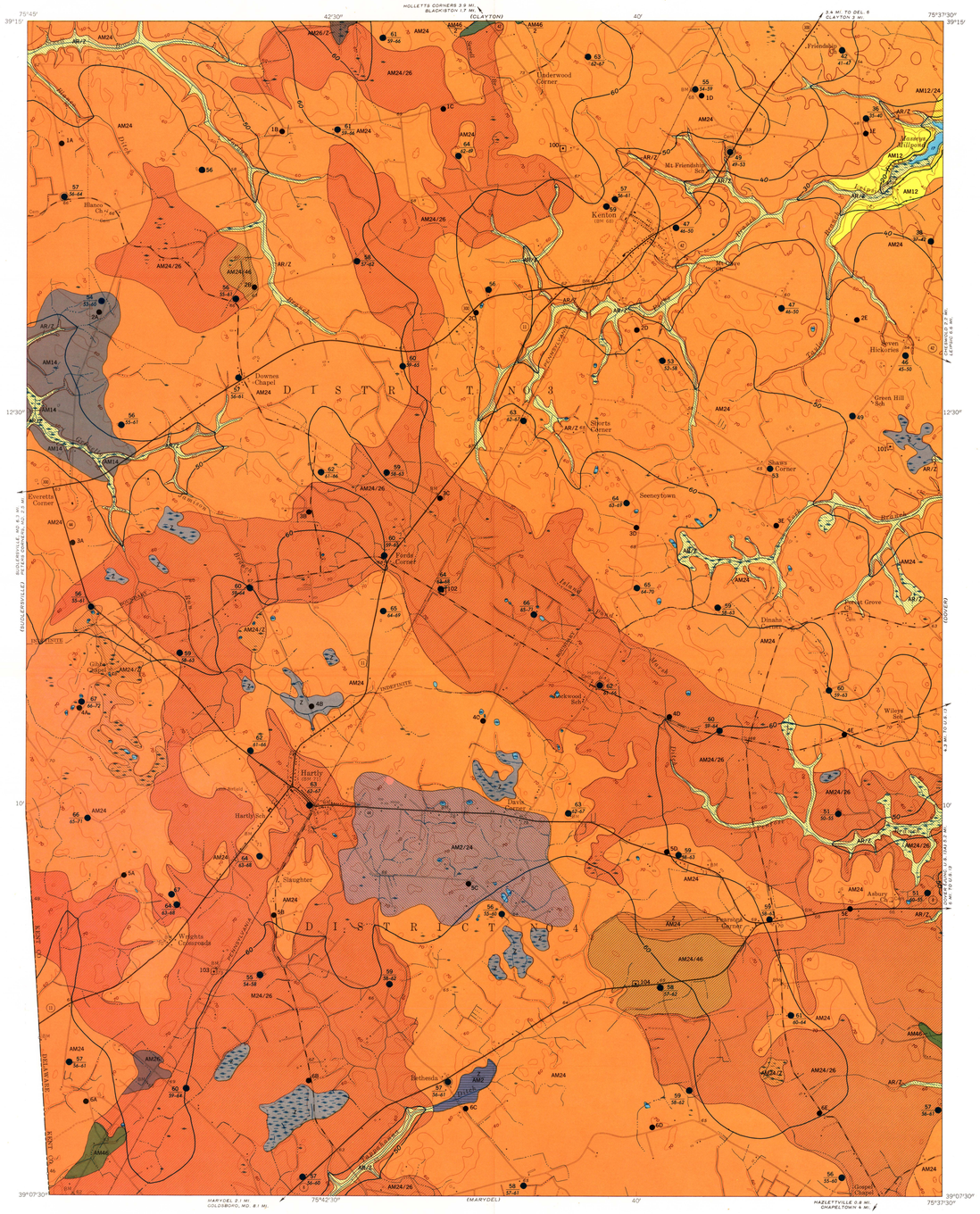
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

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

HYDROLOGIC INVESTIGATIONS
ATLAS HA-138



EXPLANATION

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

AM14 — Nonplastic to slightly plastic gravelly and silty soil derived from fluvial deposits of Pleistocene age

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

AM26 — Nonplastic to highly plastic sandy 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

Z — Swamp deposits

AR/2 — Flood-plain deposits associated with swamp deposits

AM12/24 — AM12 soil associated with AM24 soil

AM2/24 — Nonplastic to slightly plastic sandy soil derived from fluvial deposits of Pleistocene age associated with AM24 soil

AM24/26 — AM24 soil associated with AM26 soil

AM26/46 — AM24 soil associated with AM46 soil

AM24/Z — AM24 soil associated with swamp deposits

AM26/Z — AM26 soil associated with swamp deposits

AM46/Z — AM46 soil underlain by nonplastic sandy soil derived from fluvial deposits of Pleistocene age

AM2/Z — Swamp deposits underlain by nonplastic to slightly plastic sandy soil derived from fluvial deposits of Pleistocene age

AM24/Z — Swamp deposits underlain by AM24 soil

100 — Soil sample pit
Location and number of pit from which soil samples were obtained for laboratory analyses (See table 3). General characteristics are summarized in table 4

6E — Soil sample site
Location and number of secondary soil sample sites. Samples were collected with a one-inch-diameter long-core soil sampler. For results of laboratory analyses see table 3; for general characteristics see table 4

49 / 49-53 — Primary observation well
Numerator is altitude of water table in October 1959. Denominator shows measured range in altitude of water table during 1950-62

57 / 56-61 — Secondary observation well
Numerator is altitude of water table in October 1959. Denominator shows estimated range in altitude of water table during 1950-62 based on measurements from 1958 to 1962 and comparison with primary observation-well records

51 / 50-55 — Domestic or farm well
Numerator is altitude of water table in October 1959. Denominator, where given, shows estimated range in altitude of water table during 1950-62, based on 2 or 3 measurements and comparison with primary and secondary observation-well records

60 — Water-table contour
Number shows altitude of water table (in feet above mean sea level in October 1959. Contour interval 10 feet. Relative position of water table in October 1959 is shown in hydrograph (fig 2)

Perennial stream
Bottom of stream channel almost always below water table

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

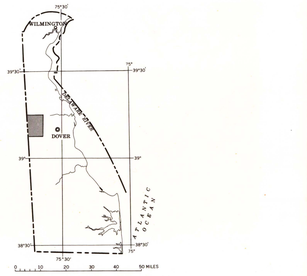


FIGURE 1.—*Index map of Delaware showing location of the Kenton area.*

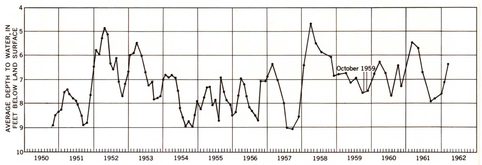


FIGURE 2.—*Hydrograph showing average depth to water in 13 water-table wells in Delaware.*

TABLE 1.—*Explanation of letter symbols.*

Symbol	Explanation
AM	Surficial alluvial mantle, Pleistocene age.
AR	Recent alluvial deposit.
Z	Swamp deposit.

SOIL SYMBOLS

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). A two-digit number indicates that two soil types are present within the same soil profile; for example, the symbol AM24 implies that both A-2 and A-4 soils are present in the same soil profile, but usually in different horizons.

Two different soil symbols may be combined by either a horizontal bar or a diagonal bar. A horizontal bar (AM12/24) indicates that the soil designated by the denominator underlies the soil designated by the numerator within a depth of 20 to 72 inches. If a letter symbol is used only in the numerator, it also applies to the denominator. A diagonal bar (AM2/24) indicates that two soil types (AM2and AM24) are present within the same area, but not necessarily in the same profile. The two soils are so finely interspersed that they cannot be mapped separately.

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: Highway Research Board Bull. 28, p. 17-35, Washington.

Rogers, F. C., 1955, Engineering soil survey of New Jersey, Report No. 1: Rutgers Univ. Eng. Research Bull. 15, 114 p., New Brunswick, N. J.

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		A-8
	a	b		4	5	6	7				5[1]	6[2]	
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.	
Characteristics 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[3]	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 gravel and sand		Clean sand and gravelly sand	Poorly graded, silty or clayey sand and gravel				Silty soil	Plastic silt	Plastic clay	Expansive plastic clay		Muck-peat

[1]Plasticity index of A-7-5 subgroup is equal to or less than the liquid limit minus 30.
[2]Plasticity index of A-7-6 subgroup is greater than the liquid limit minus 30.
[3]The group index is calculated according to the following formula: Group index = 0.2a + 0.005ac + 0.01 bd
in which: a = That portion of the percentage passing No. 200 sieve greater than 35 percent and not exceeding 75 percent, expressed as a positive whole number (1 to 40).
b = That portion of the percentage passing No. 200 sieve greater than 15 percent and not exceeding 55 percent, expressed as a positive whole number (1 to 40).
c = That portion of the numerical liquid limit greater than 40 and not exceeding 60, expressed as a positive whole number (1 to 20).
d = That portion of the numerical plasticity index greater than 10 and not exceeding 30, expressed as a positive whole number (1 to 20).

TABLE 3.—*Results of laboratory analyses of soil samples.*

Liquid limit: NL, nonliquid — Plasticity index: NP, nonplastic

Sample pit and site nos.	Depth of interval sampled (inches)	Mechanical analyses: Cumulative percent by weight 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 (0.062 to 0.0039mm.)	Clay (<0.0039mm.)	Liquid limit[2]	Plasticity index[2]	Moisture-density[3]: Maximum density (lbs. per cu. ft.)	Optimum moisture (percent by weight)	Classification: HRB[4]	Map symbol[5]
100	0-18	100	100	99.2	79.7	38.0			16	NP			A-4 (1)	A M24
	18-47	100	99.9	99.0	78.5	39.1			NL	NP	120	9	A-2-4 (0)	
	47-64	100	99.9	98.4	72.5	9.0			NL	NP	126	10	A-3 (0)	
101	0-5	100	100	99.8	83.9	41.1			22	NP			A-4 (1)	A M34
	5-48	100	100	99.8	84.9	52.7	35	15	23	6	125	9	A-4 (3)	
	48-60	100	99.6	97.9	70.3	1.1			NL	NP	122	7	A-3 (0)	
102	0-5	100	100	99.7	85.0	11.2			NL	NP			A-2-4 (0)	A M2
	5-60	100	100	100	74.1	18.8			NL	NP			A-2-4 (0)	
	60-54	100	100	99.9	67.7	11.0			NL	NP			A-2-4 (0)	
103	0-6	99.7	99.2	98.1	84.2	58.5			24	4			A-4 (3)	A M24
	6-18	100	99.9	99.5	88.8	51.9	38	11	22	4			A-4 (3)	
	18-48	100	85.6	55.0	41.5	24.8	12	13	32	17			A-2-6 (1)	
104	0-8	100	99.9	99.4	87.2	41.4			16	NP			A-4 (1)	A M24
	8-25	100	100	99.9	89.5	58.1	38	17	20	7	126	10	A-4 (3)	
	25-50	100	100	99.8	88.7	16.0			NL	NP	120	11	A-2-4 (0)	
1A	12-54			100	87.4	60.4			<40	<10			A-4 (5)	
1B	42-72			97.7	86.0	31.7			<40	<10			A-2-4 (0)	
	72-84			98.2	88.4	59.7			<40	<10			A-4 (5)	
1C	23-72			99.7	89.8	15.8			<40	<10			A-2-4 (0)	
	72-93			99.8	89.0	61.8			<40	NP			A-4 (5)	
	93-84			99.0	93.9	33.5			NL	NP			A-2-4 (0)	
1D	24-72			97.8	82.9	14.5			<40	<10			A-2-4 (0)	
	72-96			99.5	83.2	58.1			<40	<10			A-4 (5)	
1E	36-72			97.6	83.3	16.7			<40	<10			A-2-4 (0)	
	72-96			99.1	93.0	59.0			<40	<10			A-4 (5)	
2A	24-72			99.0	97.0	47.0			<40	<10			A-2-4 (0)	
	72-92			99.0	95.0	39.4			<40	<10			A-2-4 (0)	
2B	23-48			73.0	45.0	12.1			<40	< 5			A-1-b (0)	
	48-95			99.6	94.7	66.4			38	15			A-6 (10)	
2C	36-72			99.9	85.1	63.2			24	6			A-4 (8)	
	42-53			99.0	91.0	49.0			<40	<10			A-4 (3)	
	53-73			99.6	97.4	80.9			<40	<10			A-4 (5)	
2D	0-21			97.8	97.5	39.4			<40	<10			A-2-4 (0)	A M24
	21-37			98.8	85.7	49.6			<40	<10			A-4 (3)	
	37-72			99.6	88.0	59.3			<40	<10			A-4 (5)	
2E	37-72			95.8	66.6	22.2			<40	<10			A-2-4 (0)	
	72-93			99.0	93.1	53.7			<40	<10			A-4 (4)	
3A	37-72			93.2	79.0	25.4			<40	<10			A-2-4 (0)	
	42-95			100	97.2	64.5			<40	<10			A-4 (8)	
3B	30-72			92.6	62.8	26.6			<40	<10			A-2-4 (0)	
	42-56			99.1	73.5	29.1			<40	<10			A-2-4 (0)	
3C	36-72			99.4	76.9	37.0			19	5			A-4 (0)	A M4
	0-18			99.6	88.4	54.7			<40	<10			A-4 (1)	
	18-60			99.2	84.8	39.9			<40	<10			A-4 (1)	
3D	18-37			97.0	74.1	31.0			<40	<10			A-2-4 (0)	
	37-72			99.4	81.2	17.8			<40	<10			A-2-4 (0)	
3E	13-53			99.0	81.7	50.5			<40	<10			A-4 (3)	
	53-72			95.0	62.1	28.0			<40	< 10			A-2-4 (0)	
4A	13-45			99.0	76.2	29.0			<40	<10			A-2-4 (0)	
	45-72			99.4	79.5	39.1			<40	<10			A-2-4 (0)	
4B	13-43			94.0	73.6	35.2			25	3			A-4 (5)	
	43-72			98.0	83.1	53.1			31	5			A-4 (4)	
4C	12-72			95.3	57.2	15.8			<40	< 10			A-2-4 (0)	
4D	24-30			95.0	70.0	39.0			40	20			A-7-6 (0)	
	30-48			99.2	84.0	42.6			NL	NP			A-4 (1)	
	48-65			97.5	78.0	37.0			<40	<10			A-2-4 (0)	
4E	12-60			99.1	88.2	52.2			<40	<10			A-4 (3)	
	60-72			98.7	60.3	13.5			<40	<10			A-2-4 (0)	
5A	12-47			97.8	57.0	8.2			<40	NP			A-3 (0)	
	47-61			98.8	78.5	40.4			<40	NP			A-4 (1)	
	61-72			92.3	51.7	16.5			<40	<10			A-2-4 (0)	
5B	18-30			99.0	88.0	33.0			<40	<10			A-2-4 (0)	
	30-72			99.7	90.7	58.8			<40	<10			A-4 (5)	
5C	12-37			95.1	75.0	19.0			<40	<10			A-2-4 (0)	
	37-72			99.4	77.3	14.0			<40	<10			A-2-4 (0)	
5D	12-57			99.6	81.5	24.6			<40	<10			A-2-4 (0)	
	57-72			99.9	90.3	43.7			<40	<10			A-4 (2)	
5E	12-42			100	81.2	62.0			<40	<10			A-4 (3)	
	42-72			94.7	73.7	26.6			<40	<10			A-2-4 (0)	
6A	18-49			99.0	70.0	13.0			<40	<10			A-2-4 (0)	
	49-72			99.2	90.2	31.4			<40	<10			A-2-4 (0)	
6B	12-30			100	88.2	43.3			<40	<10			A-4 (2)	
	30-55			99.6	89.0	61.3			18	NP			A-4 (1)	
	55-72			99.5	83.3	21.0			<40	<10			A-2-4 (0)	
6C	12-35			99.6	78.6	8.6			<40	NP			A-3 (0)	
	35-72			99.5	67.5	3.3			<40	NP			A-3 (0)	
6D	12-60			99.4	87.6	53.2			<40	<10			A-4 (3)	
	60-65			99.4	84.3	24.3			<40	<10			A-2-4 (0)	
6E	12-34			99.8	88.7	47.5			<40	<10			A-4 (2)	
	34-72			99.5	83.9	23.9			<40	<10			A-2-4 (0)	

[1]Based on AASHO (American Association of State Highway Officials) Designation: T89-49.
[2]Based on AASHO Designation: T91-49.
[3]Based on AASHO Designation: T180-57.
[4]Highway Research Board system (see table 2); group index given in parentheses.
[5]Map symbol was determined from laboratory data and does not always agree with unit shown on map. Detailed field reconnaissance has shown that some sampling sites were not representative of the predominant soil in the area.

TABLE 4.—*Characteristics of the engineering soil types in the Kenton area.*

Soil type[1]	Description	Origin	Engineering properties: In place — Suitability as a subgrade[2]	In place — Suitability as a wearing surface[2]	Disturbed[3] — Suitability as embankment material	Disturbed[3] — Compaction characteristics	Suitable compaction equipment
AM12	Nonplastic to slightly plastic, gravelly and sandy soil.	Fluvial deposits of Pleistocene age.	Excellent	Good if surface is A-1, Excellent to good, depending on binder, if surface is A-2,	Excellent	Excellent	Rubber-tired equipment,
AM14	Nonplastic to slightly plastic, gravelly and silty soil.	Fluvial deposits of Pleistocene age.	Excellent if material left after grading is predominantly A-1, Fair if material left after grading is predominantly A-4,	Good if surface is A-1, Poor if surface is A-4,	Excellent if predominant material is A-1, Fair if predominant material is A-4,	Excellent if predominant material is A-1, Fair if predominant material is A-4,	Rubber-tired equipment,
AM2	Nonplastic to slightly plastic sandy soil.	Fluvial deposits of Pleistocene age.	Good	Excellent to good depending on binder present,	Good	Good	Rubber-tired equipment,
AM24	Nonplastic to slightly plastic, sandy and silty soil.	Fluvial deposits of Pleistocene age.	Good if material left after grading is predominantly A-2, Fair if material left after grading is predominantly A-4,	Excellent to good depending on binder present if surface is A-2, Fair to poor if surface is A-4,	Good if predominant material is A-2, Fair if predominant material is A-4,	Good if predominant material is A-2, Fair if predominant material is A-4,	Rubber-tired equipment,
AM26	Nonplastic to highly plastic, sandy and clayey soil.	Fluvial deposits of Pleistocene age.	Good if material left after grading is predominantly A-2, Poor if material left after grading is predominantly A-6 or poorly drained A-2,	Good if surface is A-2, Poor if surface is poorly drained A-2, Very poor if surface is A-6,	Fair if predominant material is A-2, Very poor if predominant material is A-6,	Fair if predominant material is A-2, Poor if perdominant material is A-6,	Rubber-tired equipment for soil which is predominantly A-2, Sheeps-foot rollers for soil which is predominantly A-6,
AM46	Slightly plastic to highly plastic, silty and clayey soil,	Fluvial, paludal, and lacustrine deposits of Pleistocene age,	Poor if material left after grading is predominantly A-4, Very poor if material left after grading is predominantly A-5,	Poor if surface is A-4, Very poor if surface is A-6,	Poor if predominant material is A-4, Very poor if predominant material is A-6,	Poor	Sheeps - foot rollers,
AR	Alluvial gravel, sand, silt, and clay.	Alluvium of Recent age,	Variable	Variable	Variable	Variable	Variable.
Z	Soil rich in organic material and frequently poorly drained. May be underlain at shallow depths by gravel, sand, or clay.	Swamp deposits of Recent age,	Variable	Variable	Variable	Variable	Variable.

[1]Two different soil types may be combined into a single map symbol (AM2/24), but the engineering characteristics of the individual soil types are described separately.
[2]For soil types designated by two-digit numbers, these columns refer to the composite soil.
[3]When not subject to frost action. Frost will affect soils that contain appreciable silt and clay and have a high moisture content.
[4]Unrated. Additives may aid in stabilization of the sandy soils and minimize dusty conditions.

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WATER-TABLE, SURFACE-DRAINAGE, AND ENGINEERING SOILS MAP OF THE KENTON AREA, DELAWARE

By
Durward H. Boggess and John K. Adams

1965

HYDROLOGIC INVESTIGATIONS
ATLAS HA-138

For sale by U.S. Geological Survey, price 75 cents