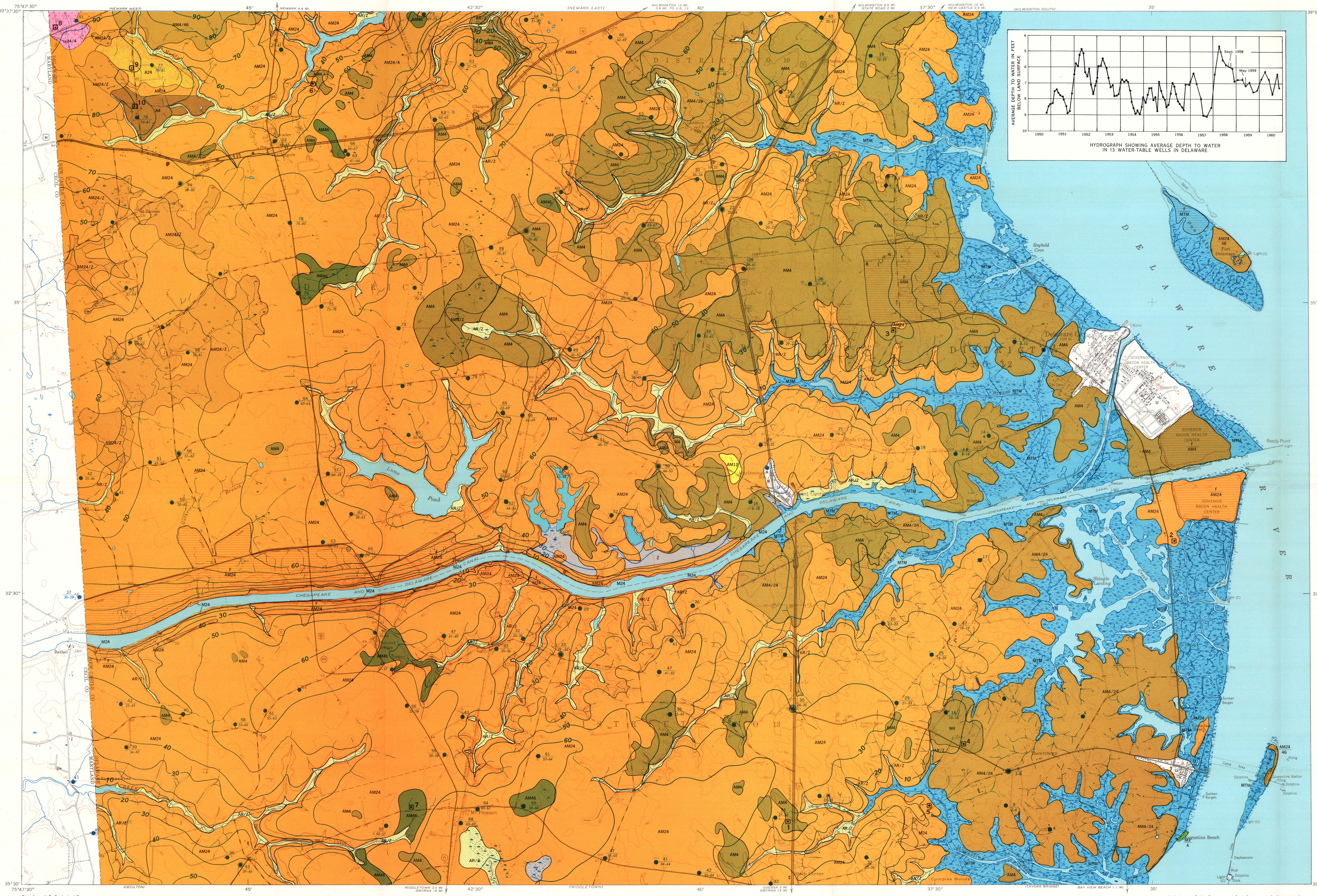
PREPARED IN COOPERATION WITH
THE DELAWARE GEOLOGICAL SURVEY
AND THE DELAWARE STATE HIGHWAY DEPARTMENT



HYDROGRAPH SHOWING AVERAGE DEPTH TO WATER IN 13 WATER-TABLE WELLS IN DELAWARE

Base from U.S. Geological Survey topographic quadrangles

SCALE 1:24 000

CONTOUR INTERVAL 10–20 FEET
DATUM IS MEAN SEA LEVEL

Hydrology by D. H. Boggess and O. J. Coskery, U. S. Geological Survey
Engineering Soils Map by J. K. Adams, Delaware Geological Survey
assisted by C. F. Davis and W. H. Tewelow, U. S. Geological Survey

EXPLANATION

Primary observation well (30 / 26–30)

The numerator is the altitude of the water table, in feet above mean sea level, in September 1958. The denominator shows the measured range in altitude of the water table over the period 1950–60

Secondary observation well (52 / 44–53)

The numerator is the altitude of the water table, in feet above mean sea level, in September 1958. The denominator shows the estimated range in altitude of the water table for the period 1950–60, based on measurements from 1957 to 1960 and comparison with primary observation-well records

Domestic or farm well (29 / 21–52)

The numerator is the altitude of the water table, in feet above mean sea level, in September 1958. The denominator shows the estimated range in altitude of the water table for the period 1950–60, based on 2 or 3 measurements and comparison with primary and secondary observation-well records

Water-table contour (20)

Number shows altitude of water table in September 1958. Contour interval 10 feet. Datum is mean sea level. Position of water table in September 1958 was well above normal, as shown by hydrograph

Perennial stream

Bottom of stream channel is almost always below the water table

Intermittent stream

Bottom of stream channel is above the water table part of the time and below the water table part of the time

AM12 — Nonplastic gravelly and sandy soil derived from fluvial deposits of Pleistocene age

AM24 — Nonplastic to slightly plastic sandy and silty soil derived from fluvial deposits of Pleistocene age

AM4 — Slightly plastic silty and clayey soil derived from fluvial deposits of Pleistocene age

AM46 — Slightly plastic to highly plastic silty and clayey soil derived from fluvial deposits of Pleistocene age

A24 — Nonplastic to slightly plastic sandy and silty soil derived from fluvial deposits of Cretaceous age

A4 — Slightly plastic silty and clayey soil derived from fluvial deposits of Cretaceous age

M24 — Nonplastic to slightly plastic sandy and silty soil derived from marine sediments of Cretaceous and Tertiary age

M4 — Slightly plastic silty and clayey soil derived from marine sediments of Cretaceous and Tertiary age

MTM — Marine tidal-marsh deposits

U — Urban areas where soil has been altered by man

Z — Poorly drained organic swamp soil

AR/Z — Flood-plain deposits associated with swamp deposits

AM24/4 — AM24 soil associated with diminutive amounts of AM4 soil

AM4/24 — AM4 soil associated with diminutive amounts of AM24 soil

AM4/46 — AM4 soil associated with diminutive amounts of AM46 soil

AM24/Z — AM24 soil associated with swamp deposits

AM4/Z — AM4 soil associated with swamp deposits

Ia24/4 — Nonplastic to slightly plastic sandy and silty soil associated with silty and clayey soil derived from gabbro

AM24 / 46 — AM24 soil underlain by AM46 soil

M3 / 4 — Nonplastic sandy soil underlain by slightly plastic silty and clayey soil derived from marine sediments

F / AM24 — Fill underlain by AM24 soil

F / AM4 — Fill underlain by AM4 soil

F / M24 — Fill underlain by nonplastic to slightly plastic sandy and silty soil derived from marine sediments

F / MTM — Fill underlain by soil developed in marine tidal marshes

⊡7 — Location and number of pit from which soil samples were obtained for laboratory analysis. The results of the laboratory analyses are summarized in table 3. General characteristics are summarized in table 4

SOIL SYMBOLS

A	Alluvial deposit, Cretaceous age
AM	Surficial Alluvial Mantle, Pleistocene age
AR	Recent Alluvial deposit
M	Marine deposit
Ia	Gabbro
F	Fill
MTM	Marine Tidal Marsh
U	Urban area
Z	Swamp deposit

The map symbols used in this report to designate the various types of soils are a modification of the system used in the Engineering Soil Survey of New Jersey (Rogers, 1955). The first part of the symbol is a letter, or group of letters, which identifies the parent material according to the classification developed by Lueder (1950) (see table 1). The second part of the symbol is a number which identifies the soil group according to the classification system adopted by the Highway Research Board (Allen and others, 1945) and used with some modifications by the Delaware State Highway Department (see table 2). When a two digit number is used, it means that two soil types are present within the same soil profile; for example, the symbol A·24 implies that both A 2 and A 4 soils are present in the same soil profile, but usually in different soil horizons. Two different soil symbols may be combined by either a horizontal bar ($\frac{F}{AM4}$) or a diagonal bar (AM4/24). When the horizontal bar is used, it means that the soil designated by the denominator underlies the soil designated by the numerator within a depth of 20 to 72 inches. When the letter symbol is omitted from the denominator, the parent material is the same as that shown for the numerator. When the diagonal bar is used, it means that two soils are interspersed within the area so designated, but they are not present in the same soil profile. The predominant soil type is identified by the symbol that precedes the diagonal bar

REFERENCES

Allen, Harold, and others, 1945, Report of committee on classification of materials for subgrades and granular type roads: Highway Research Board, 25th Ann. Mtg., Oklahoma City, 1946, Highway Research Board Proc., v. 25, p. 375–388, Washington

Lueder, D. R., 1950, A system for designating map-units on engineering soil-maps in soil exploration and mapping: Higway Research Board Bull. 28, p. 17–35, Washington

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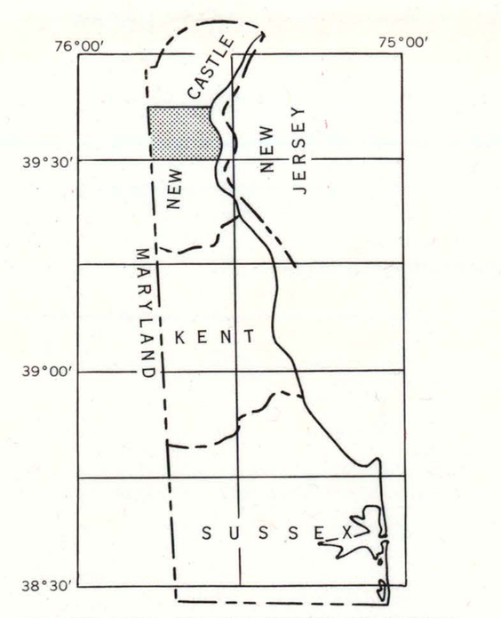

INDEX MAP OF DELAWARE SHOWING LOCATION OF THE ST. GEORGES AREA

Table 2.—Soils classification

General classification	Granular materials (35 percent or less passing a No. 200 sieve)							Silt-clay materials (more than 35 percent passing a No. 200 sieve)					
Group classification	A-1		A-3	A-2				A-4	A-5	A-6	A-7[1]		A-8
	a	b		4	5	6	7				5	6	
Sieve analysis: Percent passing: No. 10 sieve; No. 40 sieve; No. 200 sieve	50 max.; 30 max.; 15 max.	50 max.; 25 max.	51 min.; 10 max.	35 max.	35 max.	35 max.	35 max.	36 min.	36 min.	36 min.	36 min.	36 min.	
Characterisitcs of fraction passing: No. 40 sieve; Liquid limit; Plasticity index	6 max.	6 max.	Nonplastic	40 max.; 10 max.	41 min.; 10 max.	40 max.; 11 min.	41 min.; 11 min.	40 max.; 10 max.	41 min.; 10 max.	40 max.; 11 min.	41 min.; 11 min.	40 min.; 11 min.	42–400; 0–60
Group index	0		0	0		4 max.		8 max.	12 max.	16 max.	20 max.		
General subgrade rating	Excellent		Good	Good		Fair		Poor	Poor	Poor	Very poor		Unsatisfactory
Material	Well-graded gravels and sands		Clean sands and gravelly sands	Poorly graded, silty or clayey sands and gravels				Silty soils	Plastic silts	Plastic clays	Expansive plastic clays		Muck-peat

[1]Plasticity index of A-7-5 subgroup is equal to or less than the liquid limit minus 30. Plasticity index of A-7-6 subgroup is greater than the liquid limit minus 30.

Table 3.—Results of laboratory analyses of soil samples

Sample pit number	Depth of interval sampled (inches)	Soil horizon	Mechanical analyses: Cumulative percent passing sieve— 3/4 in.	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 200 (0.074 mm.)	Percent by weight: Silt	Clay	Liquid limit[1]	Plasticity index[2]	Moisture-density[3]: Maximum density (lbs. per cu. ft.)	Optimum moisture (percent)	Classification: H. R. B.[4]	Unified[5]	Map symbol
1	0–10	A	100	100	99.9	94.9	84.9	69	12	33	NP	95.3*	16 *	A-4 (8)	ML	AM4
	28–43	B	100	100	100	97.7	93.3	63	28	28	9	105.8*	16.2*	A-4 (8)	CL	
2	0–9	A	100	99.8	99.8	92.6	58.2	------	------	22	NP	------	------	A-4 (5)	ML	AM24
	27–33	B	100	100	100	97.1	80.3	48.2	26.8	25.5	10.7	------	------	A-4 (8)	CL	
	46–54	C	100	99.6	99.5	90.2	19.9	------	------	NL	NP	------	------	A-2–4 (0)	SM	
3	0–8	A	100	99.9	99.8	99.8	94.0	------	------	25	4.6	114	14	A-4 (8)	CL–ML	AM4
	14–38	B	100	100	100	99.0	94.5	------	------	28	3	123.5	11.5	A-4 (8)	ML	
	52–56	C	100	100	100	98.8	91.9	72	15	22	NP	------	------	A-4 (8)	ML	
4	0–6	A	100	99.8	99.5	96.6	88.2	------	------	27	3	119	10.7	A-4 (8)	ML	M4
	6–40	B	100	100	100	98.9	95.9	------	------	29	12	------	------	A-6 (9)	CL	
	40–48	C	100	100	100	97.7	85.9	49	34	26	8	------	------	A-4 (8)	CL	
5	0–12	A	100	99.9	99.8	91.5	70.2	------	------	19	NP	------	------	A-4 (7)	ML	M24
	12–50	B	100	99.9	99.2	79.2	48.3	------	------	25	3	------	------	A-4 (3)	SM	
	50–72	C	97.5	93.5	91.7	51.6	12.2	------	------	NL	NP	------	------	A-2–4 (0)	SM	
6	0–9	A	100	98.1	95.2	75.3	47.4	------	------	30	NP	119	12	A-4 (2)	SM	AM24
	9–30	B	66.8	61.5	57.4	39.4	18.9	------	------	17	NP	135.3	6.8	A-1–b (0)	SM	
	39–68	C	100	100	99.8	99.8	89.6	46	40	27	10	121	11.3	A-4	CL	
7	0–12	A	100	100	99.9	96.2	91.6	63	26	35	16	110.5	14.7	A-6 (10)	CL	AM46
	12–40	B	100	100	99.7	97.7	93.7	60	30	33	16	113.5	12	A-6 (10)	CL	
8	0–8	A	96.6	93.3	91.7	86.6	51.6	------	------	26.5	NP	116	11.5	A-4 (4)	ML	Ia4
	8–33	B	97.6	94.8	90.6	85.8	63.7	------	------	24	5.2	125	10	A-4 (6)	CL–ML	
	33–48	B–C	100	100	99.7	96.7	83.9	59	21	26.5	1.5	118	13.5	A-4 (8)	ML	
9	0–9	A	100	97.4	94.4	65.2	28.9	------	------	NL	NP	126.2	9.3	A-2–4 (0)	SM	A24
	9–37	B	99.4	93.5	89.1	59.6	24.1	------	------	NL	NP	132.8	8	A-2–4 (0)	SM	
	37–48	B–C	100	96.9	92.7	67.9	35.6	25	9	16	NP	132.8	6.2	A-4 (0)	SM	
10	0–6	A	99.8	98.3	97.7	84.3	60.4	------	------	32.5	NP	114.2	11	A-4 (5)	ML	A4
	6–28	B	100	98.9	98.1	85.2	63.6	------	------	25	NP	120	10	A-4 (6)	ML	
	28–48	B–C	100	99.4	98.0	89.3	65.0	42	20	28.3	12.2	125	10.2	A-6 (7)	CL	

[1]Based on AASHO (American Association of State Highway Officials) Designation: T89–49. Liquid limit: NL, nonliquid.
[2]Based on AASHO Designation: T91–49. Plasticity index: NP, nonplastic.
[3]Based on AASHO Designations: T99–49 and 180T (all unstarred entries were determined by Designation 180T).
[4]Highway Research Board system (see table 2); group index given in parentheses.
[5]Unified Soil Classification system: Technical Memorandum No. 3–357, Vol. 1, Waterways Experiment station, Corps of Engineers, March 1953.

Table 4.—Characteristics of the engineering soil types in the St. Georges Area

Soil type	Description	Origin	Engineering properties: In place: Suitability as a subgrade[2]	In place: Suitability as a wearing surface[3]	Disturbed[1]: Suitability as embankment material	Disturbed[1]: Compaction characterisitcs	Suitable equipment
AM12	Nonplastic to slightly plastic, gravelly and sandy soil	Fluvial terrace deposits of Pleistocene age	Excellent	Good to excellent depending on amount of binder present	Excellent	Excellent	Rubber-tired equipment
AM24	Nonplastic to slightly plastic, sandy and silty soil	Fluvial deposits of Pleistocene age	Fair to good depending on amount of A-2 material left after grading	Poor if surface is A-4. Good to excellent, depending on amount of binder present, if surface is A-2	Fair to good depending on relative amounts of A-2 and A-4 present	Fair to good depending on relative amounts of A-2 and A-4 present	Rubber-tired equipment
AM4	Slightly plastic, silty and clayey soil	Fluvial and possibly eolian deposits of Pleistocene age	Fair	Fair	Fair	Fair	Rubber-tired equipment
AM46	Slightly plastic to highly plastic, silty clay and clayey silt	Fluvial, paludal, and lacustrine deposits of Pleistocene age	Not suitable to poor, depending on amount of A-6 material left after grading	Not suitable, if surface is A-6. Poor if surface is A-4	Not suitable to poor, depending on relative amounts of A-4 and A-6 present	Poor	Sheep's-foot rollers
A24	Nonplastic to slightly plastic, sandy and silty soil	Fluvial deposits of Cretaceous age	Fair to good depending on amount of A-2 material left after grading	Poor if surface is A-4. Good to excellent, depending on amount of binder present, if surface is A-2	Fair to good depending on relative amounts of A-2 and A-4 present	Fair to good depending on relative amounts of A-2 and A-4 present	Rubber-tired equipment
A4	Slightly plastic, silty and clayey soil		Fair	Fair	Fair	Fair	Rubber-tired equipment
M24	Nonplastic to slightly plastic, sandy and silty soil	Marine deposits of Cretaceous and Tertiary age	Fair to good depending on amount of A-2 material left after grading[4]	Poor if surface is A-4. Good to excellent, depending on amount of binder present, if surface is A-2[4]	Fair to good depending on relative amounts of A-2 and A-4 present[4]	Fair to good depending on relative amounts of A-2 and A-4 present[4]	Rubber-tired equipment
M4	Slightly plastic, silty and clayey soil		Fair	Fair	Fair	Fair	Rubber-tired equipment
F	Fill. In general, nonplastic to slightly plastic, gravelly soil		Engineering properties are variable and unpredictable				
MTM	Soil rich in organic material and subject to innundation by high tides. No definite profile	Tidal marsh deposits	Variable	Variable	Variable	Variable	Variable
U	Urban areas where soil has been altered extensively by man	Undetermined	Variable	Variable	Variable	Variable	Variable
Z	Poorly drained soil rich in organic material.	Swamp deposits of Recent age	Not suitable	Not suitable	Not suitable	Impractical	Variable
AR/Z	Alluvial gravel sand silt, and clay mixed with organic material	Alluvium and swamp deposits	Engineering properties are variable, but fill will be required in these areas				
Ia24/4	Nonplastic to slightly plastic sandy and silty soil associated with silty and clayey soil	Weathered gabbro	Fair to good depending on amount of A-2 material left after grading	Poor if surface is A-4. Good to excellent, depending on amount of binder present, if surface is A-2	Fair to good depending on relative amounts of A-2 and A-4 present	Fair to good depending on relative amounts of A-2 and A-4 present	Rubber-tired equipment
M3/4	Nonplastic, well-sorted sand underlain by slightly plastic silty and clayey soil	Marine deposits of Cretaceous or Tertiary age	Poor to fair depending on amount of A-3 material left after grading	Poor if surface is A-4. Fair if surface is A-3	Poor to good depending on relative amounts of A-3 and A-4 present	Poor to good depending on relative amounts of A-3 and A-4 present	Vibratory equipment best for sand. Rubber-tired equipment best for mixtures of sand and silt

[1]For soil types designated by two-digit numbers, these columns refer to the composite soil.
[2]When not subject to frost action. Frost action will be a problem with those soils which contain appreciable amounts of silt and clay, and have a high moisture content.
[3]Untreated. Additives may aid in stabilization of the sandy soils and minimize dusty conditions.
[4]Some difference may be induced by the presence of glauconite which occurs as friable pellets.

WATER-TABLE, SURFACE-DRAINAGE, AND ENGINEERING SOIL MAP OF THE ST. GEORGES AREA, DELAWARE

By John K. Adams and Durward H. Boggess

1963

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