limitations, dependent on surface topography and drainage; moderately erodible; surface configuration, thickness and clay mineralogy.	Fair to good for heavy structures. Bearing strength 1–4 tons/sq ft near surface, increasing to 5 tons/sq ft or more at depth.	Stable in near-vertical cuts of 15 ft (4.5 m) or more. Where foliation or joints inclined toward cut face, may require shoring. Where used as fill, slopes gentler than 1:1 apt to slump (Withington and Coulter, 1964). Effective friction angle 30°–36°.	Saprolite clay locally used in brick manufacture. Presence of mica precludes use in aggregate. Fair to poor used as fill, and care necessary to assure slope stability (Withington and Coulter, 1964).	Bedrock pinnacles and core stones of unweathered rock surrounded by saprolite common in areas underlain by gneiss (5D), mafic rock (5F), diabase (5G), and quartzite (5C). Drainage commonly excessive on quartzite (5C), phyllite (5A), and sandstone; commonly impeded on clay-rich mafic (5F) parent rock.

[1]Foundation stability: Approximate bearing capacity (tons/sq ft) developed from local practice of a footing 4 ft wide, above water table; below water table, bearing capacity should be reduced 50 percent. Bearing capacities of wider footings should also be reduced 20–40 percent (statement modified from Duncan, 1965, p. 31).

[2]Slopes listed as ratio of horizontal to vertical, i.e., 1½:1 = 1½/1

Common equivalents and conversions
1 inch = 25 millimetres (2.54 cm)
1 foot = 0.3 metre
1 sq ft = 0.09 sq metre
1 ton (avdp) = 908 kilograms





E X P L A N A T I O N

1 — ARTIFICIAL FILL.—Heterogeneous mixture of soil, saprolite, rock, gravel, and other material which has usually been moved a short distance from artificial cuts or borrow pits; includes man-made and disturbed ground; highly variable. Commonly less stable and with less bearing and shear strength than undisturbed parent material; readily eroded unless stabilized

2 — ALLUVIUM.—Sand, gravel, silt, and clay; in stream valleys; coarse fraction mainly quartz and quartzite; poorly sorted; unconsolidated; usually less than 20 feet (6 m) thick; subject to recurrent flooding

3 — UPLAND GRAVEL DEPOSITS.—Cobbles, pebbles, boulders, sand, silt, and clay; caps ridges, hills, and terraces; coarse fraction predominantly quartz, quartzite, and chert; poorly sorted; may fill channels; unconsolidated; locally more than 50 feet (16 m) thick; includes colluvium

4 — COASTAL PLAIN STRATA.—Unconsolidated or partly consolidated gravel, sand, and clay; locally ferruginous conglomerate and sandstone; coarse fraction mainly quartz, quartzite, and chert; fairly well sorted; as much as 100 feet (30 m) thick

SAPROLITE.—Residual silty clay and weathered bedrock; firm and cohesive where undisturbed; ferruginous and porous, locally nearly impermeable; commonly micaceous with slightly weathered fragments, chips, and core stones of unweathered bedrock and angular quartz; as much as 160 feet (50 m) thick; mapped only where more than 20 feet (6 m) thick

5A — On phyllite, gravelly, excessively drained

5B — On schist, micaceous, well drained

5C — On quartzite, sandy, excessively drained

5D — On gneiss, silty, bouldery, well drained

5F — On mafic rock, clay-rich, poorly drained

5G — On diabase, clay-rich, bouldery, poorly drained

6 — BEDROCK.—Igneous, metamorphic, and consolidated sedimentary rock; fresh, hard, and unaltered; locally overlain by as much as 20 feet (6 m) of alluvium, regolith, residuum, saprolite, and soil

——— BOUNDARY BETWEEN MAP UNITS

SURFACE MATERIALS MAP OF MONTGOMERY COUNTY, MARYLAND

By
Albert J. Froelich
1975

INTERIOR—GEOLOGICAL SURVEY, RESTON, VIRGINIA—1975

For sale by U.S. Geological Survey, price $1.00