1971/3

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BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Record 1971/3

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SOIL SURVEY, DIVISION OF WATSON, CANBERRA, A.C.T.
1970

by

J.R. Kellett

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SUMMARY

A soil survey of the suburb of Watson in the Australian Capital Territory was carried out in 1970 at the request of the Commonwealth Department of Works. Its purpose was to make an accurate map of the different soil types in the area and to establish their volume change characteristics. Data from the investigation are to be used by the CDW as part of their pilot study of stormwater and groundwater infiltration into sewer installations.

Soils which had a similar sequence of identical layers were grouped into 'soil types'. Field sampling revealed a relationship between soil types and topography. Parent material ranges from Silurian sediments to Recent colluvium, but generally the soil is so mature that it no longer depends on these materials for its properties. Soil cover ranges in thickness from 2 feet at the highest elevation in the east to 6 feet on the lowest areas in the south and west. All the soils show well developed profiles with sharp horizon boundaries, especially those formed in situ from weathering of Silurian sediments.

Estimates of potential volume change in this report are based on swell index properties and should be considered carefully in context with variations in soil moisture occurring within close proximity to underground installations. The most potentially expansive clay is the B_2 horizon yellow illitic material of the sedentary soils. The most stable soils are the A_2 horizon silts which blanket almost the whole area and range in thickness from 2 to 4 feet.

INVESTIGATION

Sampling: The area was divided into four physiographic units (Fig. 1), using aerial photographs and contour maps. C.S.I.R.O. pedological maps of areas adjacent to Watson, by Sleeman (1959) and Taylor (1941), were studied.

Sampling commenced in late March and continued intermittently to mid-June. The soils were sampled with a hand auger to a depth of five feet or until auger refusal. In all cases the top 6 inches was discarded and borelog measurements were made to the nearest 3 inches.

Sampling was confined to nature strips and recreation areas; residential blocks, which comprise a large proportion of the area, were not entered. The effects of urban development, especially cut and fill for roadworks, had to be considered; for example, difficulty was experienced in sampling the pre-development drainage depressions.

It was necessary to investigate 102 sites before areas of similar soil types could be delineated with confidence. Soil types of those areas which were not entered were interpolated in accordance with an observed relationship between soil and topography.

Approximately 400 samples were visually classified and representative types were tested in the soil mechanics laboratory. Sample sites are shown in Plate 6.

Field Classification: Soils were grouped in accordance with the 'Unified' Classification system. (Fig. 2).

Many weathered claystones and sandstones were found. Owing to the disturbed nature of the auger sample, it was impossible to distinguish between completely weathered claystone/sandstone and a soil formed in situ from weathering of these rocks. Accordingly, the designation 'completely weathered' has not been used. The term 'highly weathered' claystone/sandstone refers to that material in which the texture of the original rock is recognizable, but which will disintegrate in water under hand pressure.

Sample Preparation: Samples were prepared for testing in accordance with procedures outlined in Australian Standard A89-1966.

Wet preparation of soils containing fragments of weathered claystones and sandstones was difficult owing to continuing disintegration of the rock particles in water. Washing for particle size analysis was continued until a clear supernatant liquid was obtained as specified in Australian Standard

Fig. 1

WATSON SOIL SURVEY

LOCALITY MAP AND PHYSIOGRAPHIC UNITS

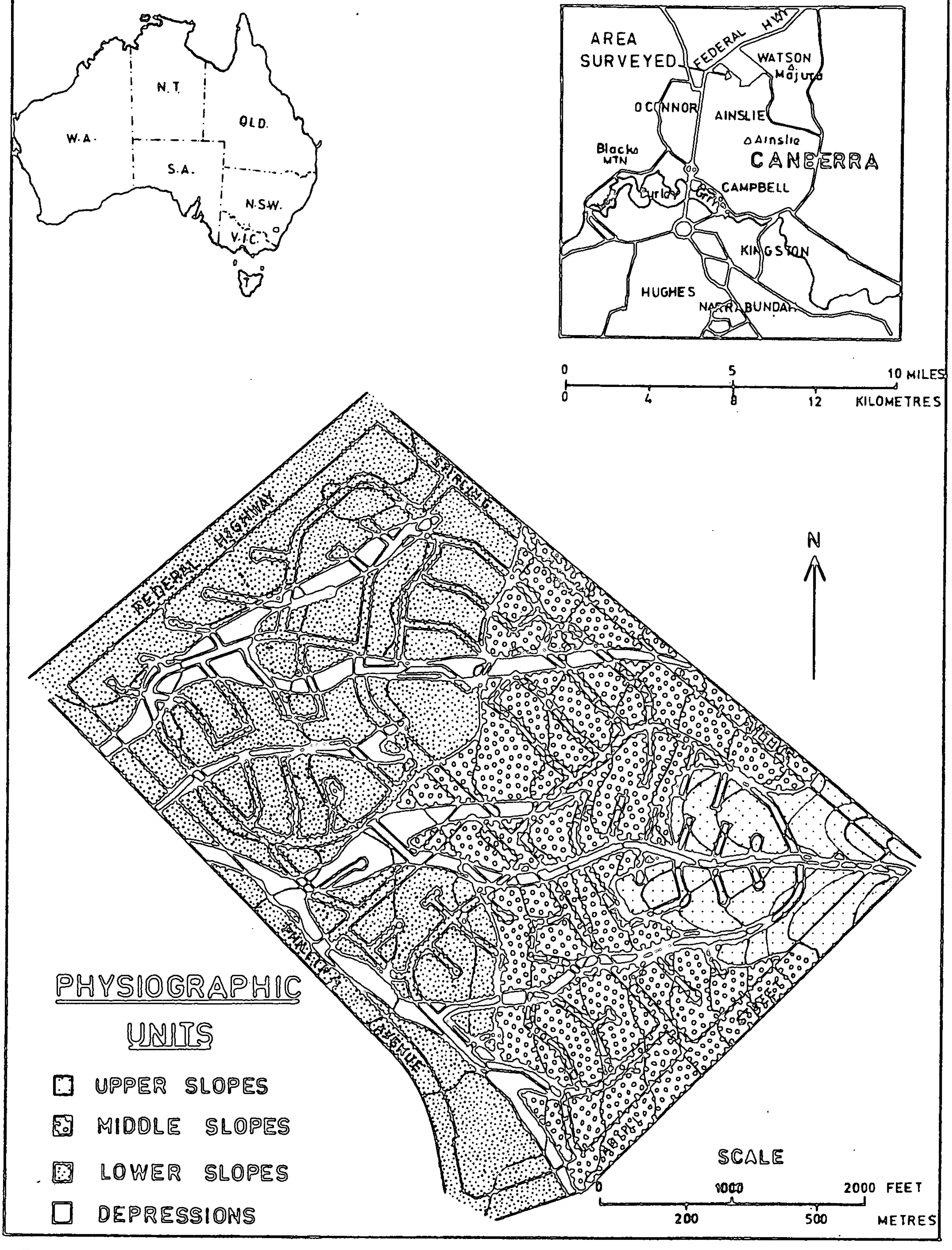


Fig. 2

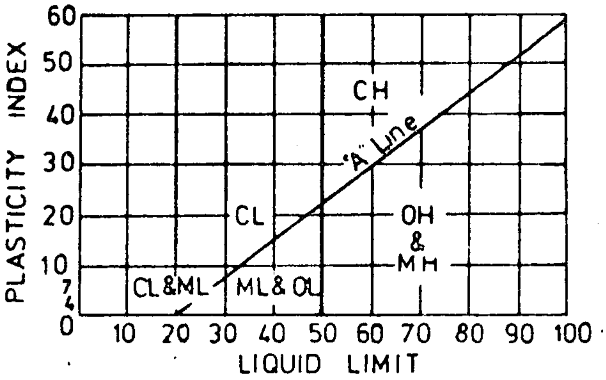
MAJOR DIVISIONS		SYMBOLS	TYPICAL NAMES
COARSE GRAINED SOILS More than 1/2 of soil >No 200 sieve size	GRAVELS. (More than 1/2 of coarse fraction > no.4 U.S. sieve size)	GW	Well graded gravels or gravel-sand mixtures, little or no fines*
		GP	Poorly graded gravels or gravel sand mixtures, little or no fines
		GM	Silty gravels, gravel-sand-silt mixtures
		GC	Clayey gravels, gravel-sand-clay mixtures
	SANDS (More than 1/2 of coarse fraction < no. 4 U.S. sieve size)	SW	Well graded sands or gravelly sands, little or no fines
		SP	Poorly graded sands or gravelly sand, little or no fines
		SM	Silty sands, sand silt mixtures
		SC	Clayey sands, sand-clay mixtures
FINE GRAINED SOILS More than 1/2 of soil <No200 sieve size	SILTS & CLAYS Liquid Limit < 50	ML	Inorganic silt and very fine sands, rock flour, silty or clayey fine sands or clayey silts with low plasticity
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
		OL	Organic silts and organic silty clays of low plasticity
	SILTS & CLAYS Liquid Limit > 50	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts
		CH	Inorganic clays of high plasticity, fat clays
		OH	Organic clays of medium to high plasticity, organic silty clays, organic silts
HIGHLY ORGANIC SOILS		Pt	Peat and other highly organic soils

CLASSIFICATION CHART
(Unified Soil Classification System)

* fines - portion of a soil finer than a no. 200 sieve

CLASSIFICATION	RANGE OF GRAIN SIZES	
	U S Standard Sieve Size	Grain Size in millimeters
BOULDERS	Above 12"	Above 305
COBBLES	12" to 3"	305 to 76·2
GRAVEL	3" to No. 4	76·2 to 4·76
coarse	3" to 3/4"	76·2 to 19·1
fine	3/4" to No. 4	19·1 to 4·76
SAND	No 4 to No 200	4·76 to 0·074
coarse	No 4 to No 10	4·76 to 2·00
medium	No 10 to No 40	2·00 to 0·420
fine	No 40 to No 200	0·420 to 0·074
SILT & CLAY	Below No 200	Below 0·074

GRAIN SIZE CHART



PLASTICITY CHART

UNIFIED SOIL CLASSIFICATION

To accompany Record 1971/3

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A89-1966, Test 7A; hence particle size in situ may be somewhat coarser than test results indicate.

Laboratory Testing: The moisture content of every sample was calculated. Plasticity tests and particle size analyses were carried out in accordance with Australian Standard A89-1966.

No apparatus was available that could accurately measure swell in terms of percentage volume increase; thus it was decided to base volume change testing on swell pressure characteristics. The 'Potential Volume Change Meter' developed by Lambe (1960) was used for this purpose.

The apparatus and test procedures are described in Appendix 3.

RESULTS

SOIL TYPES

General: The results of field classification of the soils are shown in Appendix 1 and of laboratory testing in Appendix 2. The terms gravel, sand, silt and clay refer only to the particle size determined by inspection and not to their mode of origin.

A 23-foot-deep trench near the intersection of Phillip Avenue and the Federal Highway revealed massive, deeply weathered claystone beneath 6 feet of clayey soil. No bedding or grading was observed in either the claystone or the soil.

Claystone and sandstone from which the overlying soil has been removed during roadwork construction was observed in cuts on the Antill Street extension to the Federal Highway.

In intervening areas a gradation from soil to weathered rocks is suggested by borelogs.

The soils have been classified into ten representative types,* the distribution of which is shown on Plate 1. In general, clayey soils occupy a large proportion of the area, incorporating the upper eastern slopes and lower slopes. The higher middle slopes are composed of much lighter clays with sandy and silty components.

* Characteristic sequences of soil layers. Layer is used in the sense of distinct differences in colour, texture, structure and grainsize determined during logging.

Type 1

A shallow residual soil occuring on the upper eastern slopes. The parent material is Silurian claystone which is encountered at depths of 3 to 4 feet. Horizons are clearly defined.

Layer	Average depth	Group Symbol*	Description
1A	6-12 inches	SM	Grey sand-silt mixture with some gravel-size claystone fragments.
1B	12-18 inches	CL	Reddish - brown silty clay.
1C	18-30 inches	CH	Mottled red-yellow clay; in many places containing soft claystone lumps.
1D	30-42 inches	CH	Highly weathered yellow claystone.

Type 2

A concretionary ironstone gravel capping a ridge in the eastern corner.

Layer	Average depth	Group Symbol	Description
2A	6-24 inches	GM	Reddish brown silty gravel containing hard black ironstone concretions up to 1½ inches.

Type 3

A shallow residual soil occuring on the undulating eastern slopes. Parent material is Silurian claystone and fine-grained sandstone. This soil is similar to Type 1, but horizon boundaries are more gradual.

* See Unified Soil Classification (Fig. 2).

Layer	Average depth	Group Symbol	Description
3A	6-24 inches	CL	Reddish brown silty clay, in some areas with yellow mottling. At some localities 6 inches of a reddish brown clayey silt overlies this material. In many places small soft black concretions are dotted throughout this layer.
3B	24-42 inches	CH	Yellow fat clay, with grey and red mottling at some sites. Usually friable for the top half of the layer and becoming massive with depth. Minerals identified by X-Ray diffraction are quartz, illite, and kaolinite.
3C	42-51 inches	SC-CH*	Highly weathered sandstone or claystone; often ferruginized.

Type 4

A thicker soil skirting the base of the eastern slopes. The silts and clays are granular and friable. Parent material is clayey slopewash.

Layer	Average depth	Group Symbol	Description
4A	6-18 inches	ML	Clayey or sandy silt. Colour is brown varying from greyish to reddish shades.
4B	18-48 inches	CL	Silty clay, usually yellowish brown. Local red and grey mottling.
4C	48-57 inches	CL	Silty or lean clay, usually a mottled red-grey-yellow colour. More plastic than 4B, but still friable.

* SC-CH, SC or CH

Type 5

A sandy variation of Type 4, occuring at the base of the eastern slopes, adjacent to drainage depressions.

Layer	Average depth	Group Symbol	Description
5A	6-18 inches	ML	Grey sandy silt, sometimes with shades of brown.
5B	18-33 inches	SC	Sandy clay or clayey sand. Colour is brown with red, grey and yellow shades. Occasionally silty.
5C	33-54 inches	SC-GC	Clayey sand or gravel-sand-clay mixture, brown with red and yellow shades.

Type 6

This soil occurs on gentle slopes southwest of Types 4 and 5.

Layer	Average depth	Group Symbol	Description
6A	6-24 inches	ML	Clayey silt, usually reddish brown.
6B	24-39 inches	CL	Sandy or silty clay in many places dotted with soft black concretions; sometimes gravelly. Colour is brown with occasional red and yellow mottling.
6C	39-48 inches	CL	Lean clay sometimes silty or sandy but generally more plastic than 6B. Colour is yellowish brown.
6D	48-57 inches	CH	Heavier clay than 6C but still friable. Colour is yellow, sometimes with grey mottling.

Type 7

This soil occurs on very gentle slopes to almost flat terrain in the southwestern sector.

Layer	Average depth	Group Symbol	Description
7A	6-27 inches	ML	Brown clayey silt with grey and red shades.
7B	27-39 inches	CL	Light brown silty clay.
7C	39-60 inches	CH	Mottled yellow-grey fat clay, blocky and prism-like.

Type 8

A sandy variation of Type 7, occurring on both sides of the northwest drainage depression. Parent material is indurated fine colluvium.

Layer	Average depth	Group Symbol	Description
8A	6-12 inches	ML	Reddish brown clayey silt.
8B	12-21 inches	CL	Silty or lean clay. Colours range from a reddish brown to mottled red and yellow.
8C	21-33 inches	CH	Heavy clay, usually a mottled red-grey-yellow colour.
8D	33-51 inches	SC	Sandy clay becoming a clayey sand with depth.

Type 9

The thickest soil in the area, occurring on almost flat terrain, in the southern corner and running southwest parallel to the Federal Highway. This soil has been developed in situ from weathering of claystone.

Layer	Average depth	Group Symbol	Description
9A	6-18 inches	ML	Reddish brown clayey silt.
9B	18-24 inches	CL	Mottled red and yellow silty or lean clay.
9C	24-39 inches	CH	Mottled red and yellow heavy clay; friable.
9D	39-60 inches	CH	Yellow fat clay, massive structure. Minerals identified by X-ray diffraction are quartz, illite and kaolinite.

Type 10

Soils occurring in depressions. These soils have been further divided into the following sub-types:

(a) gravelly
(b) sandy
(c) light to medium clayey
(d) heavy clayey

It became obvious in the initial sampling program that a complete investigation of these depressions would be time-consuming and complex. Since much of the area occupied by the depressions lies within residential blocks it was considered that a complete investigation was not practical.

SWELLING SOILS

The degrees of expansiveness of Watson soils were classified as Very High, High, Medium, and Low. The details of these and corresponding index properties are set out in Table 1. The distribution of potentially swelling soils is shown on Plates 2, 3, 4, and 5.

The swelling characteristics should be considered carefully in assessing the causes of disruption of sewer installations in the Watson area; they should be considered in context with the variations in soil moisture occurring within close proximity to the pipeline.

The soil capable of the largest volume change is a massive yellow clay directly overlying Silurian claystone. This clay is located about 2 feet from the surface at sites on the upper eastern slopes and on flatter areas along Phillip Avenue and the Federal Highway. A mottled red-grey-yellow heavy clay usually overlies this material.

The most stable soils are the A2 horizon silts located in the top 2 feet of almost the total area and extend to a depth of 4 feet on the higher middle slopes.

TABLE 1

ESTIMATED DEGREE OF EXPANSIVENESS

Classification	Swell Index (lb/sq.ft)	Liquid Limit %	Plasticity Index %	Linear Shrinkage %
Very High	>5 000	>60	>35	>15
High	>3 500;<5 000	>40;<60	>25;<35	>12;<15
Medium	>2 000;<3 500	>30;<40	>20;<25	>10;<15
Low	< 2 000	<30	<20	<10

REFERENCES

AS A89 - 1966 - Australian Standard Methods of Testing Soil for Engineering Purposes. Standards Association of Australia, Sydney, N.S.W.

LAMBE, T.W., 1960 - Soil PVC Meter. Technical Studies Report, FHA-701, Federal Housing Administration, Washington, D.C.

SLEEMAN, J.R., 1959 - Preliminary Report on the Soils of the Lyneham - Dickson (A.C.T.) Housing Project. C.S.I.R.O. Divisional Report 10/58.

TAYLOR J.K., 1941 - Soil Survey of C.S.I.R.O. Experimental Farm, Canberra, A.C.T. C.S.I.R.O. Divisional Report 5/1941.

APPENDIX 1

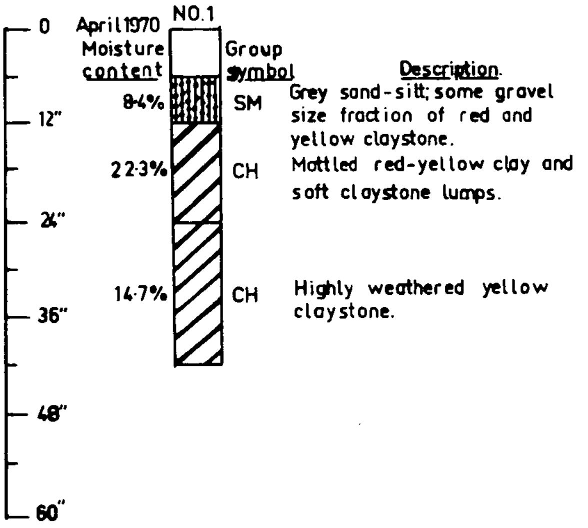
Borelogs

APPENDIX 1

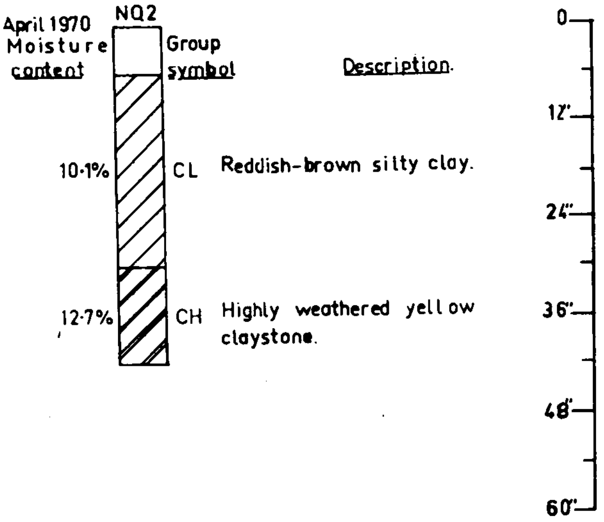
WATSON SOIL SURVEY

BORELOGS

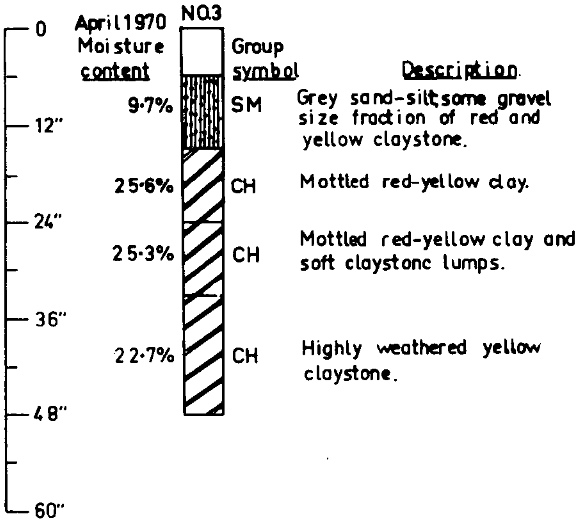
SOIL TYPE 1



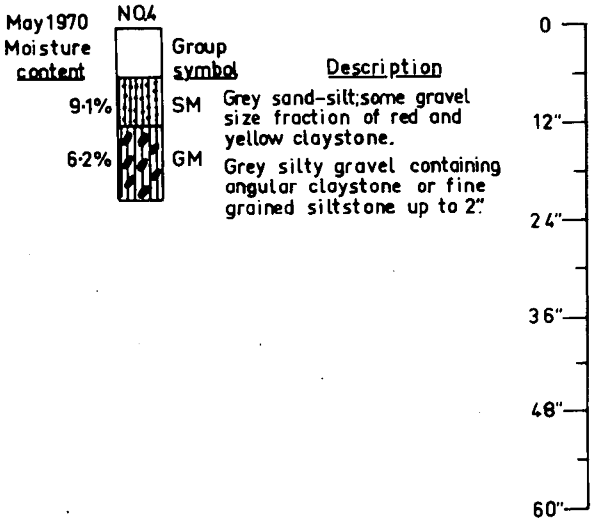
April 1970 Moisture content	Group symbol	Description
8·4%	SM	Grey sand-silt; some gravel size fraction of red and yellow claystone.
22·3%	CH	Mottled red-yellow clay and soft claystone lumps.
14·7%	CH	Highly weathered yellow claystone.



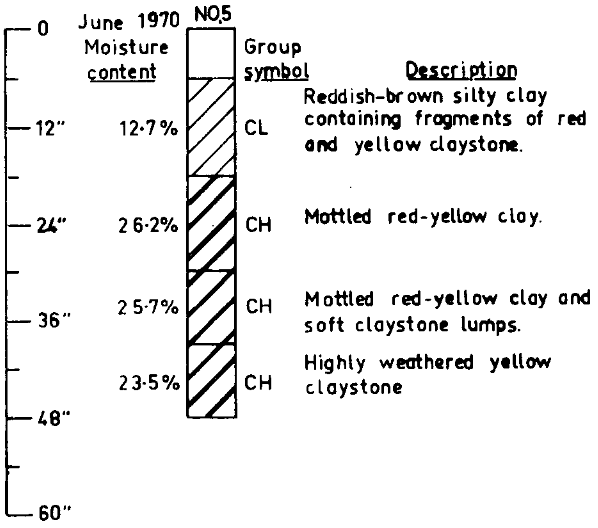
April 1970 Moisture content	Group symbol	Description.
10·1%	CL	Reddish-brown silty clay.
12·7%	CH	Highly weathered yellow claystone.



April 1970 Moisture content	Group symbol	Description.
9·7%	SM	Grey sand-silt; some gravel size fraction of red and yellow claystone.
25·6%	CH	Mottled red-yellow clay.
25·3%	CH	Mottled red-yellow clay and soft claystone lumps.
22·7%	CH	Highly weathered yellow claystone.



May 1970 Moisture content	Group symbol	Description
9·1%	SM	Grey sand-silt; some gravel size fraction of red and yellow claystone.
6·2%	GM	Grey silty gravel containing angular claystone or fine grained siltstone up to 2".



June 1970 Moisture content	Group symbol	Description
12·7%	CL	Reddish-brown silty clay containing fragments of red and yellow claystone.
26·2%	CH	Mottled red-yellow clay.
25·7%	CH	Mottled red-yellow clay and soft claystone lumps.
23·5%	CH	Highly weathered yellow claystone

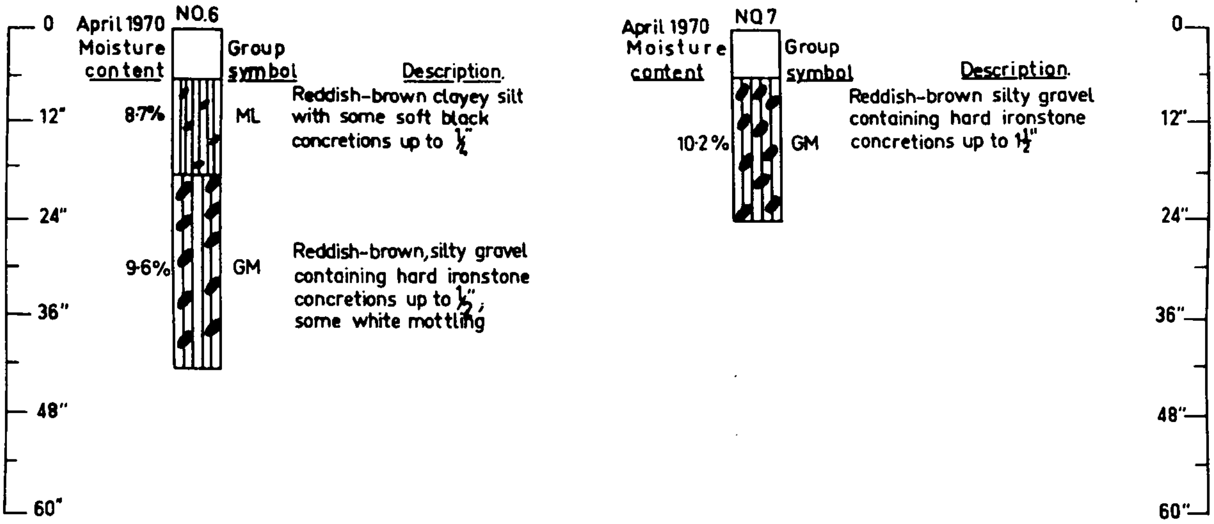
To accompany Record 1971/3

I55/A16/614

WATSON SOIL SURVEY

BORELOGS

SOIL TYPE 2



NO.6

Reddish-brown clayey silt with some soft black concretions up to ¼"

Reddish-brown, silty gravel containing hard ironstone concretions up to ½", some white mottling

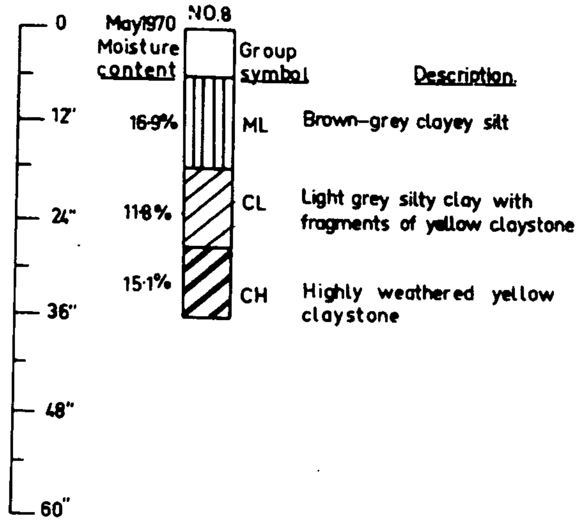
NO.7

Reddish-brown silty gravel containing hard ironstone concretions up to 1½"

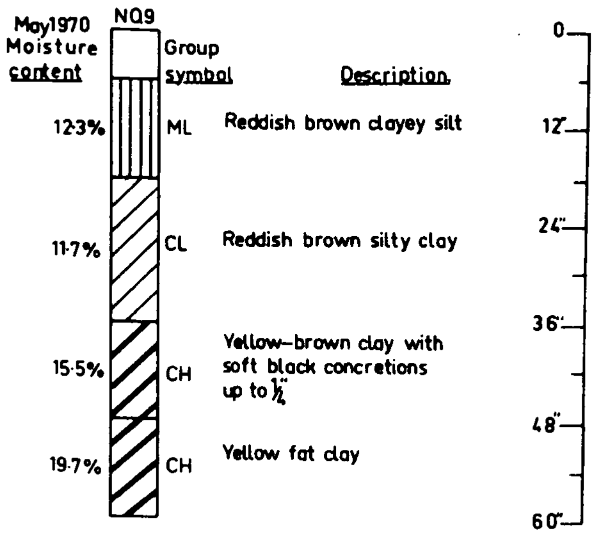
WATSON SOIL SURVEY

BORELOGS

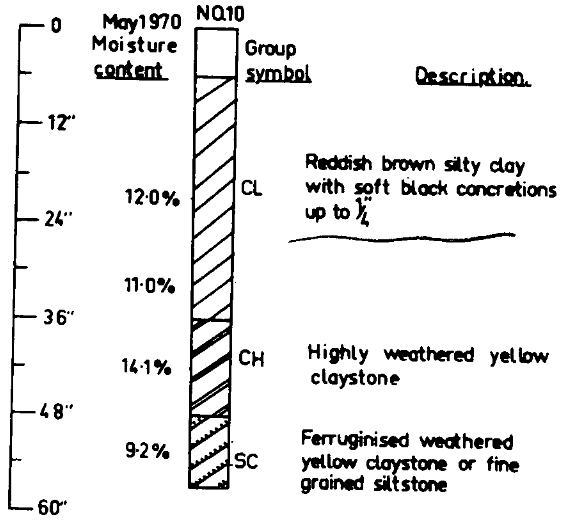
SOIL TYPE 3



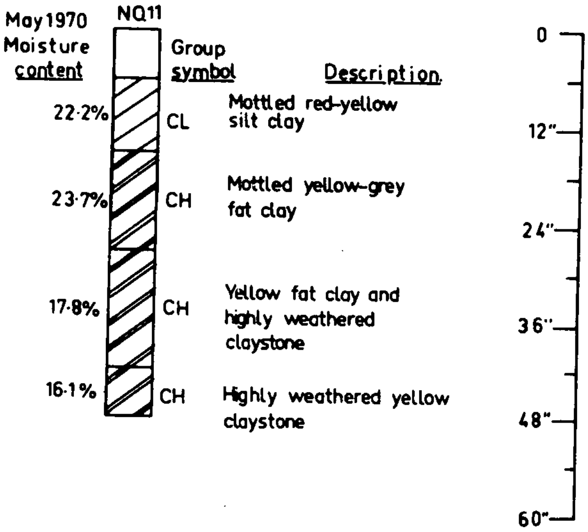
May1970 Moisture content	Group symbol	Description
16·9%	ML	Brown-grey clayey silt
11·8%	CL	Light grey silty clay with fragments of yellow claystone
15·1%	CH	Highly weathered yellow claystone



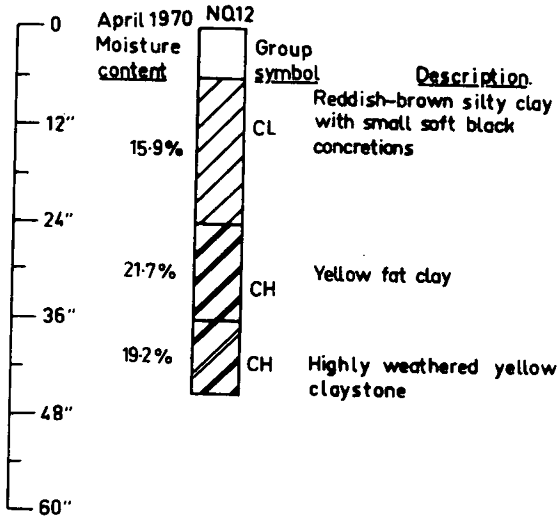
May1970 Moisture content	Group symbol	Description
12·3%	ML	Reddish brown clayey silt
11·7%	CL	Reddish brown silty clay
15·5%	CH	Yellow-brown clay with soft black concretions up to ¼"
19·7%	CH	Yellow fat clay



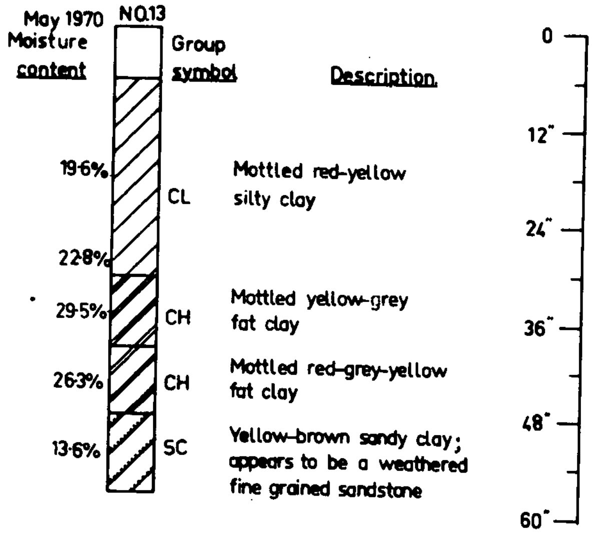
May1970 Moisture content	Group symbol	Description
12·0% 11·0%	CL	Reddish brown silty clay with soft black concretions up to ¼"
14·1%	CH	Highly weathered yellow claystone
9·2%	SC	Ferruginised weathered yellow claystone or fine grained siltstone



May1970 Moisture content	Group symbol	Description
22·2%	CL	Mottled red-yellow silt clay
23·7%	CH	Mottled yellow-grey fat clay
17·8%	CH	Yellow fat clay and highly weathered claystone
16·1%	CH	Highly weathered yellow claystone



April 1970 Moisture content	Group symbol	Description
15·9%	CL	Reddish-brown silty clay with small soft black concretions
21·7%	CH	Yellow fat clay
19·2%	CH	Highly weathered yellow claystone



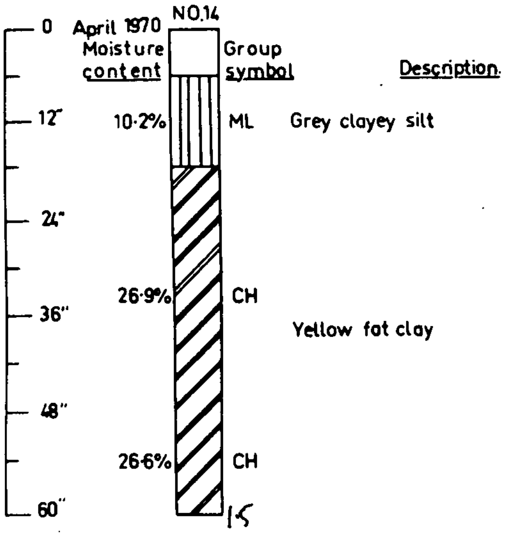
May 1970 Moisture content	Group symbol	Description
19·6% 22·8%	CL	Mottled red-yellow silty clay
29·5%	CH	Mottled yellow-grey fat clay
26·3%	CH	Mottled red-grey-yellow fat clay
13·6%	SC	Yellow-brown sandy clay; appears to be a weathered fine grained sandstone

APPENDIX 1

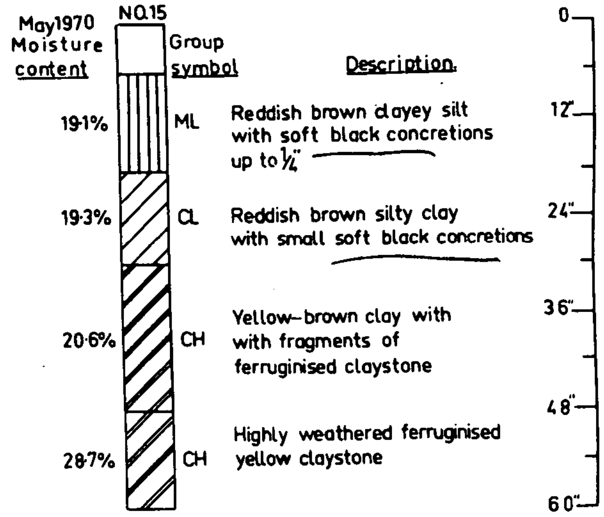
WATSON SOIL SURVEY

BORELOGS

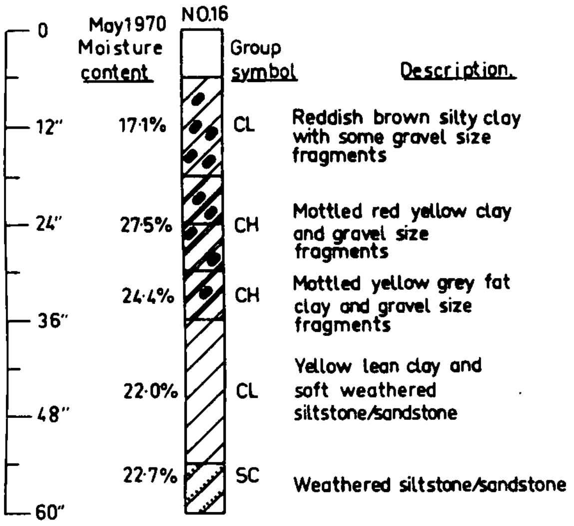
SOIL TYPE 3



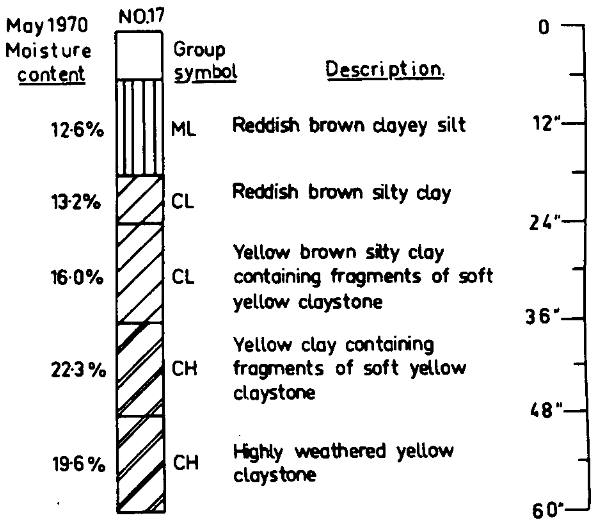
April 1970 Moisture content	Group symbol	Description.
10·2%	ML	Grey clayey silt
26·9%	CH	Yellow fat clay
26·6%	CH	



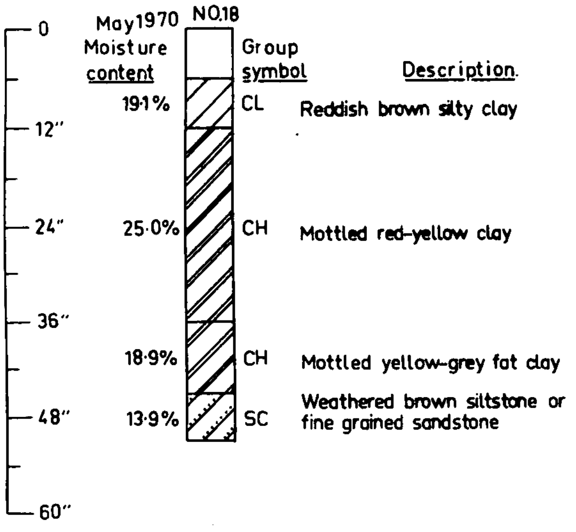
May1970 Moisture content	Group symbol	Description.
19·1%	ML	Reddish brown clayey silt with soft black concretions up to ¼"
19·3%	CL	Reddish brown silty clay with small soft black concretions
20·6%	CH	Yellow-brown clay with with fragments of ferruginised claystone
28·7%	CH	Highly weathered ferruginised yellow claystone



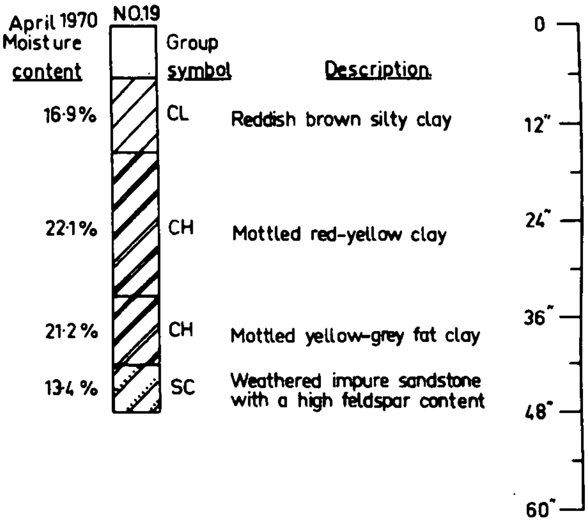
May1970 Moisture content	Group symbol	Description.
17·1%	CL	Reddish brown silty clay with some gravel size fragments
27·5%	CH	Mottled red yellow clay and gravel size fragments
24·4%	CH	Mottled yellow grey fat clay and gravel size fragments
22·0%	CL	Yellow lean clay and soft weathered siltstone/sandstone
22·7%	SC	Weathered siltstone/sandstone



May 1970 Moisture content	Group symbol	Description.
12·6%	ML	Reddish brown clayey silt
13·2%	CL	Reddish brown silty clay
16·0%	CL	Yellow brown silty clay containing fragments of soft yellow claystone
22·3 %	CH	Yellow clay containing fragments of soft yellow claystone
19·6 %	CH	Highly weathered yellow claystone



May1970 Moisture content	Group symbol	Description.
19·1%	CL	Reddish brown silty clay
25·0%	CH	Mottled red-yellow clay
18·9%	CH	Mottled yellow-grey fat clay
13·9%	SC	Weathered brown siltstone or fine grained sandstone



April 1970 Moisture content	Group symbol	Description.
16·9%	CL	Reddish brown silty clay
22·1%	CH	Mottled red-yellow clay
21·2%	CH	Mottled yellow-grey fat clay
13·4 %	SC	Weathered impure sandstone with a high feldspar content

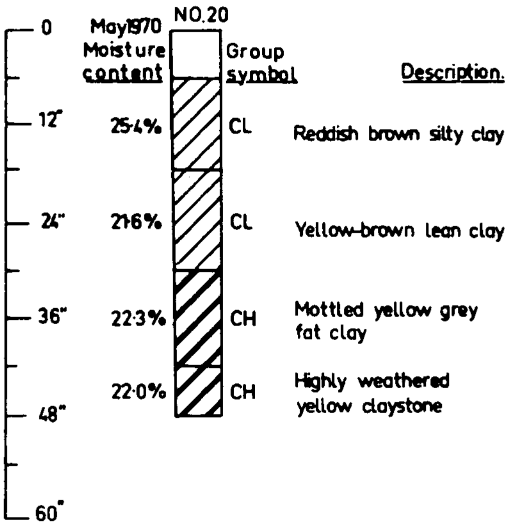
To accompany Record 1971/3

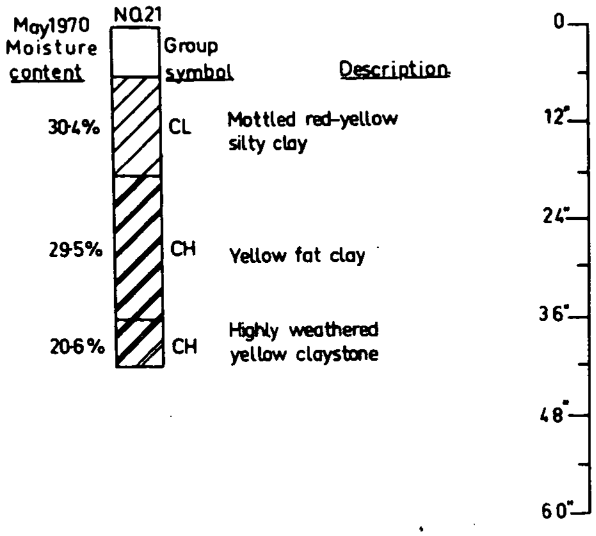
155/A16/617

WATSON SOIL SURVEY

BORELOGS

SOIL TYPE 3

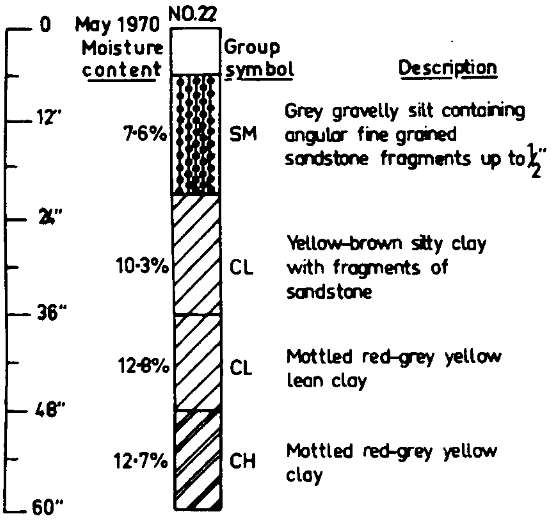




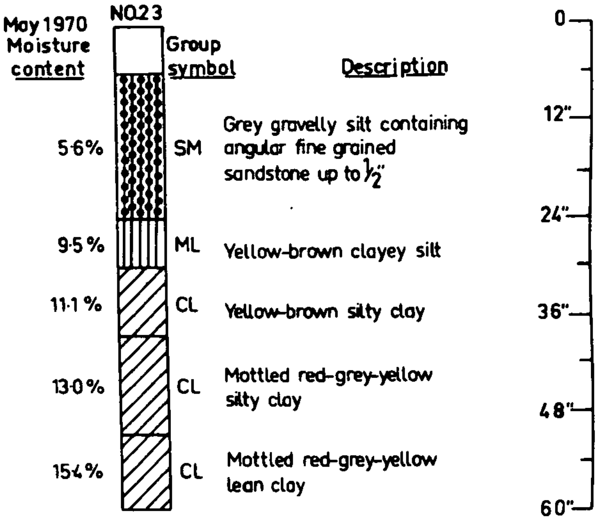
WATSON SOIL SURVEY

BORELOGS

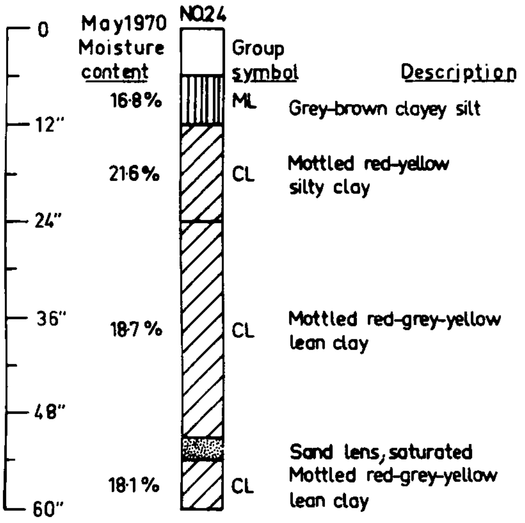
SOIL TYPE 4



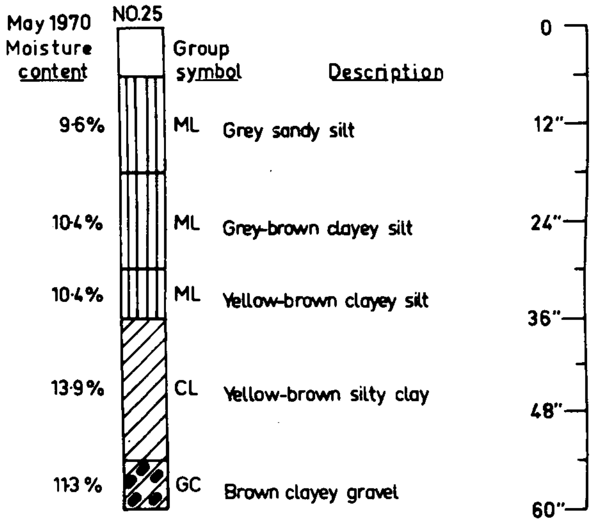
May 1970 Moisture content	Group symbol	Description
7·6%	SM	Grey gravelly silt containing angular fine grained sandstone fragments up to ½"
10·3%	CL	Yellow-brown silty clay with fragments of sandstone
12·8%	CL	Mottled red-grey yellow lean clay
12·7%	CH	Mottled red-grey yellow clay



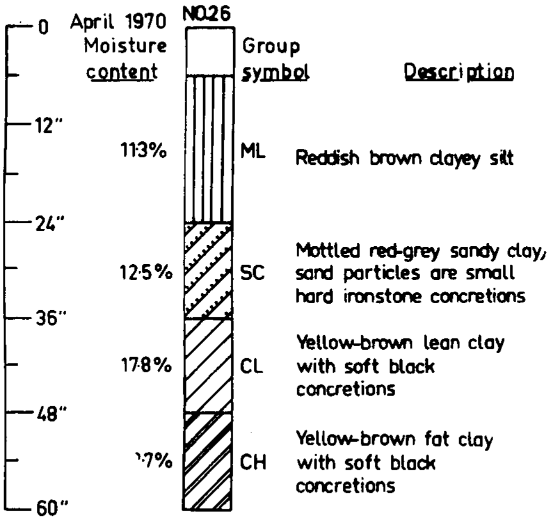
May 1970 Moisture content	Group symbol	Description
5·6%	SM	Grey gravelly silt containing angular fine grained sandstone up to ½"
9·5%	ML	Yellow-brown clayey silt
11·1%	CL	Yellow-brown silty clay
13·0%	CL	Mottled red-grey-yellow silty clay
15·4%	CL	Mottled red-grey-yellow lean clay



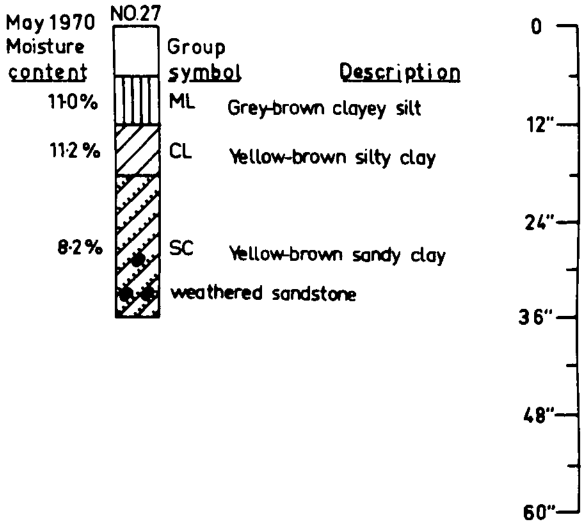
May1970 Moisture content	Group symbol	Description
16·8%	ML	Grey-brown clayey silt
21·6%	CL	Mottled red-yellow silty clay
18·7%	CL	Mottled red-grey-yellow lean clay
		Sand lens, saturated
18·1%	CL	Mottled red-grey-yellow lean clay



May 1970 Moisture content	Group symbol	Description
9·6%	ML	Grey sandy silt
10·4%	ML	Grey-brown clayey silt
10·4%	ML	Yellow-brown clayey silt
13·9%	CL	Yellow-brown silty clay
11·3%	GC	Brown clayey gravel



April 1970 Moisture content	Group symbol	Description
11·3%	ML	Reddish brown clayey silt
12·5%	SC	Mottled red-grey sandy clay, sand particles are small hard ironstone concretions
17·8%	CL	Yellow-brown lean clay with soft black concretions
·7%	CH	Yellow-brown fat clay with soft black concretions



May 1970 Moisture content	Group symbol	Description
11·0%	ML	Grey-brown clayey silt
11·2%	CL	Yellow-brown silty clay
8·2%	SC	Yellow-brown sandy clay
		weathered sandstone

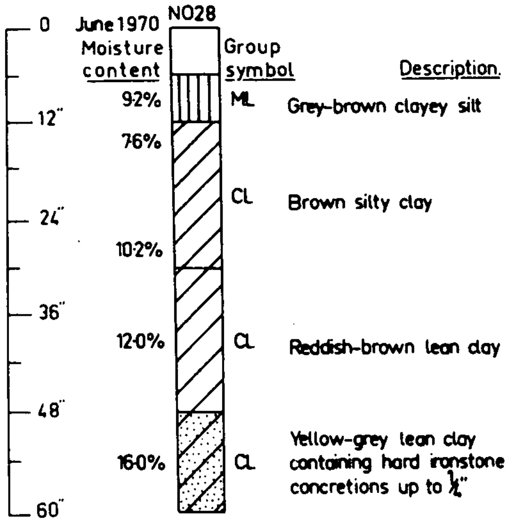
To accompany Record 1971/3

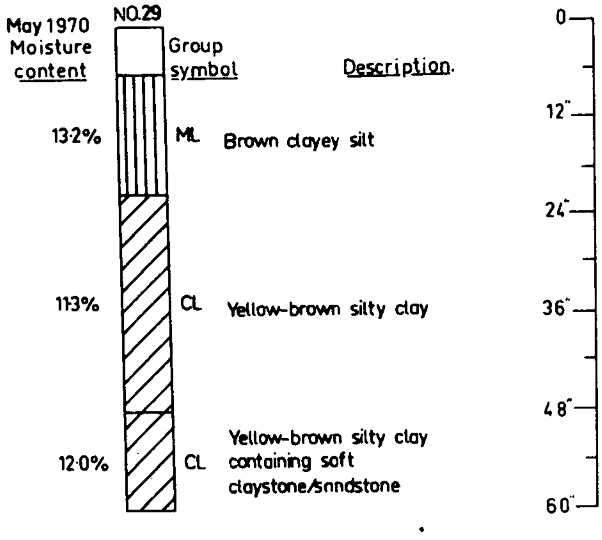
APPENDIX 1

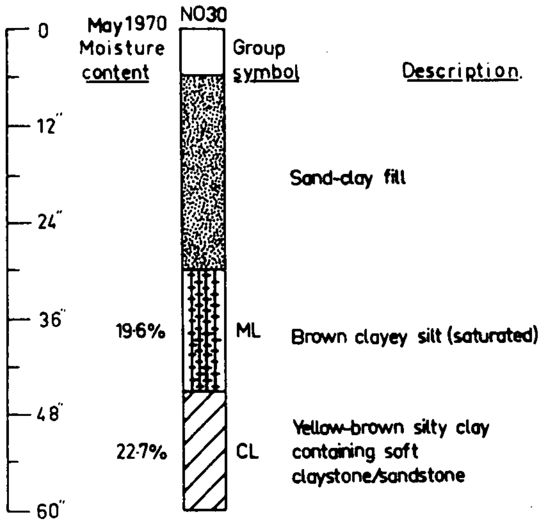
WATSON SOIL SURVEY

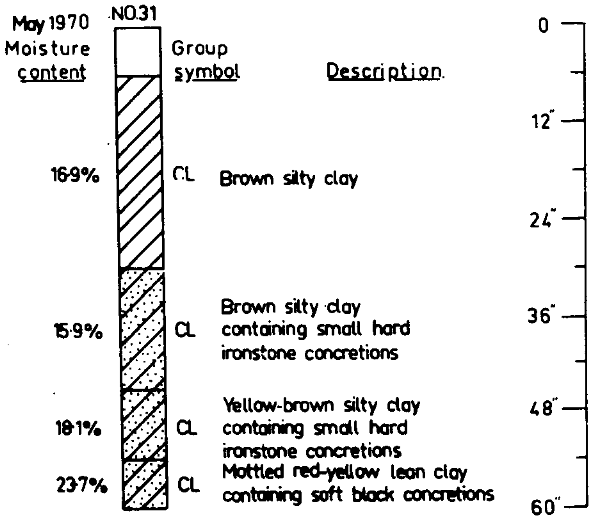
BORELOGS

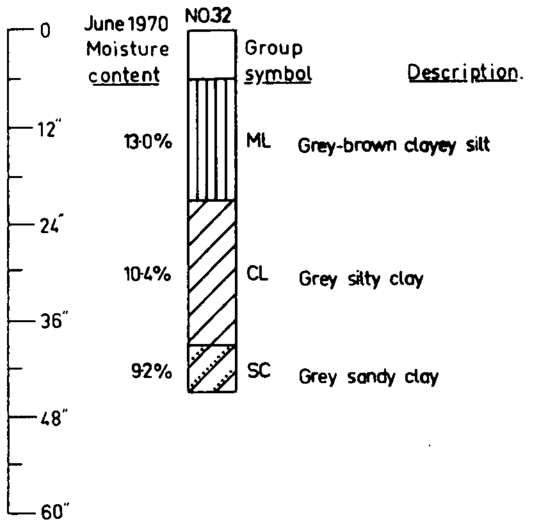
SOIL TYPE 4

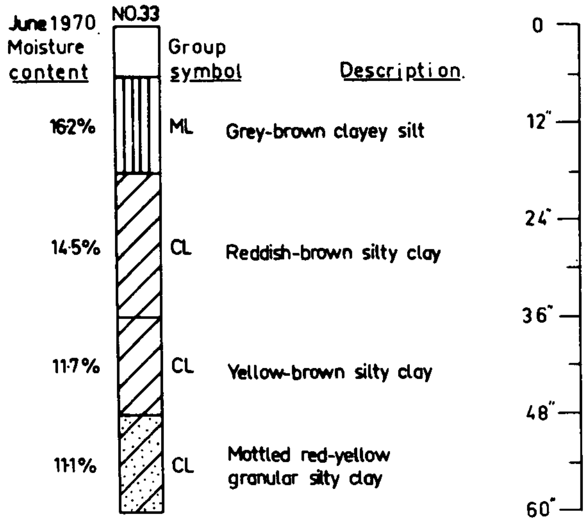












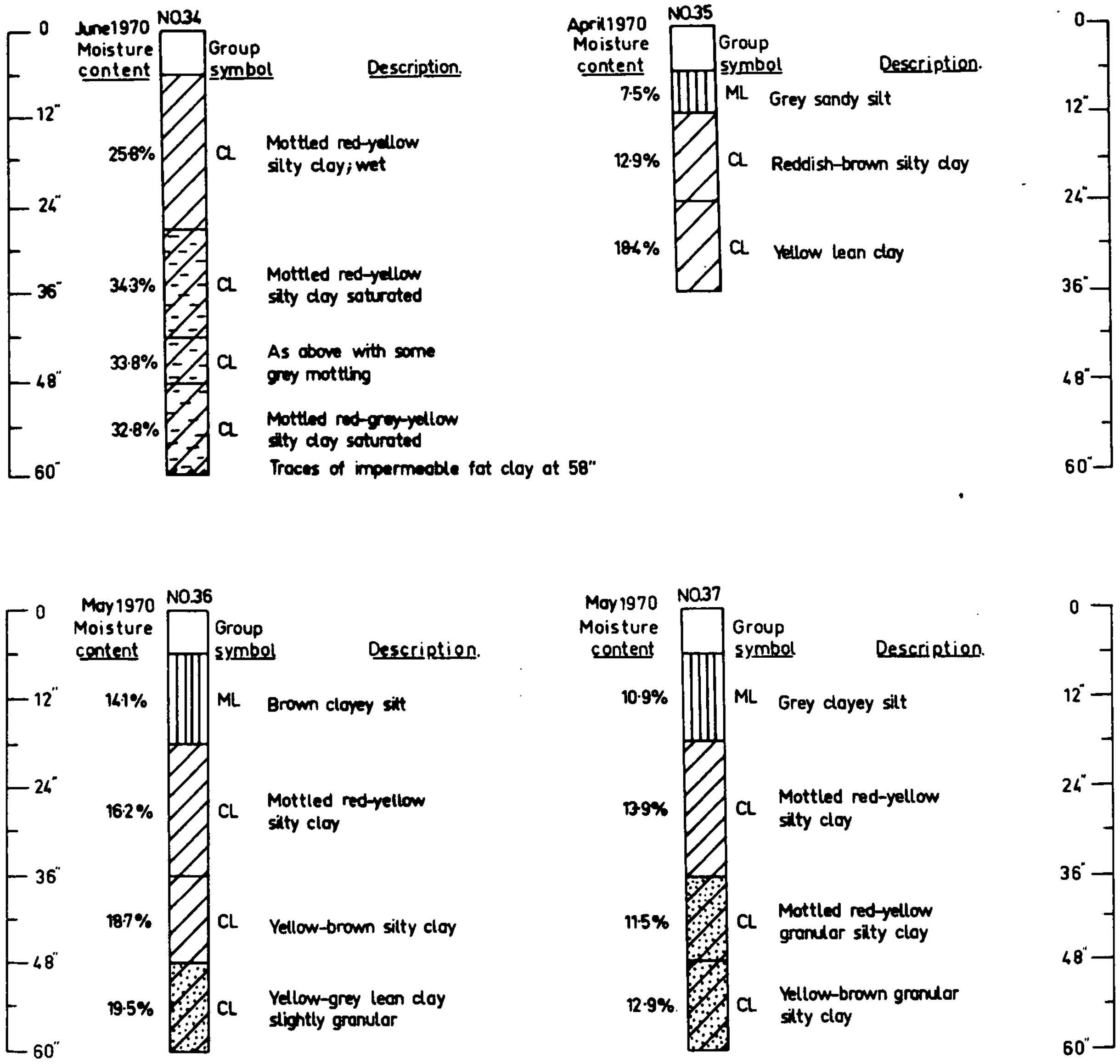
To accompany Record 1971/3

I55/A16/620

WATSON SOIL SURVEY

BORELOGS

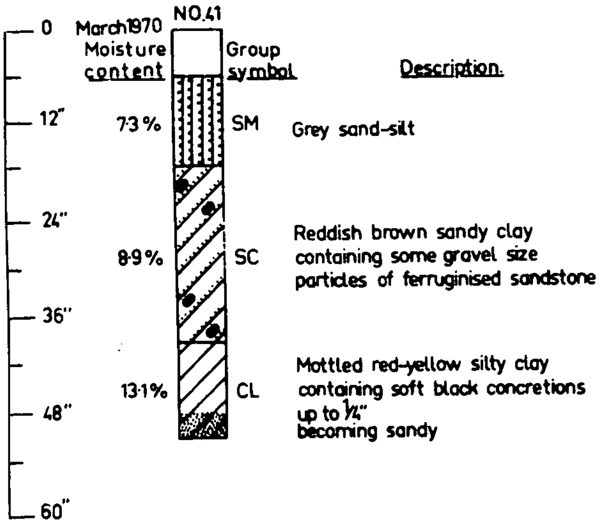
SOIL TYPE 4



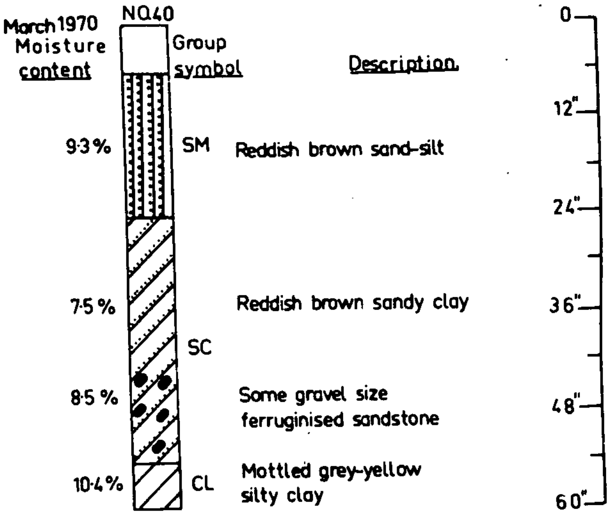
WATSON SOIL SURVEY

BORELOGS

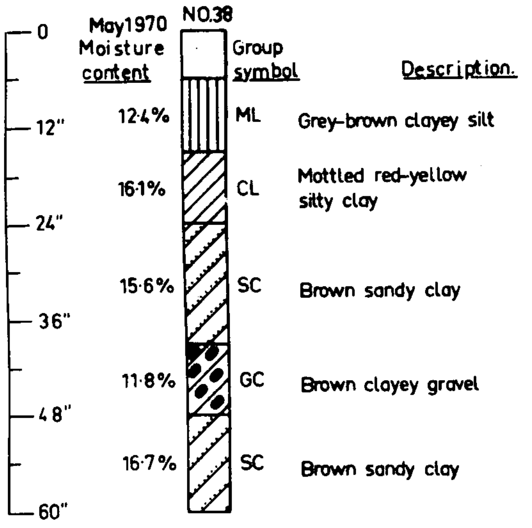
SOIL TYPE 5



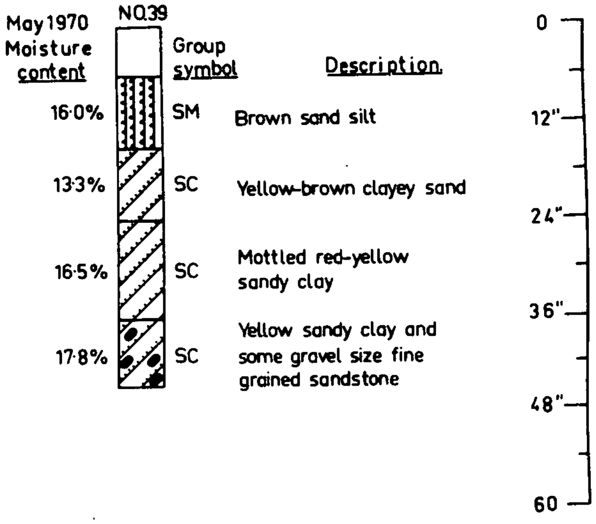
Moisture content	Group symbol	Description.
7·3 %	SM	Grey sand-silt
8·9 %	SC	Reddish brown sandy clay containing some gravel size particles of ferruginised sandstone
13·1%	CL	Mottled red-yellow silty clay containing soft black concretions up to ¼" becoming sandy



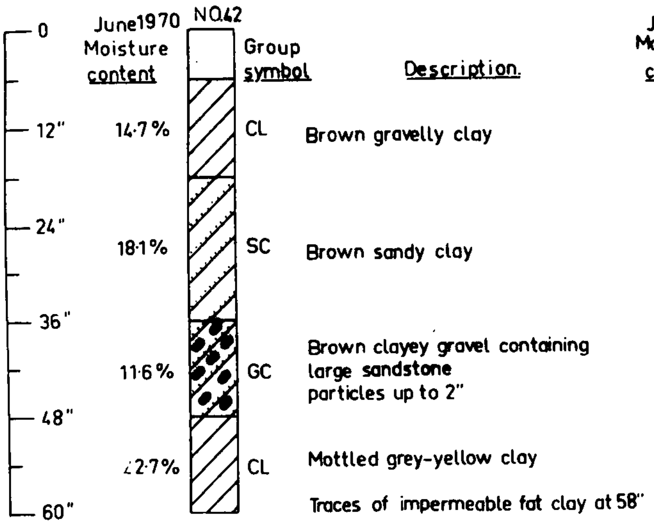
Moisture content	Group symbol	Description.
9·3 %	SM	Reddish brown sand-silt
7·5 %	SC	Reddish brown sandy clay
8·5 %		Some gravel size ferruginised sandstone
10·4 %	CL	Mottled grey-yellow silty clay



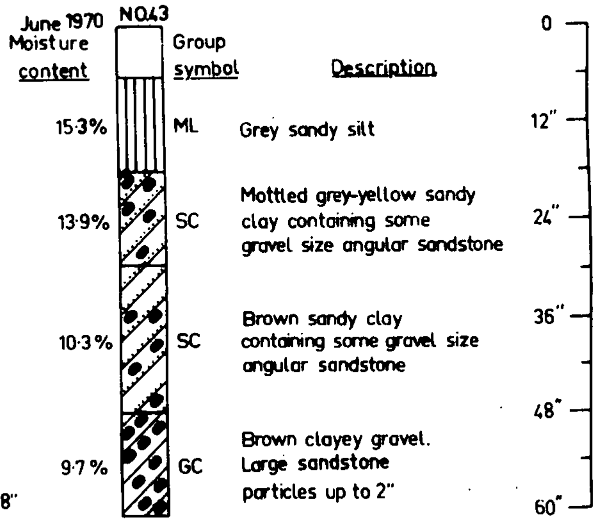
Moisture content	Group symbol	Description.
12·4%	ML	Grey-brown clayey silt
16·1%	CL	Mottled red-yellow silty clay
15·6%	SC	Brown sandy clay
11·8%	GC	Brown clayey gravel
16·7%	SC	Brown sandy clay



Moisture content	Group symbol	Description.
16·0%	SM	Brown sand silt
13·3%	SC	Yellow-brown clayey sand
16·5%	SC	Mottled red-yellow sandy clay
17·8%	SC	Yellow sandy clay and some gravel size fine grained sandstone



Moisture content	Group symbol	Description.
14·7 %	CL	Brown gravelly clay
18·1 %	SC	Brown sandy clay
11·6 %	GC	Brown clayey gravel containing large sandstone particles up to 2"
12·7%	CL	Mottled grey-yellow clay Traces of impermeable fat clay at 58"



Moisture content	Group symbol	Description
15·3%	ML	Grey sandy silt
13·9%	SC	Mottled grey-yellow sandy clay containing some gravel size angular sandstone
10·3 %	SC	Brown sandy clay containing some gravel size angular sandstone
9·7 %	GC	Brown clayey gravel. Large sandstone particles up to 2"

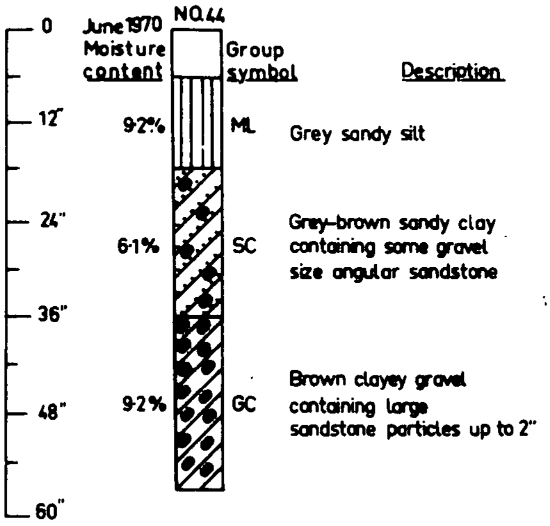
To accompany Record 1971/3

I65/A16/622

WATSON SOIL SURVEY

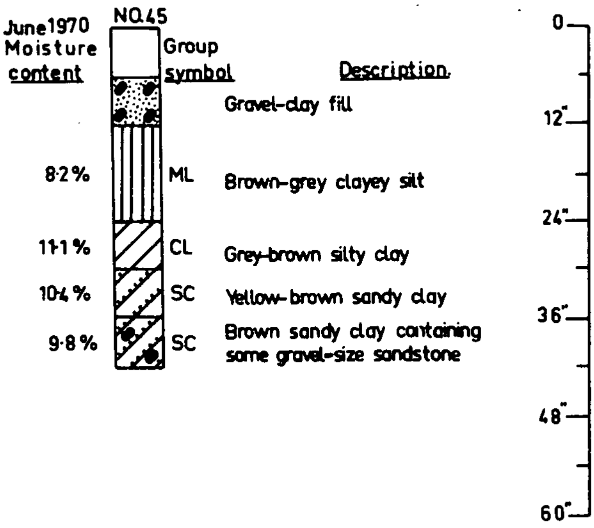
BORELOGS

SOIL TYPE 5



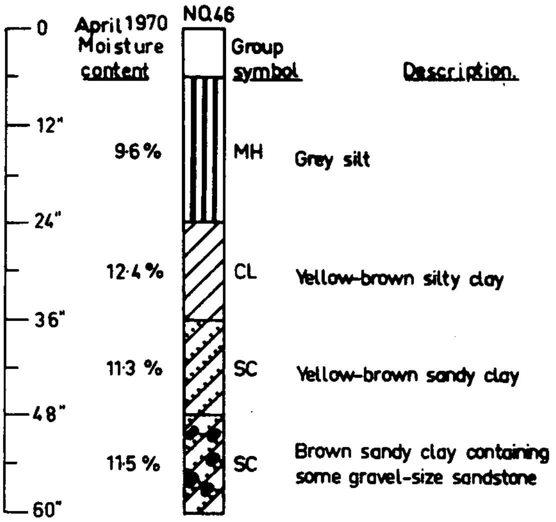
NO.44

June 1970 Moisture content	Group symbol	Description
9.2%	ML	Grey sandy silt
6.1%	SC	Grey-brown sandy clay containing some gravel size angular sandstone
9.2%	GC	Brown clayey gravel containing large sandstone particles up to 2"



NO.45

June 1970 Moisture content	Group symbol	Description
		Gravel-clay fill
8.2%	ML	Brown-grey clayey silt
11.1%	CL	Grey-brown silty clay
10.4%	SC	Yellow-brown sandy clay
9.8%	SC	Brown sandy clay containing some gravel-size sandstone



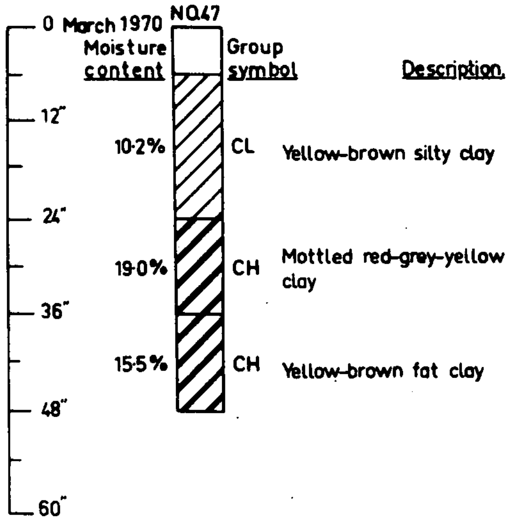
NO.46

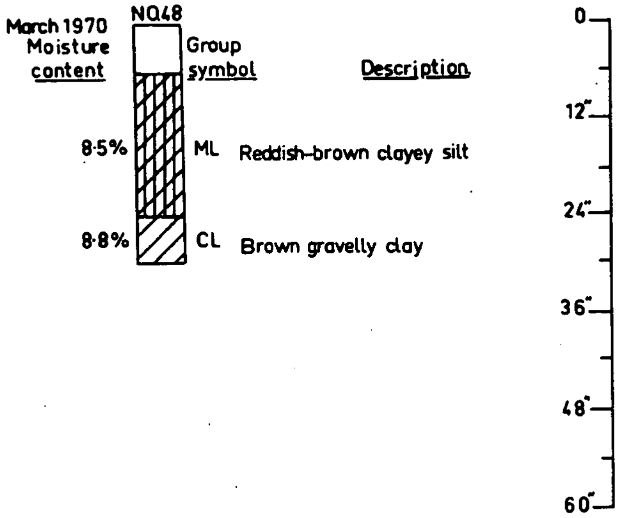
April 1970 Moisture content	Group symbol	Description
9.6%	MH	Grey silt
12.4%	CL	Yellow-brown silty clay
11.3%	SC	Yellow-brown sandy clay
11.5%	SC	Brown sandy clay containing some gravel-size sandstone

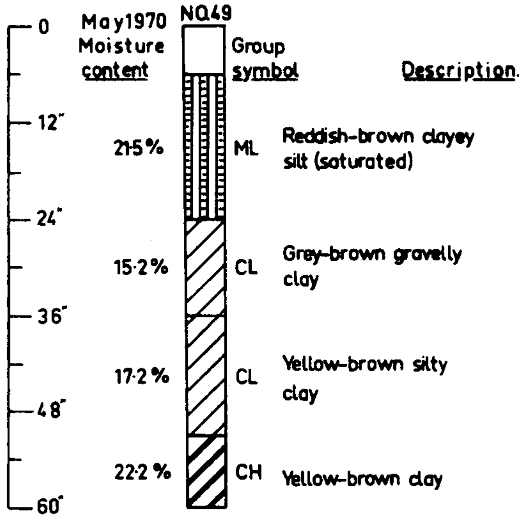
WATSON SOIL SURVEY

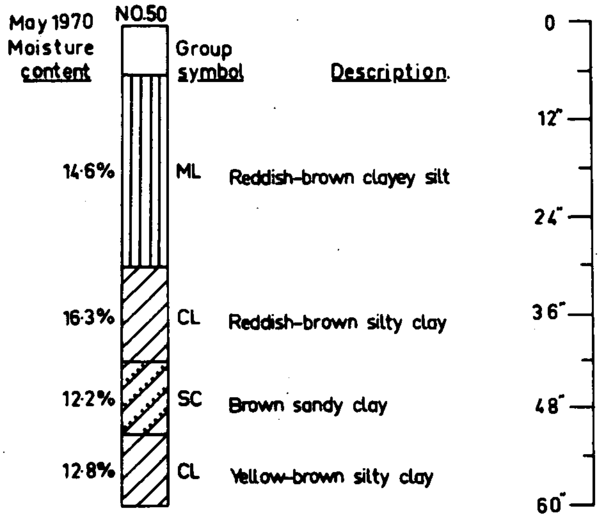
BORELOGS

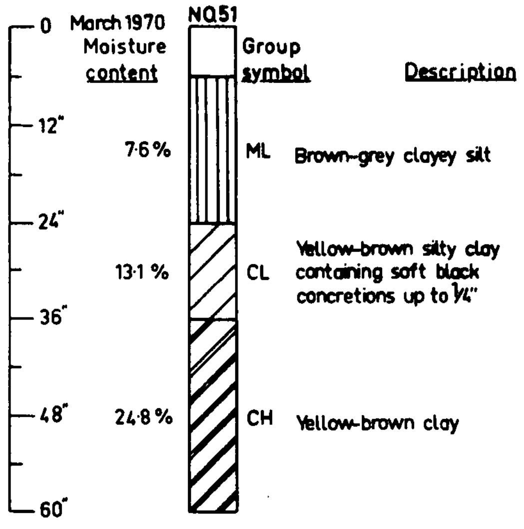
SOIL TYPE 6

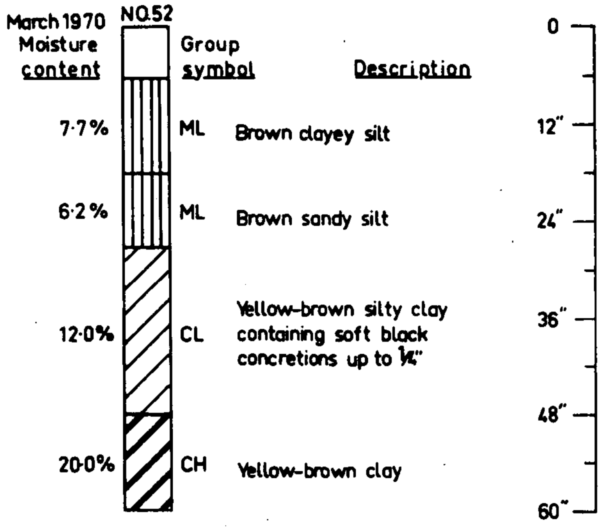












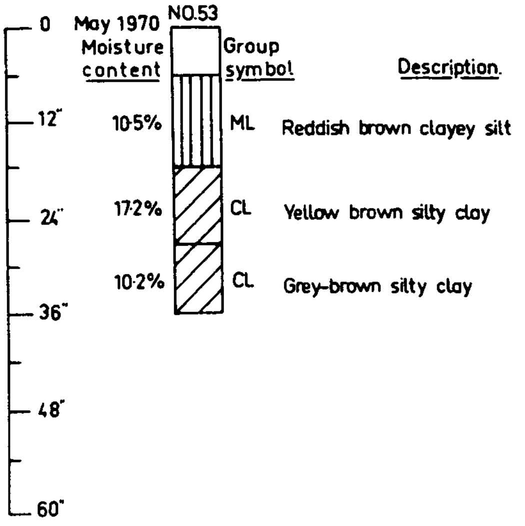
To accompany Record 1971/3

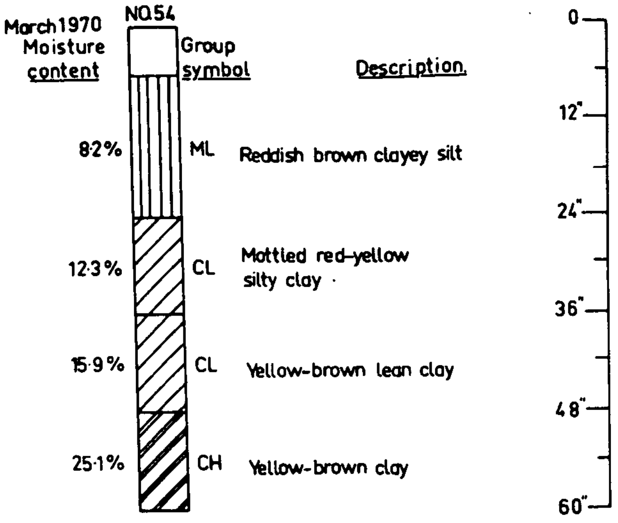
I55/A16/624

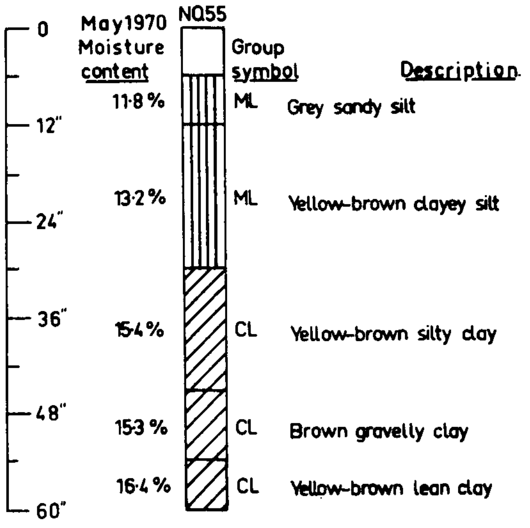
WATSON SOIL SURVEY

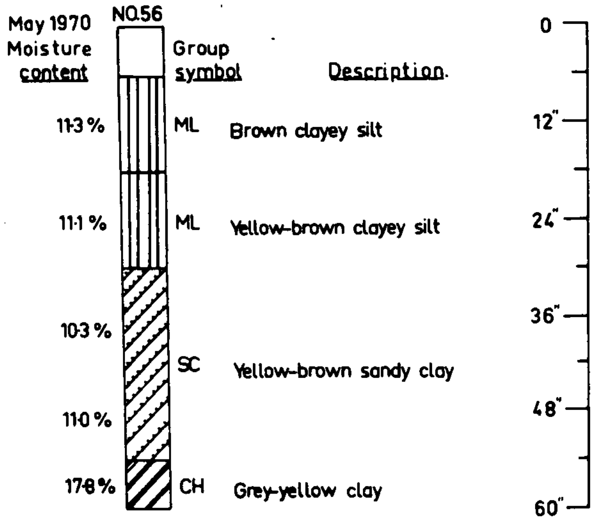
BORELOGS

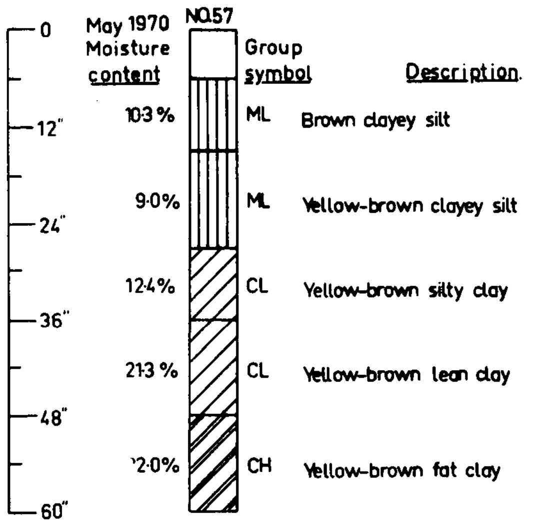
SOIL TYPE 6

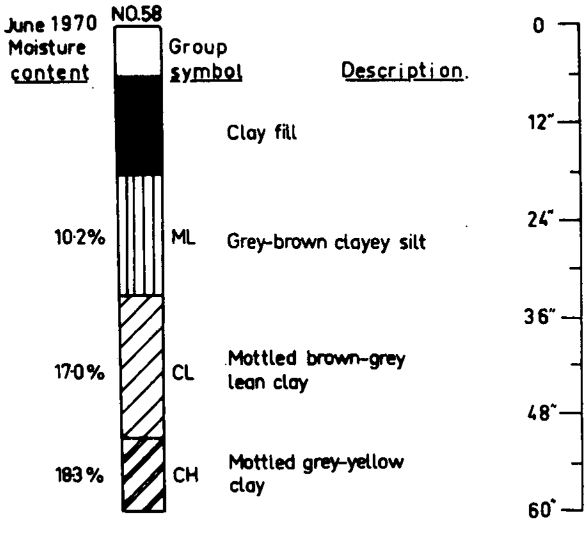










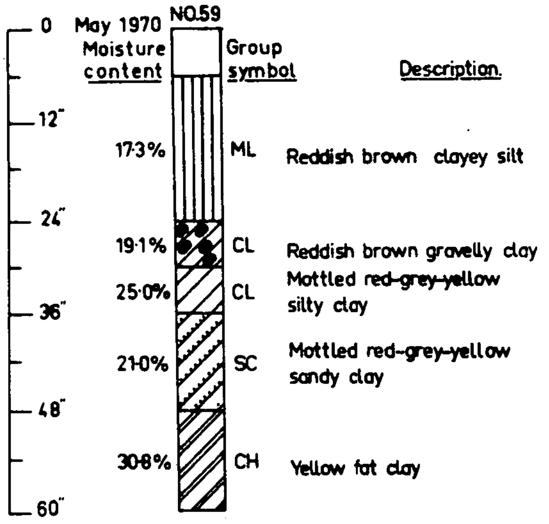


APPENDIX 1

WATSON SOIL SURVEY

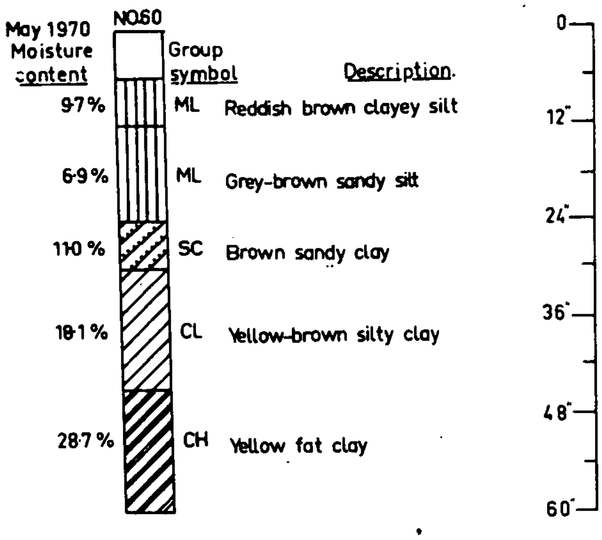
BORELOGS

SOIL TYPE 6



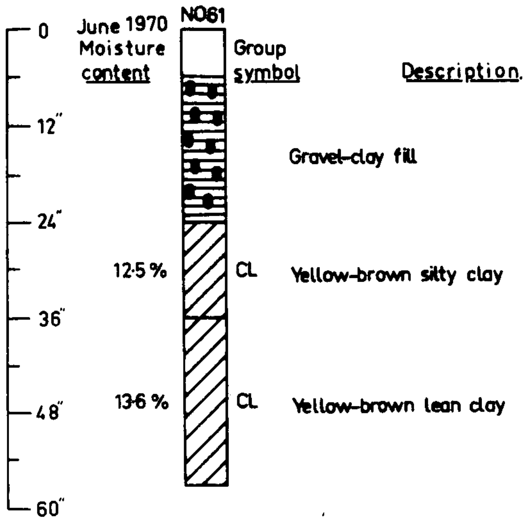
May 1970

Moisture content	Group symbol	Description.
17·3%	ML	Reddish brown clayey silt
19·1%	CL	Reddish brown gravelly clay
25·0%	CL	Mottled red-grey-yellow silty clay
21·0%	SC	Mottled red-grey-yellow sandy clay
30·8%	CH	Yellow fat clay



May 1970

Moisture content	Group symbol	Description.
9·7%	ML	Reddish brown clayey silt
6·9%	ML	Grey-brown sandy silt
11·0 %	SC	Brown sandy clay
18·1 %	CL	Yellow-brown silty clay
28·7 %	CH	Yellow fat clay



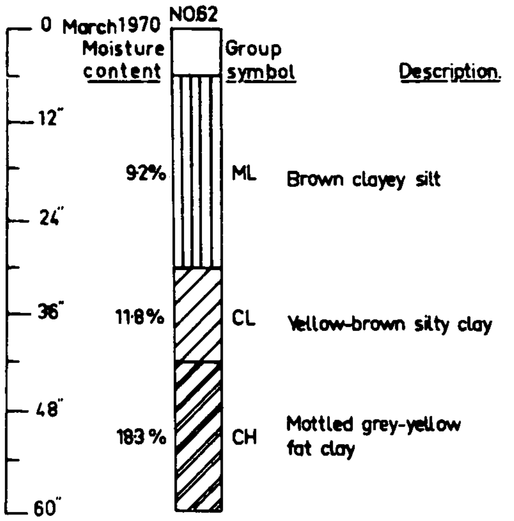
June 1970

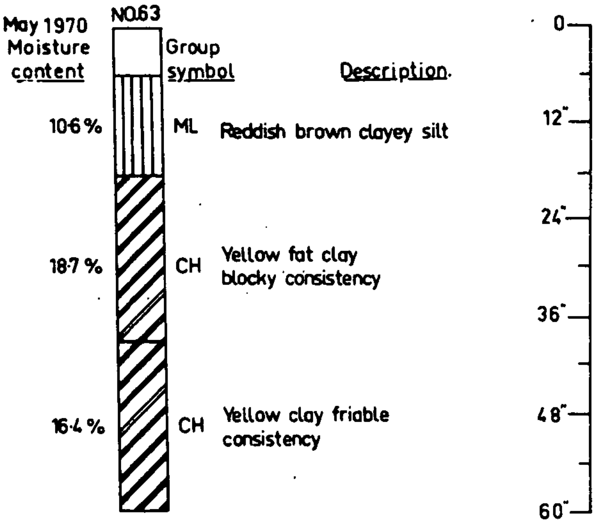
Moisture content	Group symbol	Description.
		Gravel-clay fill
12·5 %	CL	Yellow-brown silty clay
13·6 %	CL	Yellow-brown lean clay

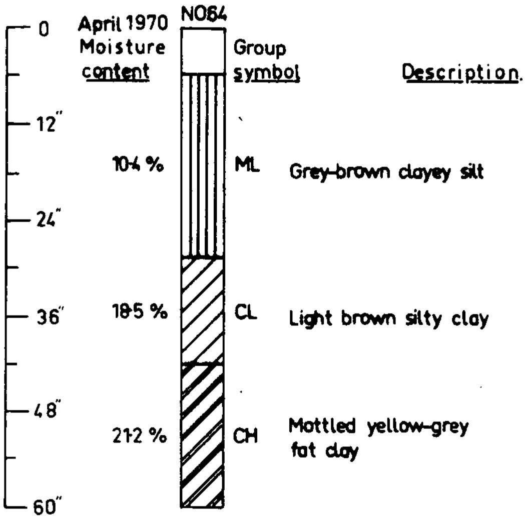
WATSON SOIL SURVEY

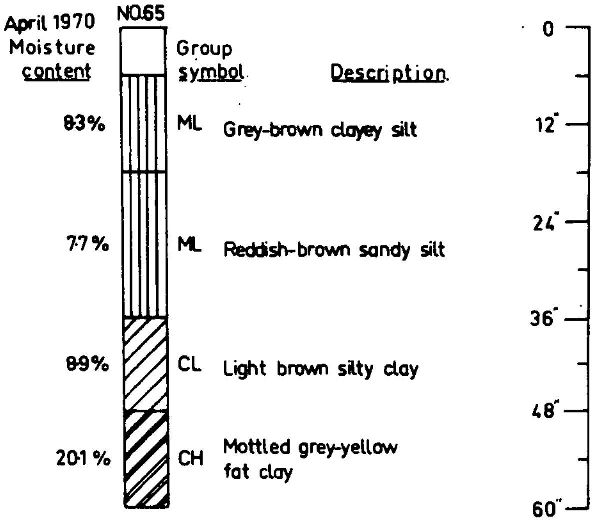
BORELOGS

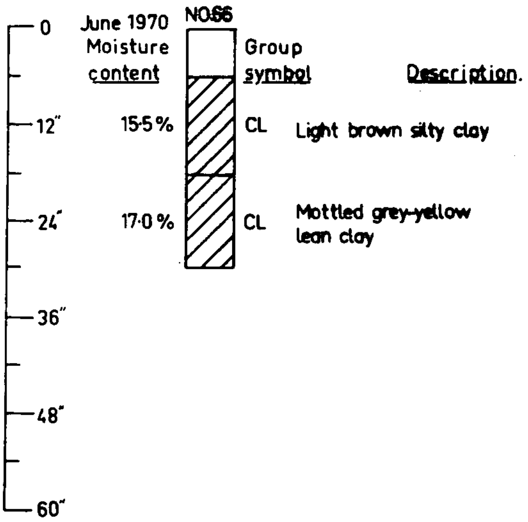
SOIL TYPE 7

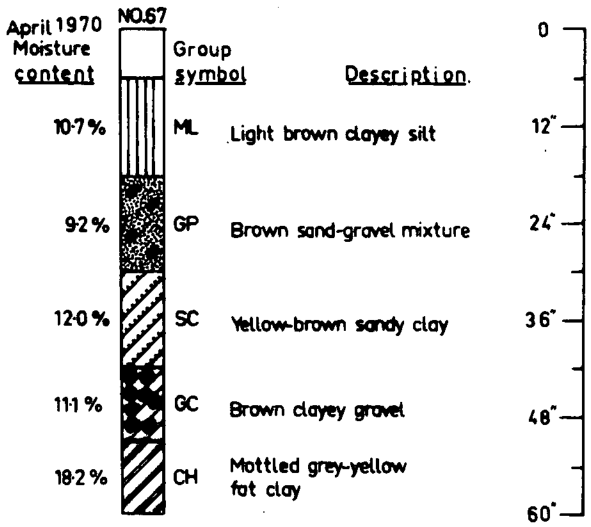








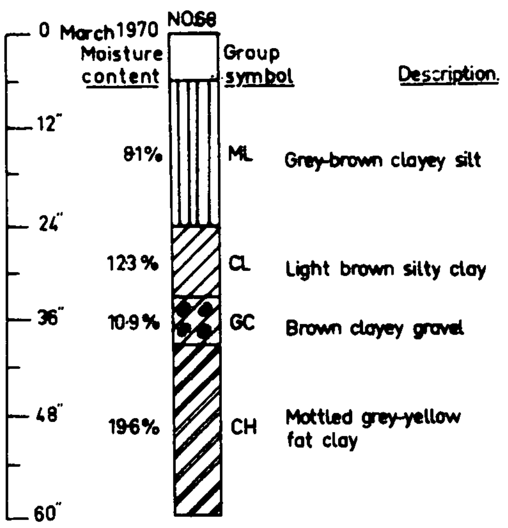


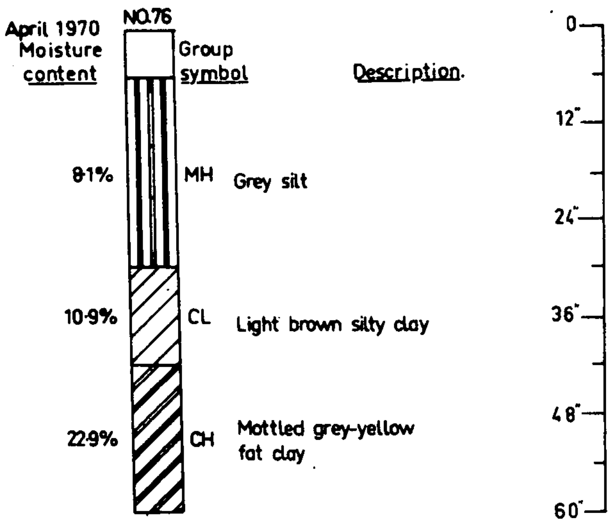


WATSON SOIL SURVEY

BORELOGS

SOIL TYPE 7



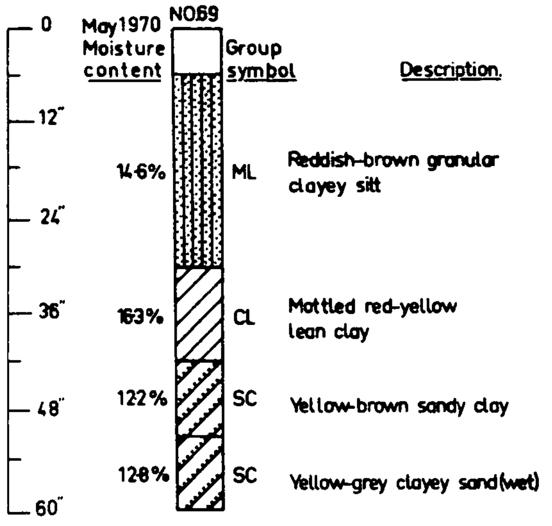


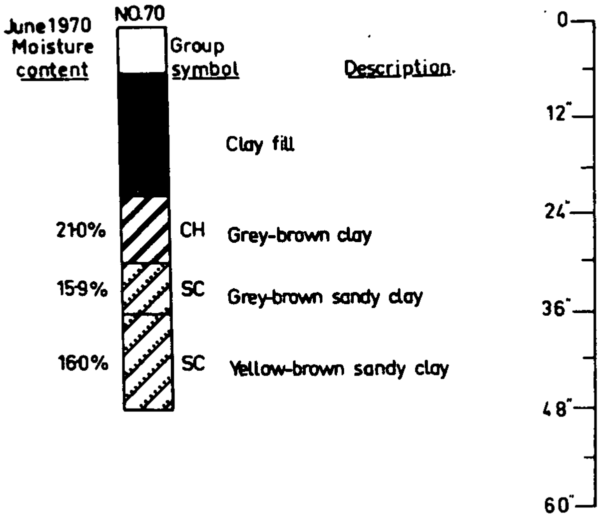
APPENDIX 1

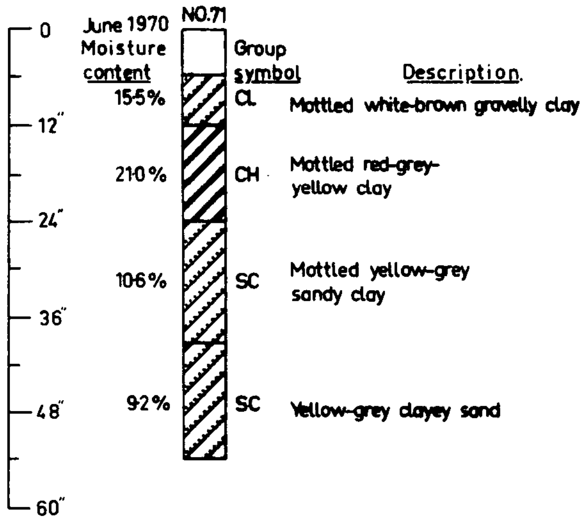
WATSON SOIL SURVEY

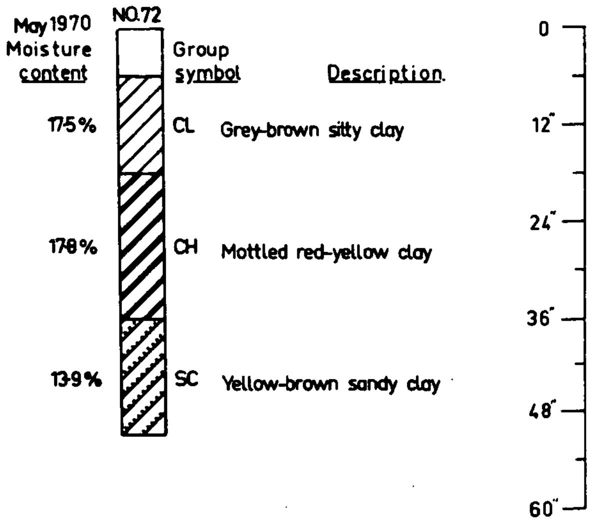
BORELOGS

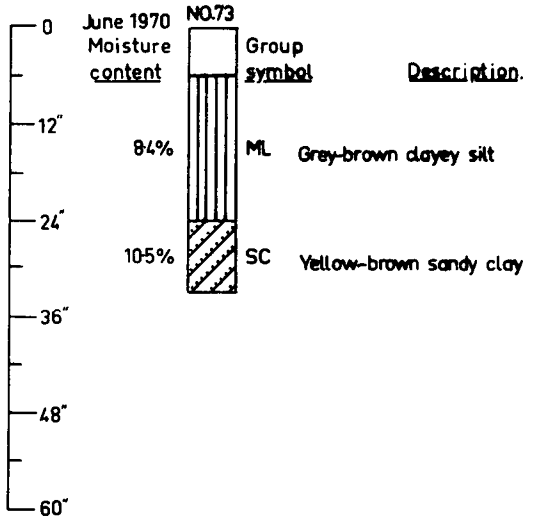
SOIL TYPE 8

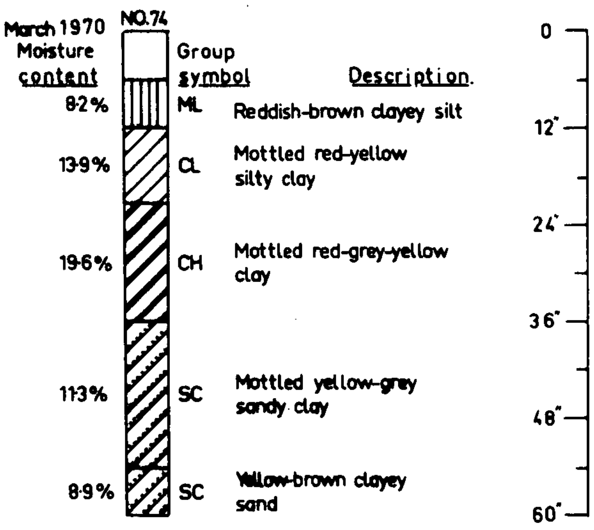












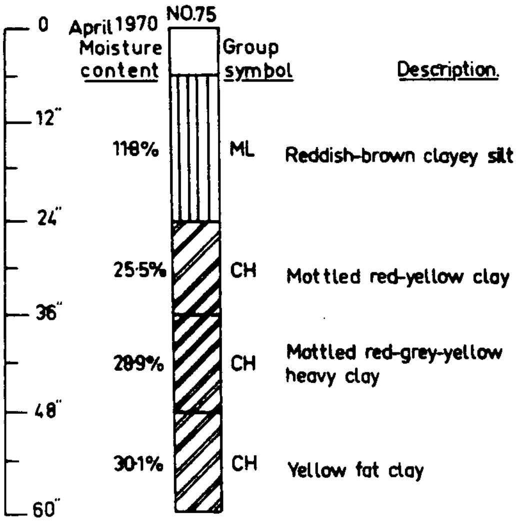
To accompany Record 1971/3

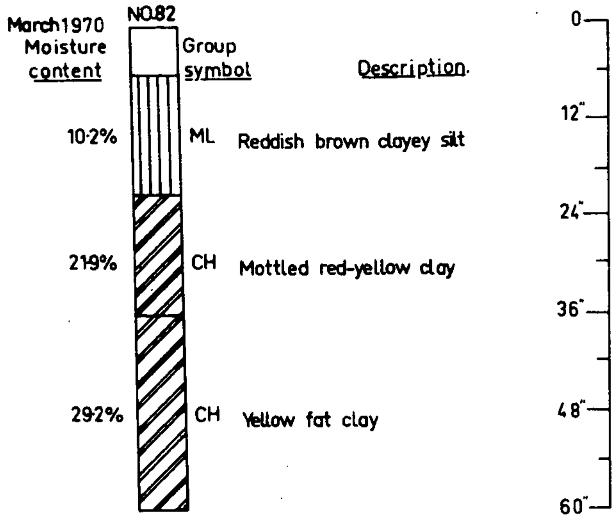
I55/A16/629

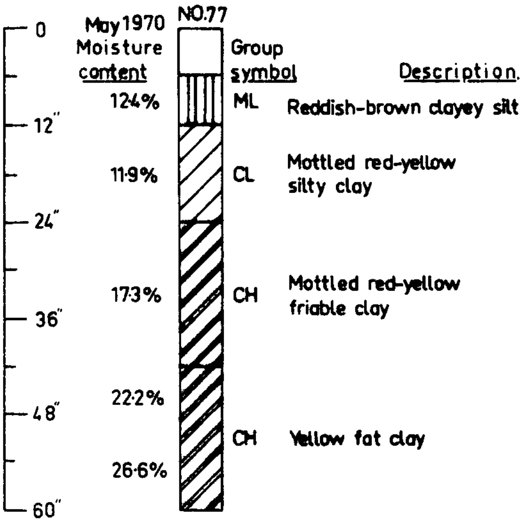
WATSON SOIL SURVEY

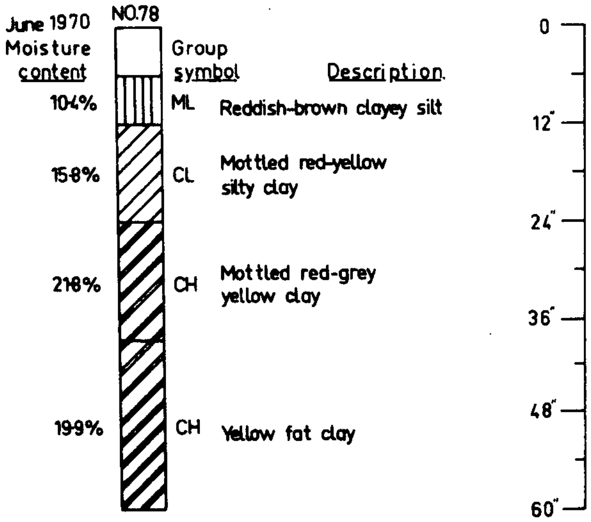
BORELOGS

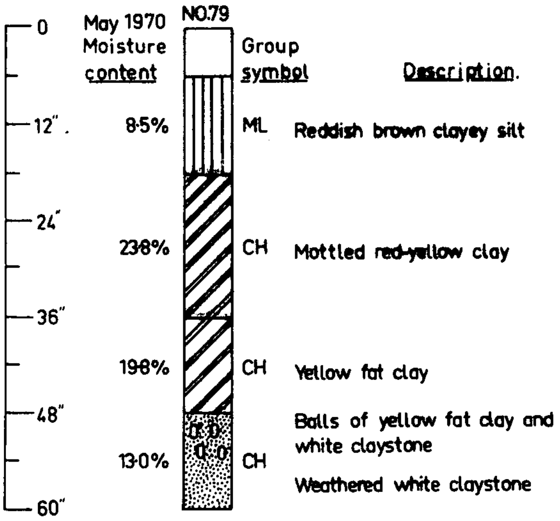
SOIL TYPE 9

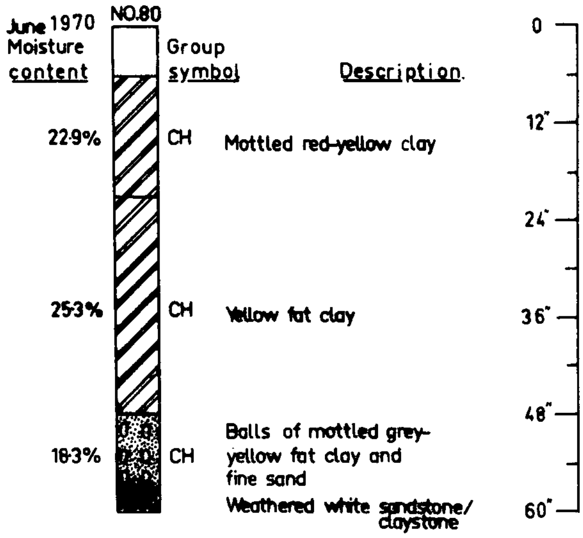










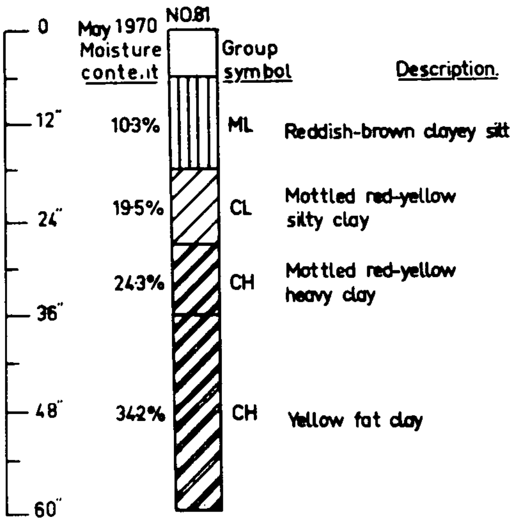


To accompany Record 1971/3

WATSON SOIL SURVEY

BORELOGS

SOIL TYPE 9

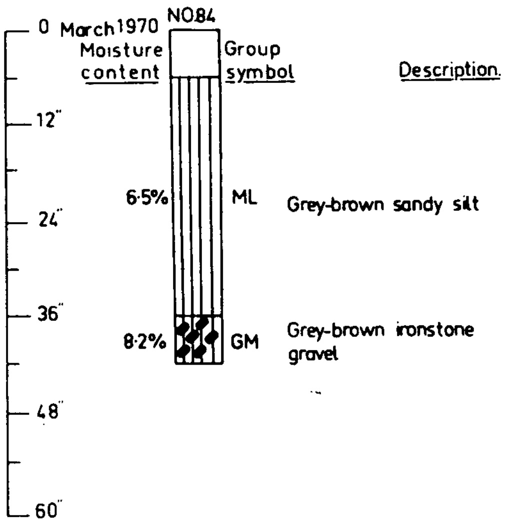


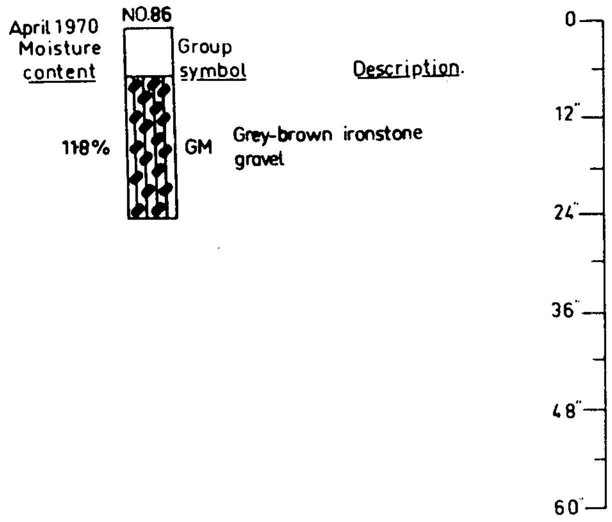
WATSON SOIL SURVEY

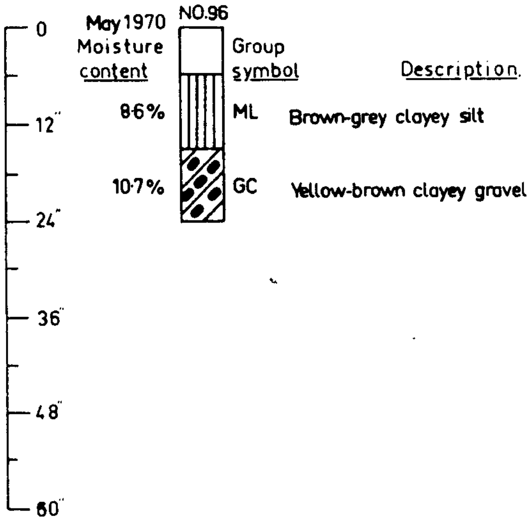
BORELOGS

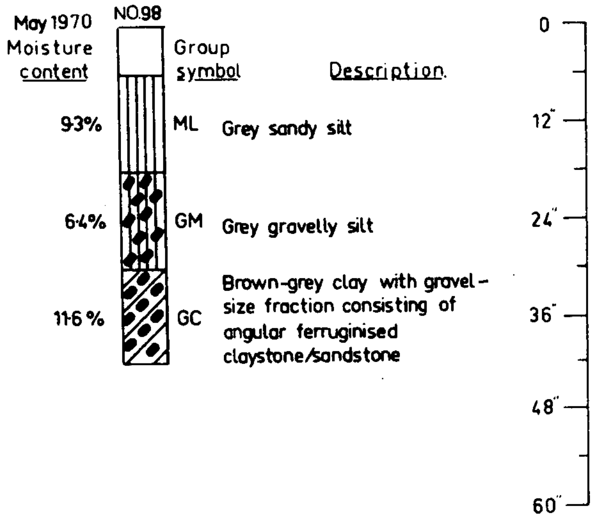
TYPE 10–SOILS OF DEPRESSIONS

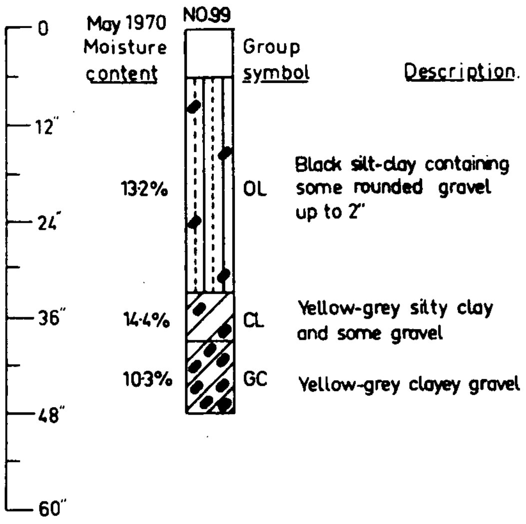
(a) GRAVELLY SUB-TYPE











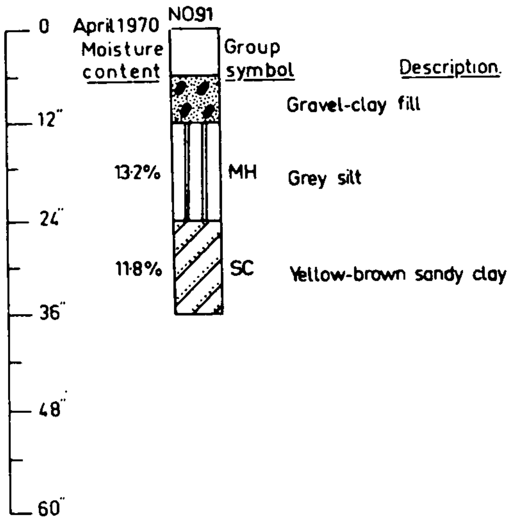
APPENDIX

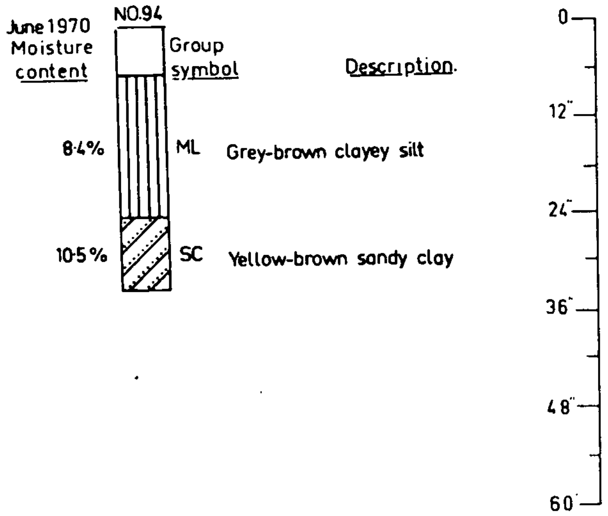
WATSON SOIL SURVEY

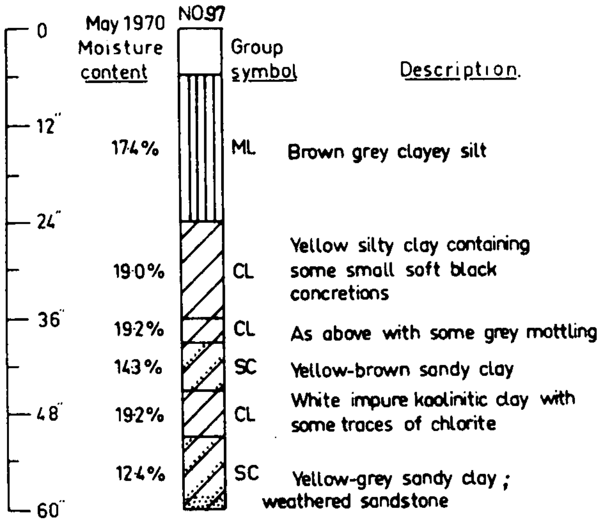
BORELOGS

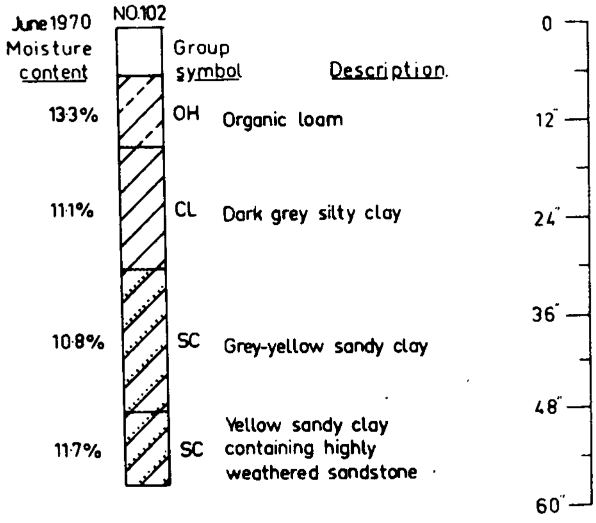
TYPE 10-SOILS OF DEPRESSIONS

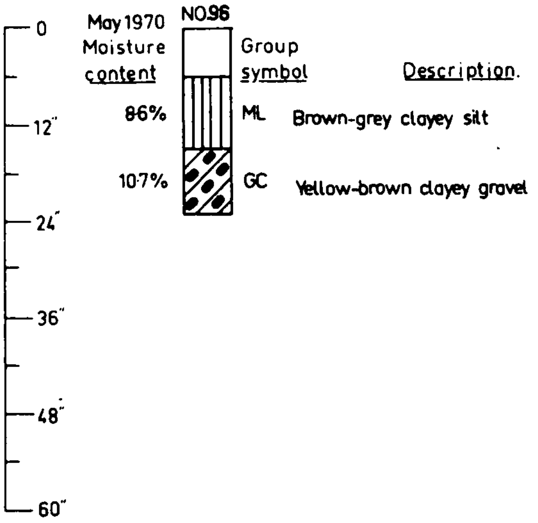
(b) SANDY SUB-TYPE









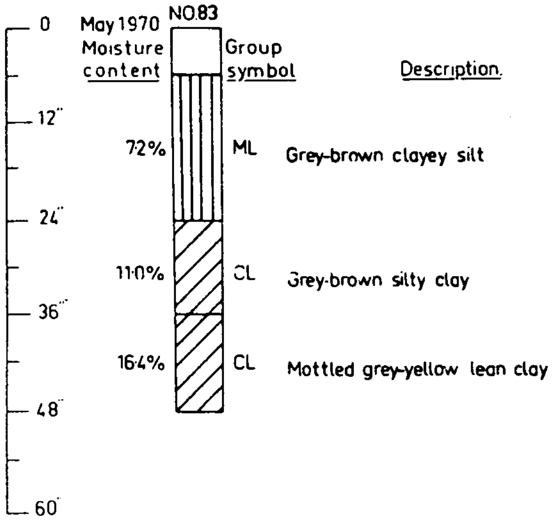


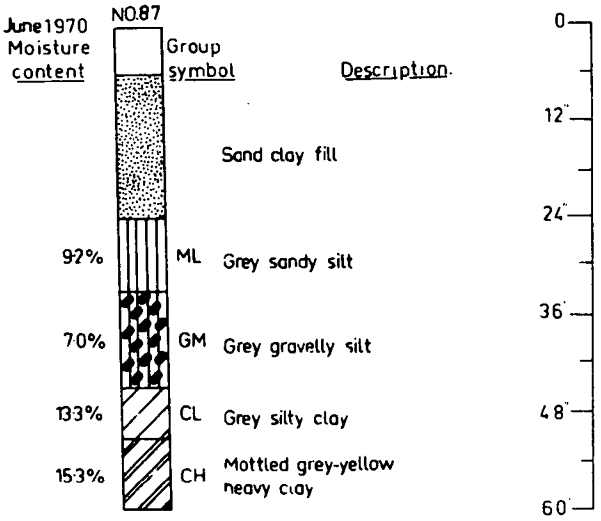
WATSON SOIL SURVEY

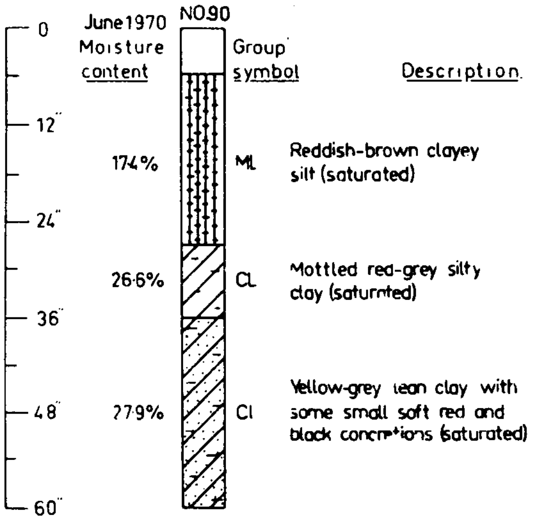
BORELOGS

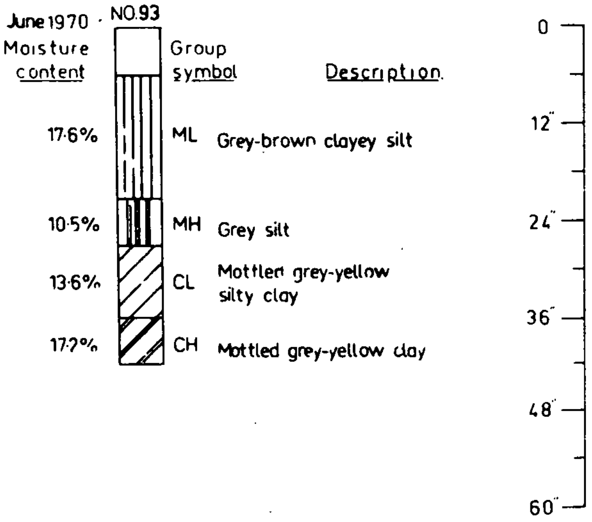
TYPE 10-SOILS OF DEPRESSIONS

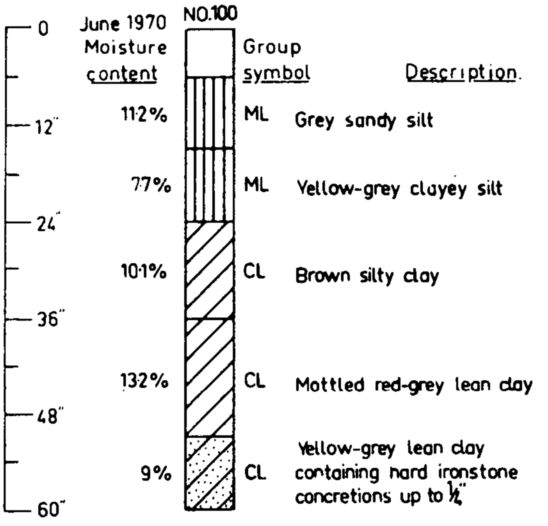
(c) LIGHT TO MEDIUM CLAYEY SUB TYPE

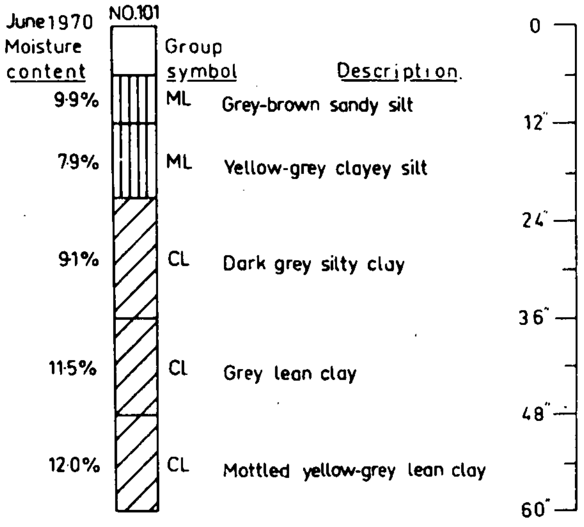










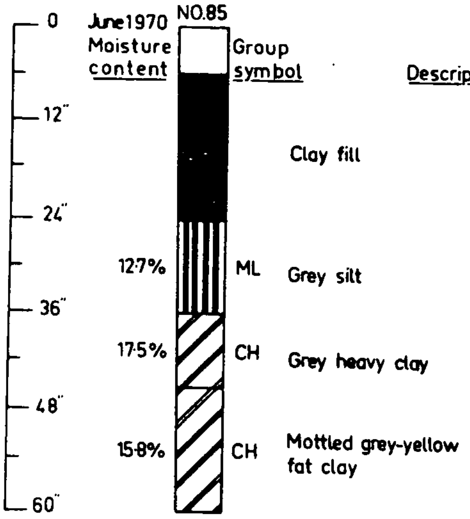


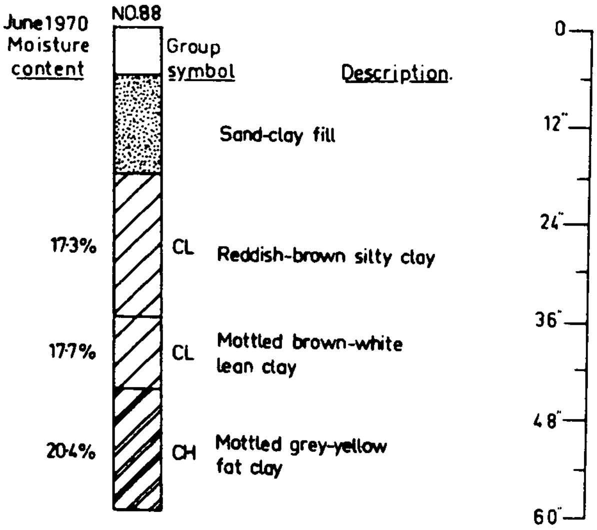
WATSON SOIL SURVEY

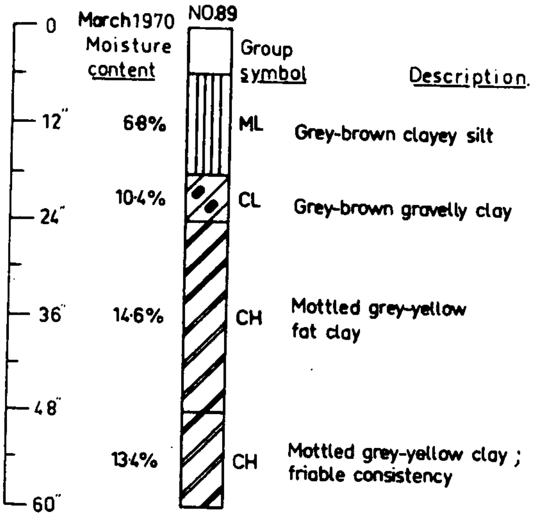
BORELOGS

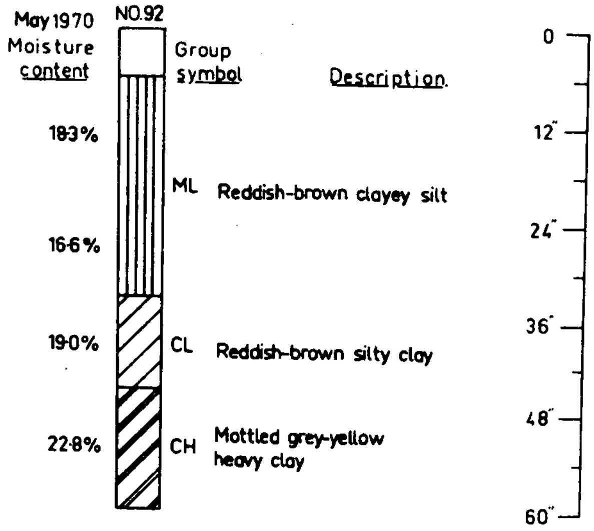
TYPE 10–SOILS OF DEPRESSIONS

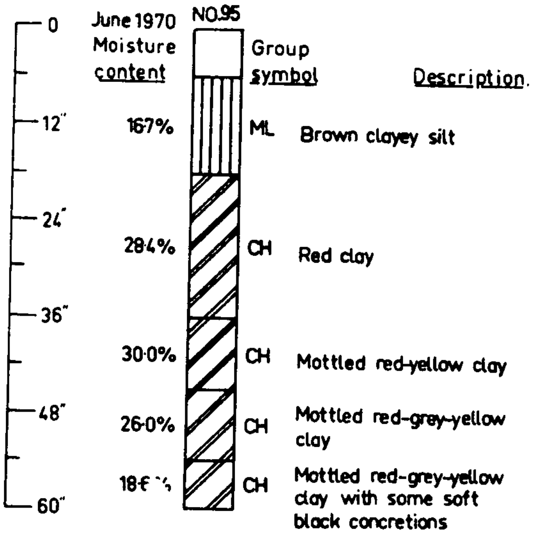
(d) HEAVY CLAYEY SUB-TYPE











To accompany Record 1971/3

I55/A16/635

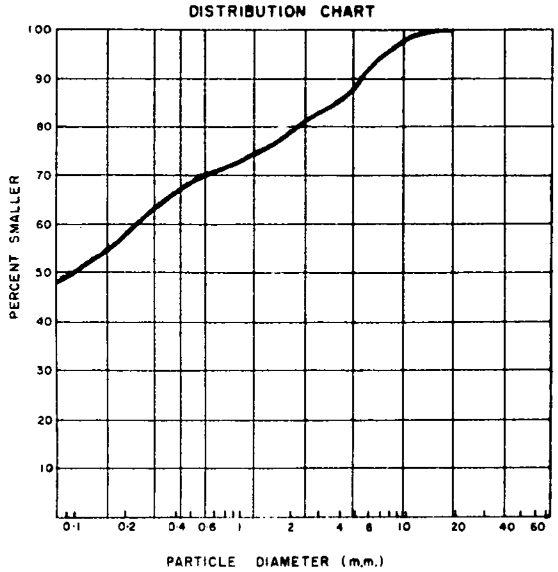
APPENDIX 2

Laboratory Test Results

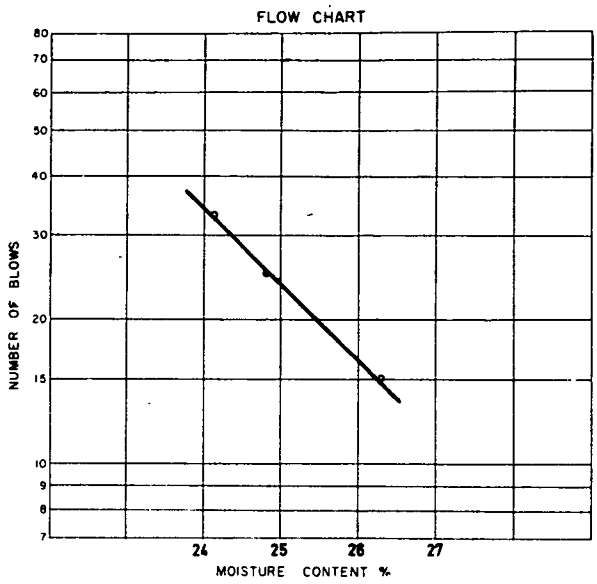
WATSON SOIL SURVEY

TEST RESULTS

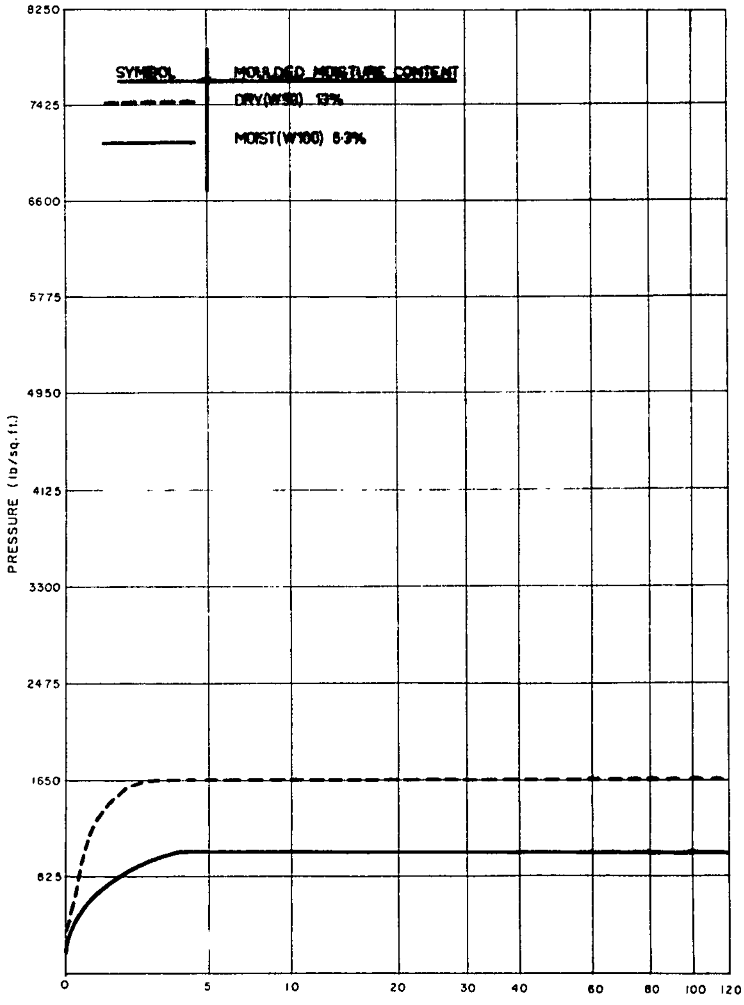
PARTICLE SIZE ANALYSIS



ATTERBERG LIMIT



POTENTIAL VOLUME CHANGE



SAMPLE No. 1A

SOIL TYPE 1

SUMMARY

Lower liquid limit	25
Lower plastic limit	17
Plasticity index	8
Linear shrinkage	5
Percent gravel	19
Percent sand	33
Percent silt and clay	48
Swell index (lb/sq.ft.)	1000
PVC rating	1·5
PVC category	NON CRITICAL

To accompany Record 1971/3

I55/A16/683

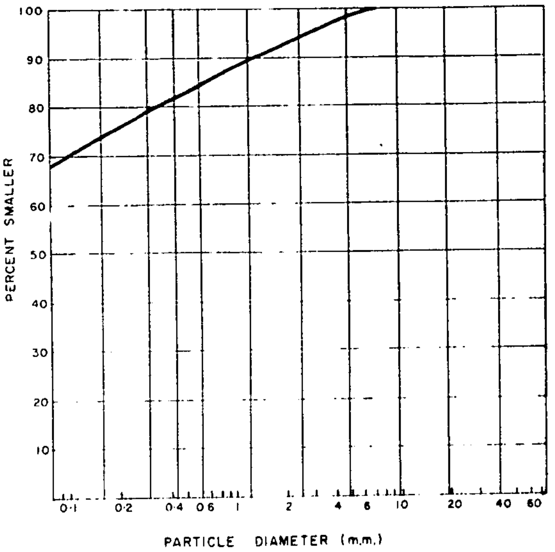
M (Pf) 121

WATSON SOIL SURVEY

TEST RESULTS

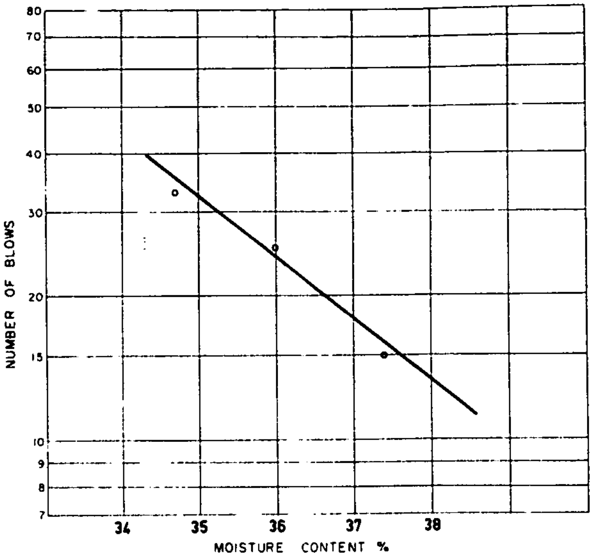
PARTICLE SIZE ANALYSIS

DISTRIBUTION CHART

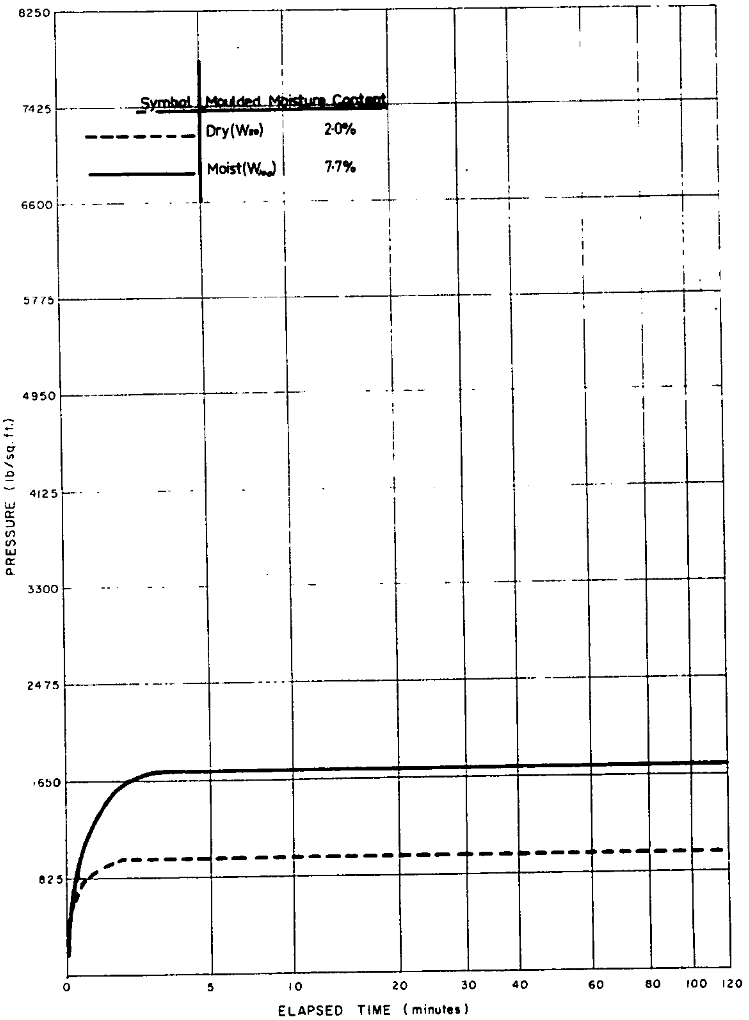


ATTERBERG LIMIT

FLOW CHART.



POTENTIAL VOLUME CHANGE



SAMPLE No. 1B

SOIL TYPE 1

SUMMARY

Lower liquid limit	36
Lower plastic limit	15
Plasticity index	21
Linear shrinkage	11
Percent gravel	6
Percent sand	26
Percent silt and clay	68
Swell index (lb/sq.ft.)	1350
PVC rating	1·5
PVC category	Non Critical

To accompany Record 1971/3

I5/A16/684

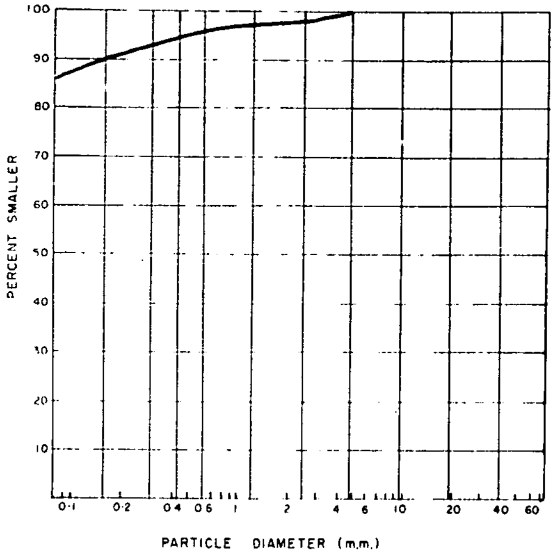
M (P1) 121

WATSON SOIL SURVEY

TEST RESULTS

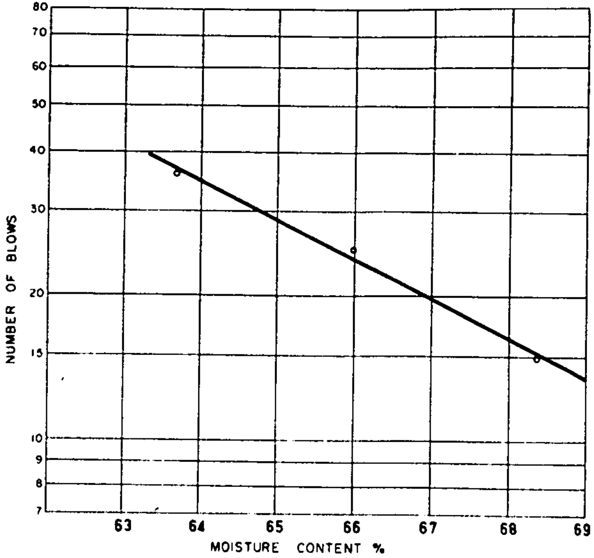
PARTICLE SIZE ANALYSIS

DISTRIBUTION CHART

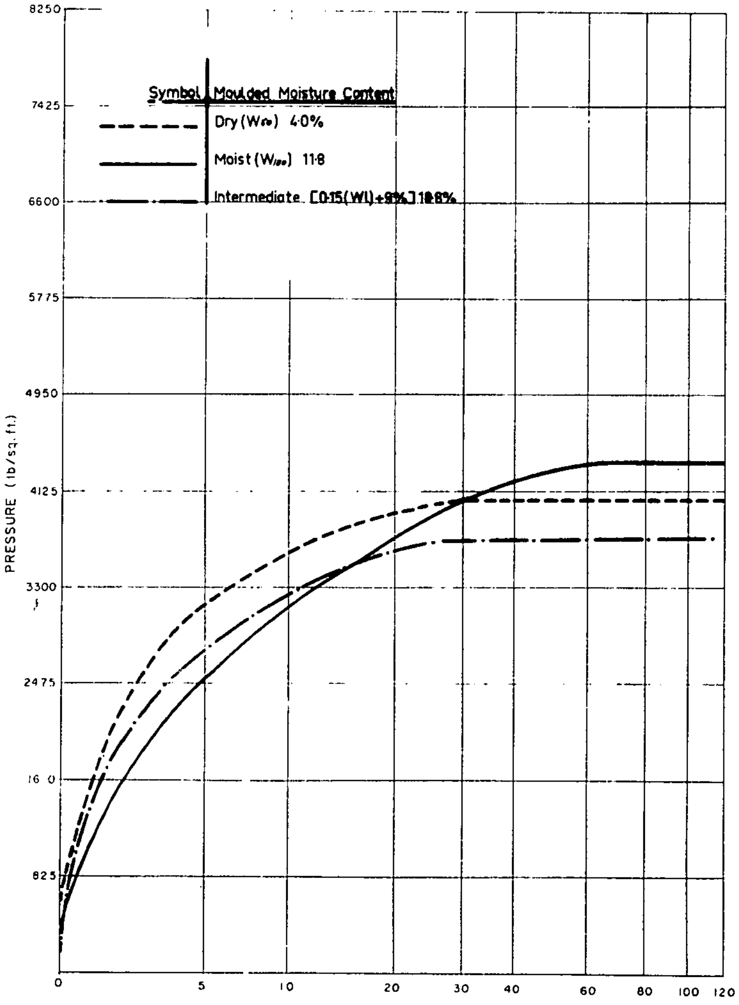


ATTERBERG LIMIT

FLOW CHART



POTENTIAL VOLUME CHANGE



SAMPLE No. 1 C

SOIL TYPE 1

SUMMARY

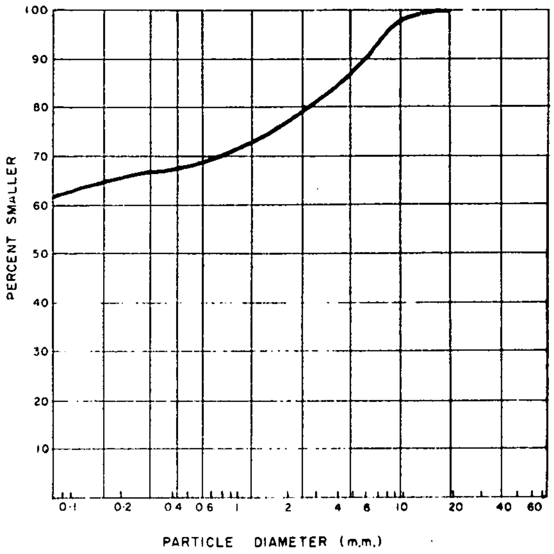
Lower liquid limit	66
Lower plastic limit	28
Plasticity index	38
Linear shrinkage	16
Percent gravel	2
Percent sand	12
Percent silt and clay	86
Swell index (lb/sq.ft.)	4200
PVC rating	5·3
PVC category	Critical

WATSON SOIL SURVEY

TEST RESULTS

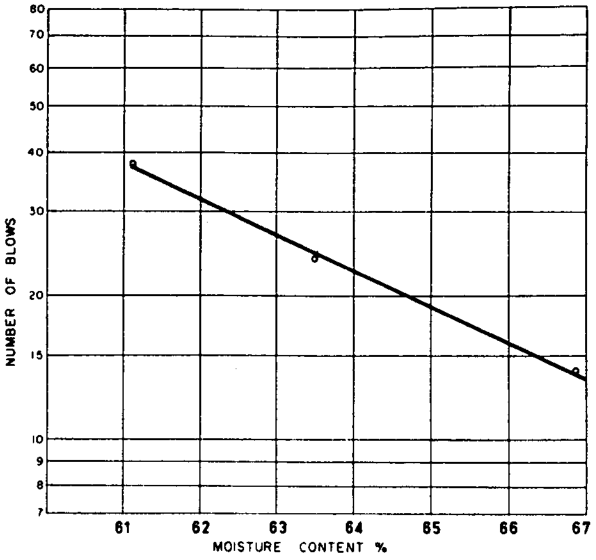
PARTICLE SIZE ANALYSIS

DISTRIBUTION CHART

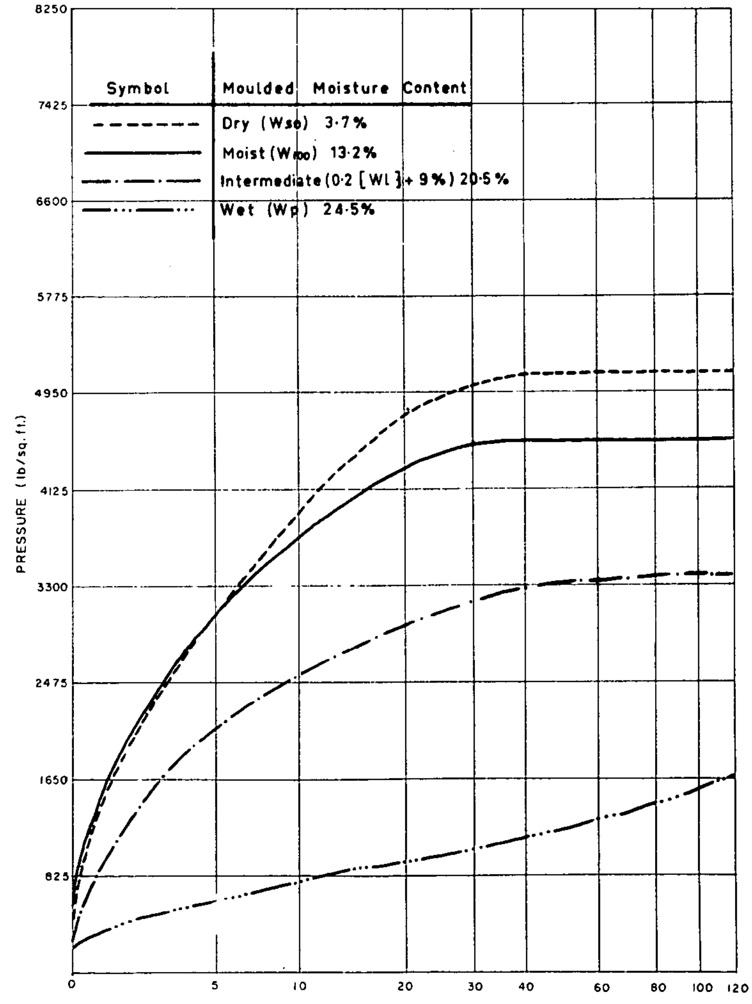


ATTERBERG LIMIT

FLOW CHART



POTENTIAL VOLUME CHANGE



(To accompany Record 1971/3

SAMPLE No. 1 D

SOIL TYPE 1

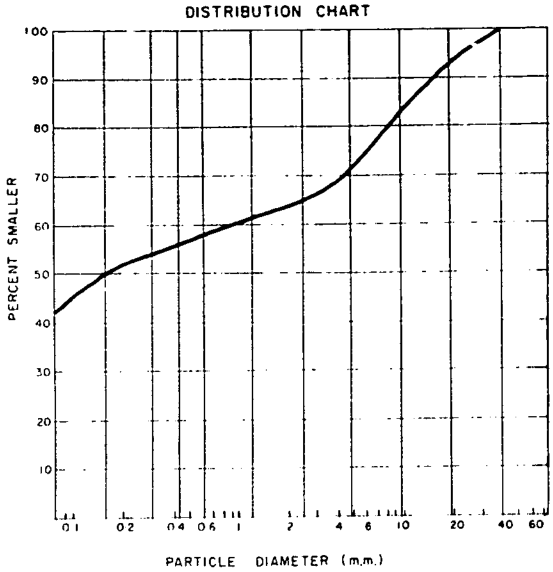
SUMMARY

Lower liquid limit	64
Lower plastic limit	24
Plasticity index	40
Linear shrinkage	15
Percent gravel	20
Percent sand	18
Percent silt and clay	62
Swell index (lb/sq.ft.)	4800
PVC rating	6·1
PVC category	Very Critical

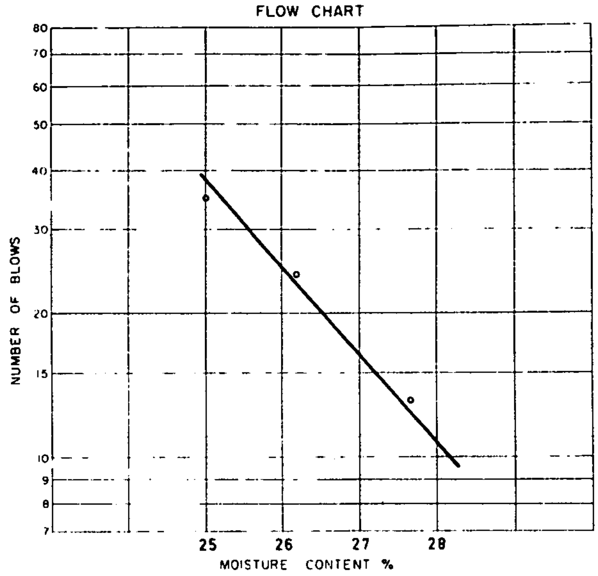
WATSON SOIL SURVEY

TEST RESULTS

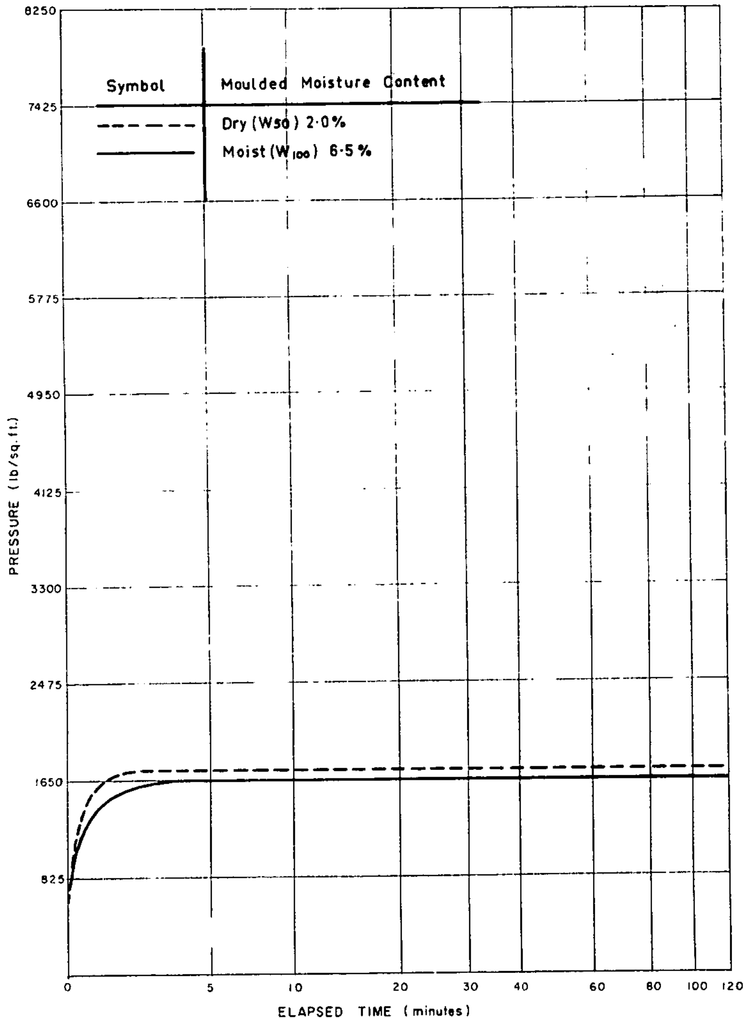
PARTICLE SIZE ANALYSIS



ATTERBERG LIMIT



POTENTIAL VOLUME CHANGE



SAMPLE No. 2 A

SOIL TYPE 2

SUMMARY

Lower liquid limit	26
Lower plastic limit	17
Plasticity index	9
Linear shrinkage	5
Percent gravel	35
Percent sand	23
Percent silt and clay	42
Swell index (lb/sq. ft.)	1700
PVC rating	1·9
PVC category	Non Critical

To accompany Record 1971/3

I55A16/687

M (Pf) 121

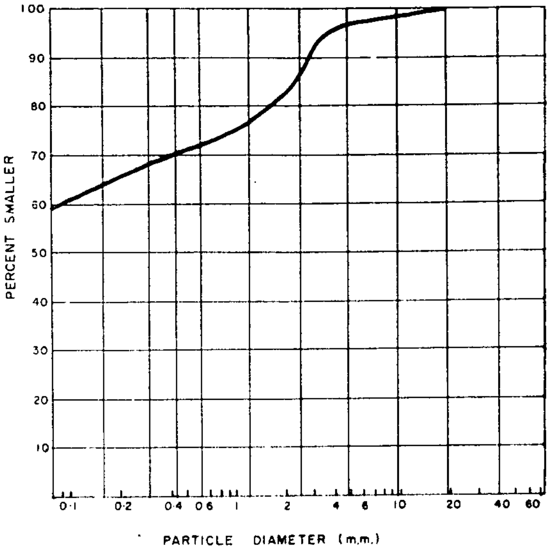
APPENDIX 2

WATSON SOIL SURVEY

TEST RESULTS

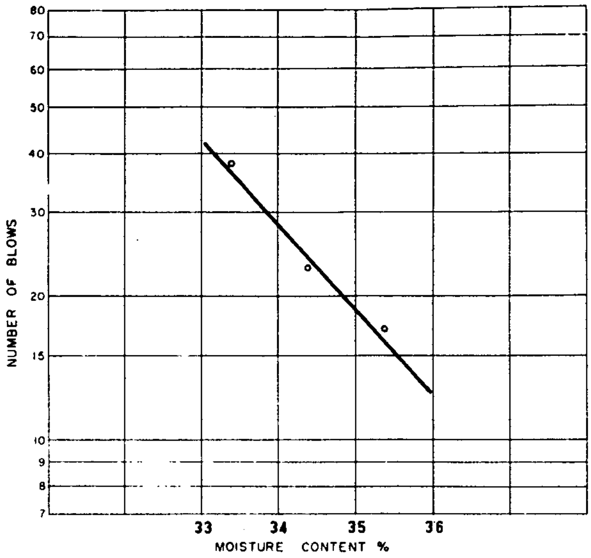
PARTICLE SIZE ANALYSIS

DISTRIBUTION CHART

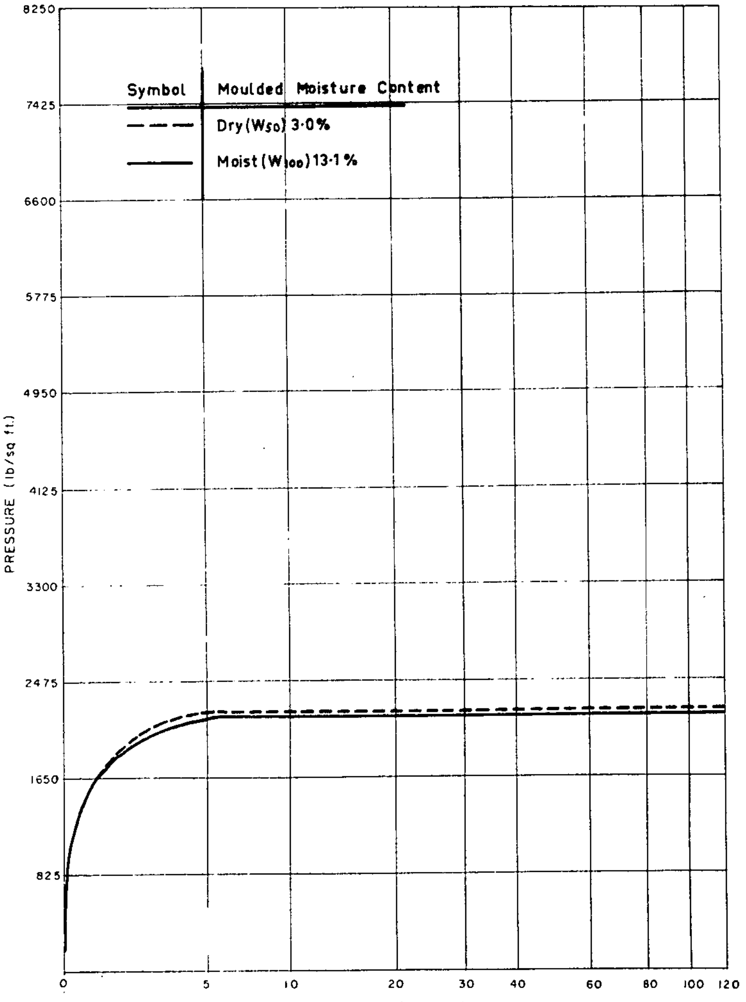


ATTERBERG LIMIT

FLOW CHART



POTENTIAL VOLUME CHANGE



SAMPLE No. 3A

SOIL TYPE 3

SUMMARY

Lower liquid limit	34
Lower plastic limit	14
Plasticity index	20
Linear shrinkage	10
Percent gravel	14
Percent sand	27
Percent silt and clay	59
Swell index (lb/sq. ft.)	2200
PVC rating	2·7
PVC category	Marginal

To accompany Record 1971/3

I55/A16/688

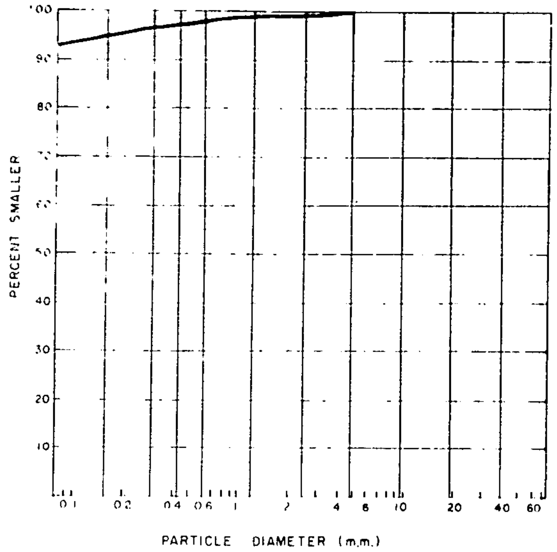
M (Pf) 121

WATSON SOIL SURVEY

TEST RESULTS

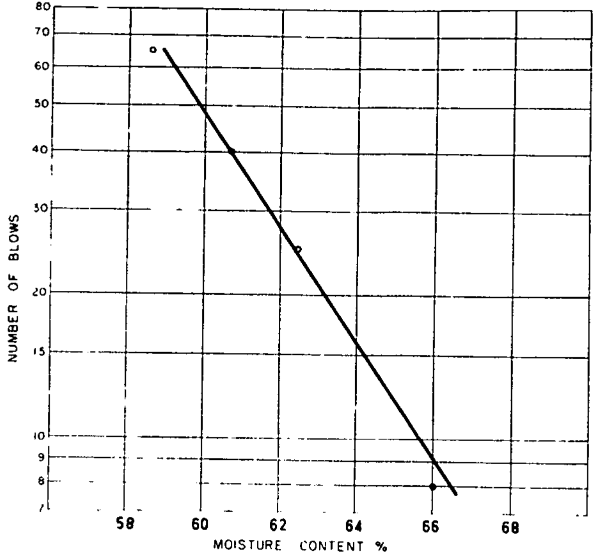
PARTICLE SIZE ANALYSIS

DISTRIBUTION CHART

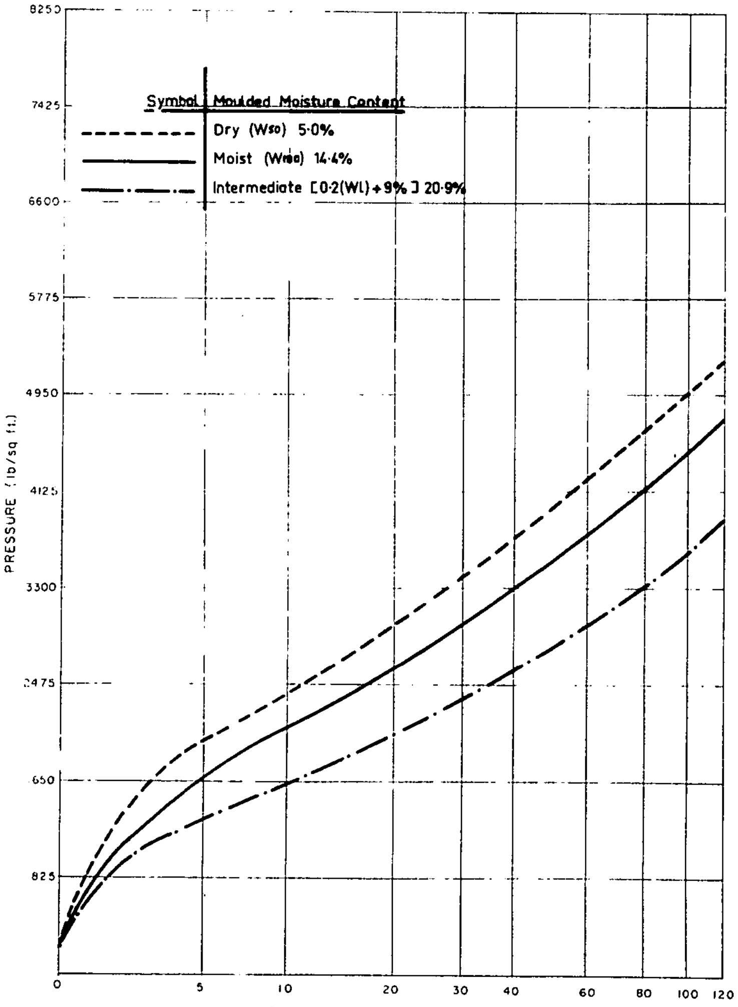


ATTERBERG LIMIT

FLOW CHART



POTENTIAL VOLUME CHANGE



SAMPLE No. 3 B(i)

SOIL TYPE 3

SUMMARY

Lower liquid limit	62
Lower plastic limit	23
Plasticity index	39
Linear shrinkage	16
Percent gravel	1
Percent sand	6
Percent silt and clay	93
Swell index (lb/sq.ft)	4950
PVC rating	63
PVC category	Very Critical

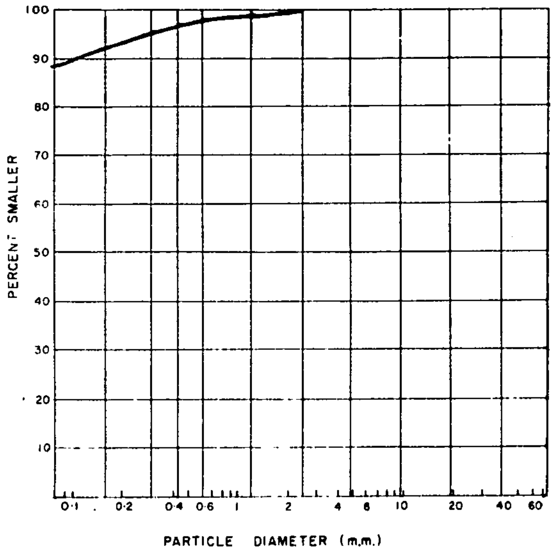
To accompany Record 1971/3

WATSON SOIL SURVEY

TEST RESULTS

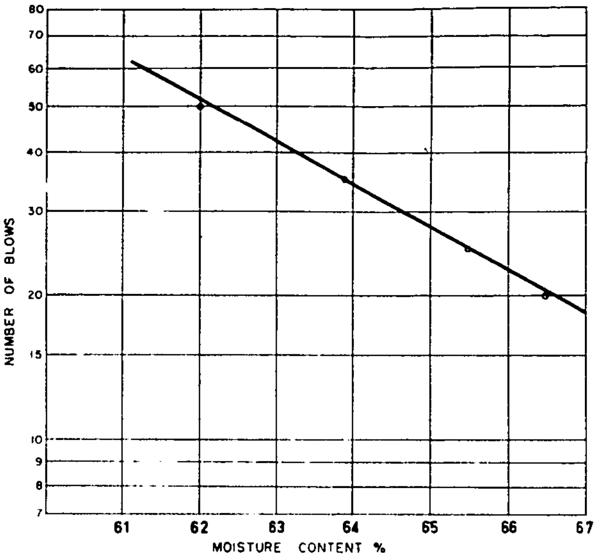
PARTICLE SIZE ANALYSIS

DISTRIBUTION CHART

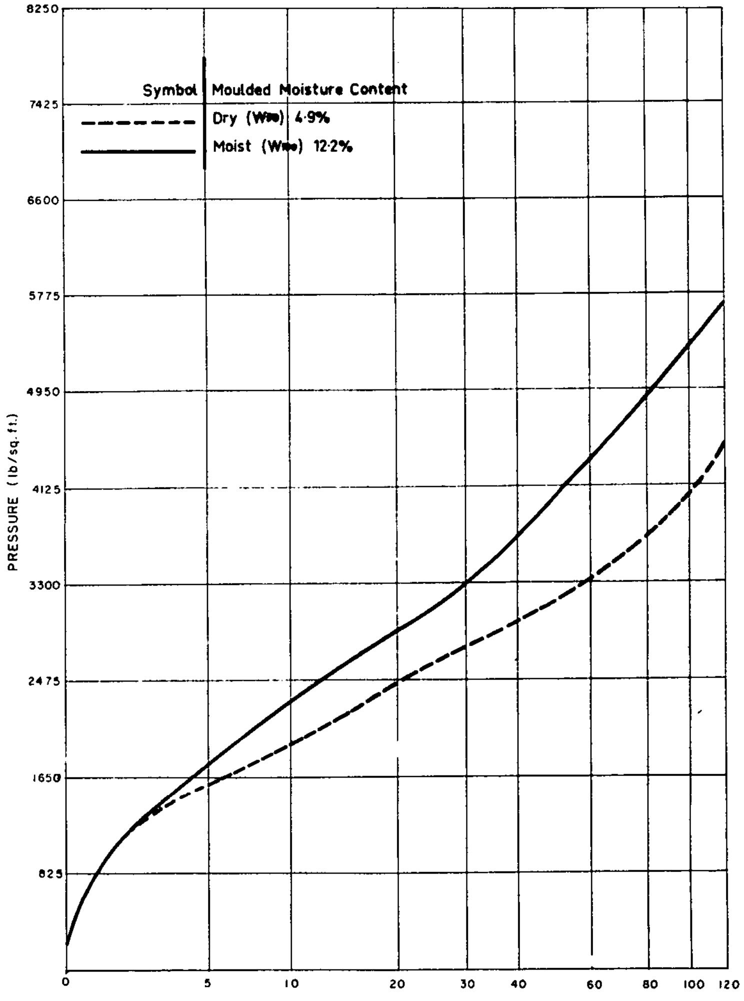


ATTERBERG LIMIT

FLOW CHART



POTENTIAL VOLUME CHANGE



SAMPLE No. 3 B(ii)

SOIL TYPE 3

SUMMARY

Lower liquid limit	66
Lower plastic limit	28
Plasticity index	38
Linear shrinkage	15
Percent gravel	NIL
Percent sand	11
Percent silt and clay	89
Swell index (lb/sq.ft.)	5100
PVC rating	6·5
PVC category	Very Critical

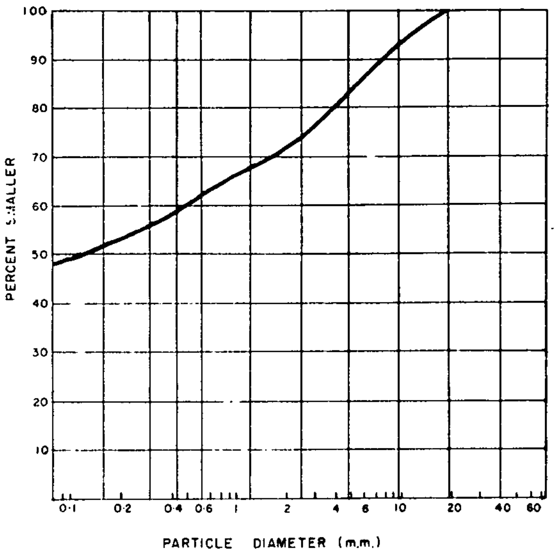
To accompany Record 1971/3

WATSON SOIL SURVEY

TEST RESULTS

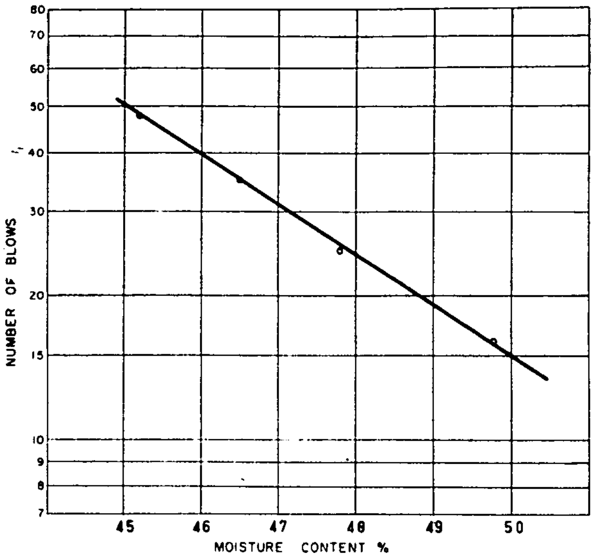
PARTICLE SIZE ANALYSIS

DISTRIBUTION CHART

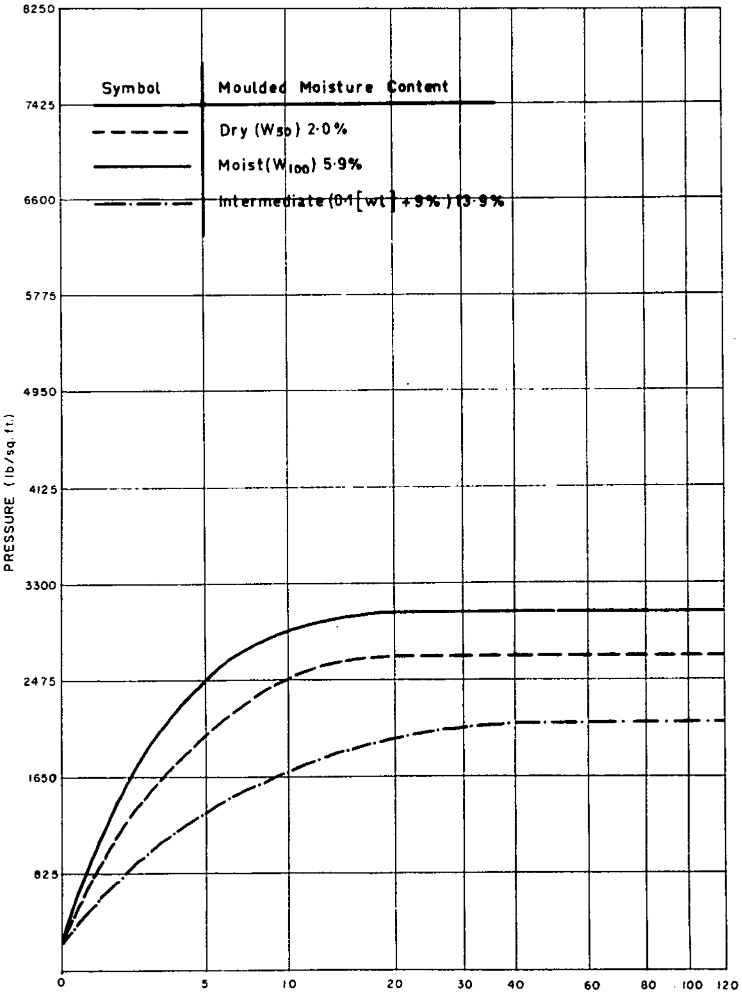


ATTERBERG LIMIT

FLOW CHART



POTENTIAL VOLUME CHANGE



SAMPLE No. 3C(i)

SOIL TYPE 3

SUMMARY

Lower liquid limit	48
Lower plastic limit	20
Plasticity index	28
Linear shrinkage	13
Percent gravel	26
Percent sand	26
Percent silt and clay	48
Swell index (lb/sq.ft.)	2050
PVC rating	2·5
PVC category	Marginal

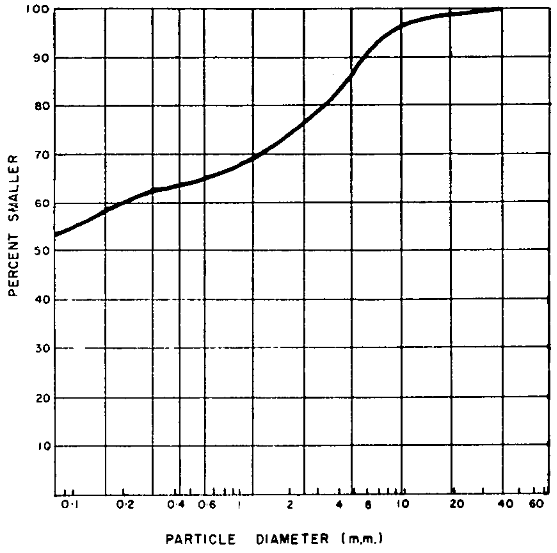
To accompany Record 1971/3

WATSON SOIL SURVEY

TEST RESULTS

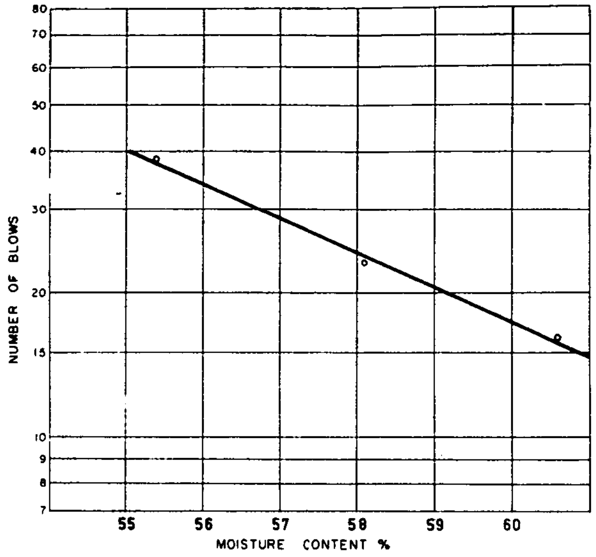
PARTICLE SIZE ANALYSIS

DISTRIBUTION CHART

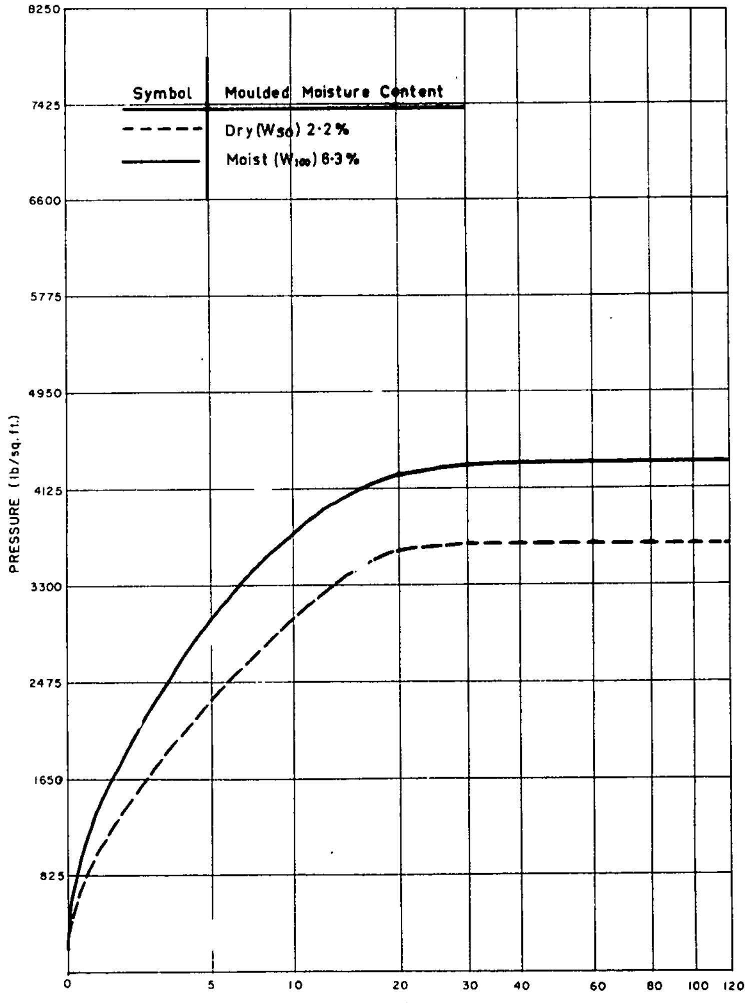


ATTERBERG LIMIT

FLOW CHART



POTENTIAL VOLUME CHANGE



SAMPLE No. 3C(ii)

SOIL TYPE 3

SUMMARY

Lower liquid limit	58
Lower plastic limit	23
Plasticity index	35
Linear shrinkage	15
Percent gravel	24
Percent sand	22
Percent silt and clay	54
Swell index (lb/sq. ft.)	4050
PVC rating	51
PVC category	Critical

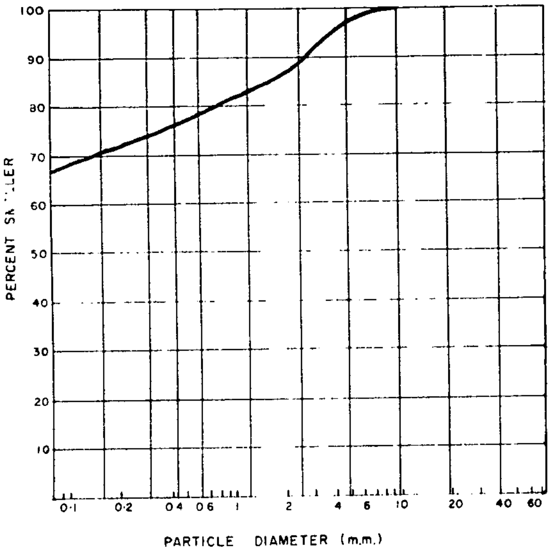
To accompany Record 1971/3

WATSON SOIL SURVEY

TEST RESULTS

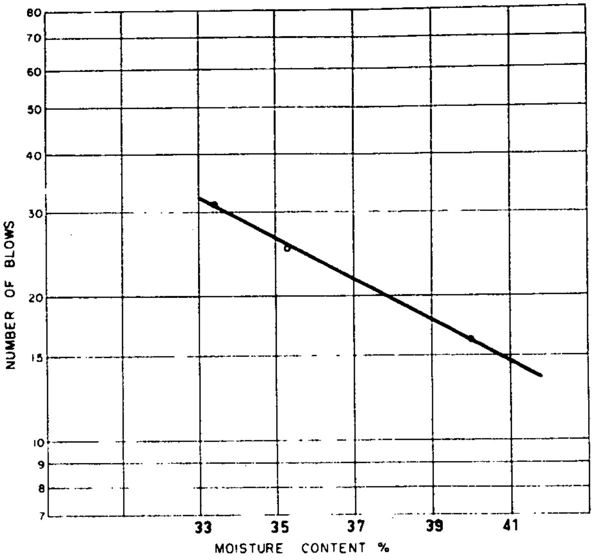
PARTICLE SIZE ANALYSIS

DISTRIBUTION CHART

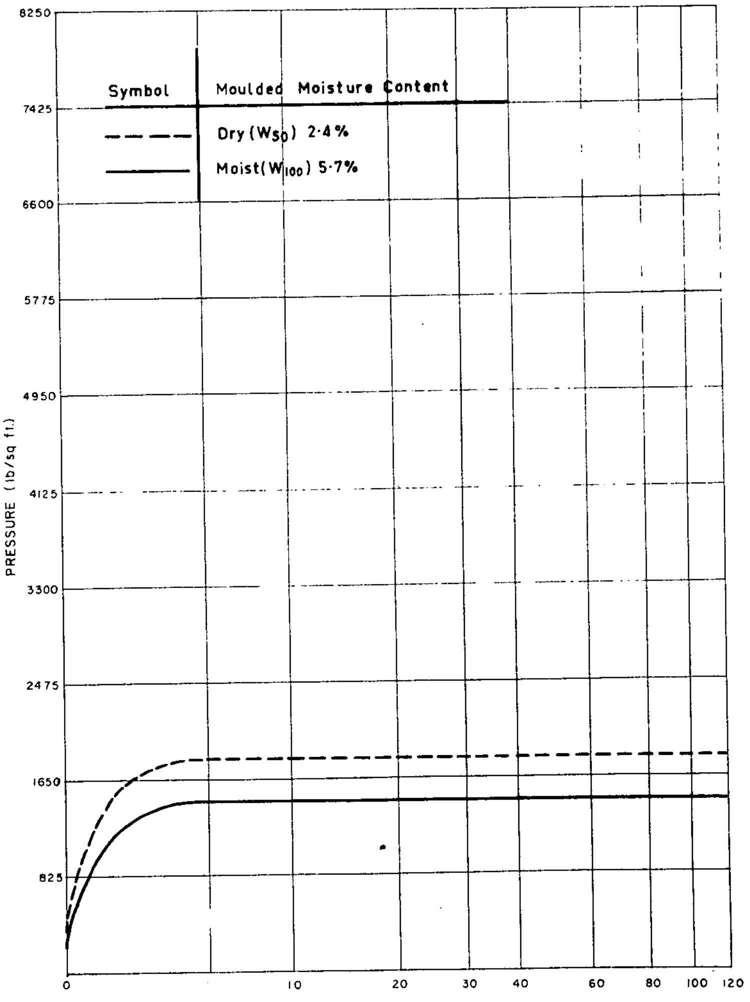


ATTERBERG LIMIT

FLOW CHART



POTENTIAL VOLUME CHANGE



SAMPLE No. 4B

SOIL TYPE 4

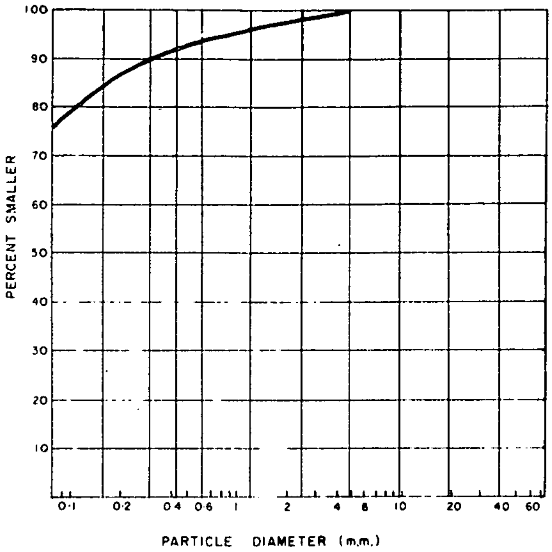
SUMMARY

Lower liquid limit	35
Lower plastic limit	14
Plasticity index	21
Linear shrinkage	9
Percent gravel	12
Percent sand	21
Percent silt and clay	67
Swell index (lb/sq. ft.)	1650
PVC rating	2·0
PVC category	Non Critical

WATSON SOIL SURVEY
TEST RESULTS

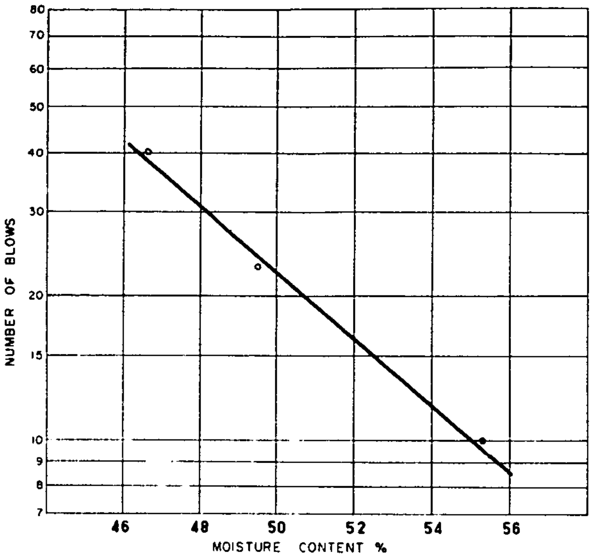
PARTICLE SIZE ANALYSIS

DISTRIBUTION CHART

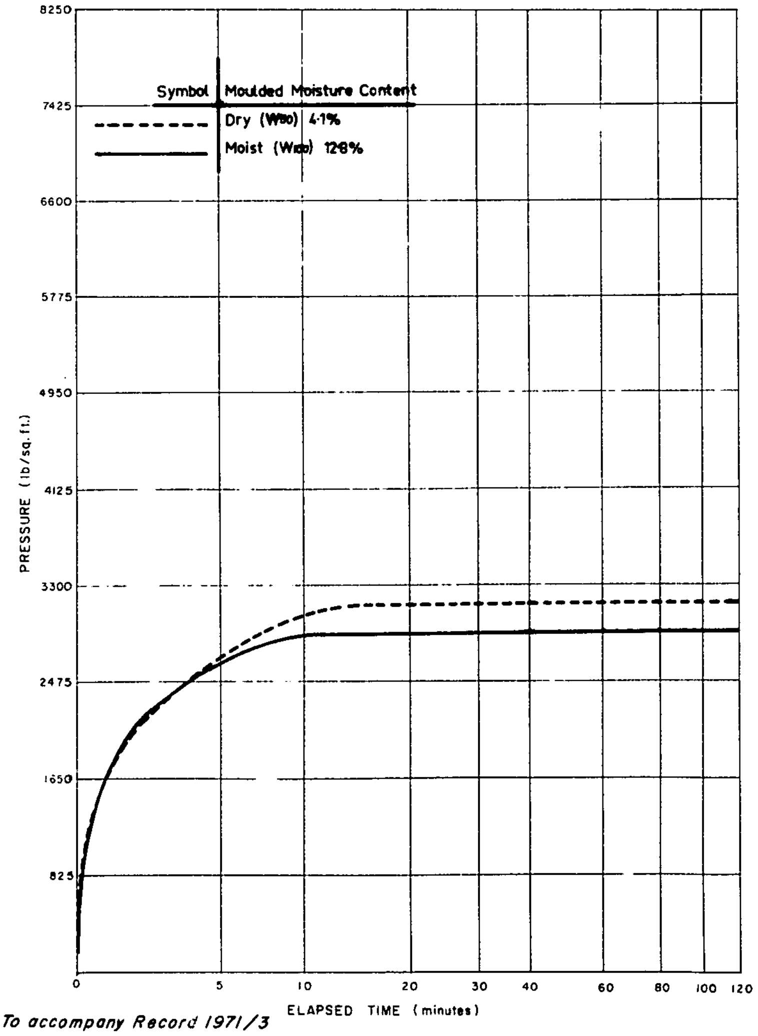


ATTERBERG LIMIT

FLOW CHART



POTENTIAL VOLUME CHANGE



SAMPLE No. 4 C(i)

SOIL TYPE 4

SUMMARY

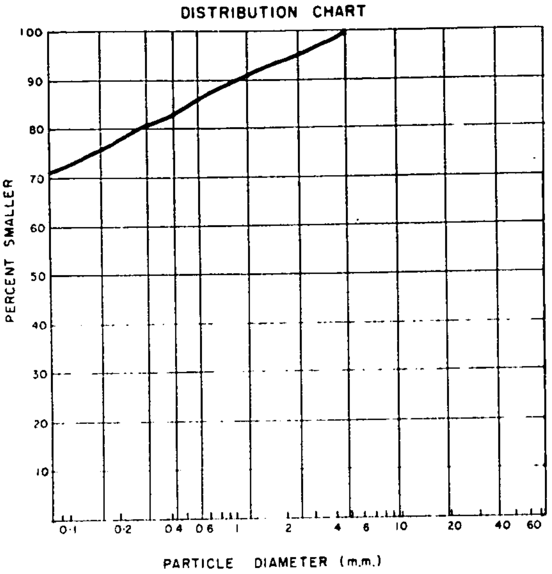
Lower liquid limit	49
Lower plastic limit	19
Plasticity index	30
Linear shrinkage	15
Percent gravel	2
Percent sand	22
Percent silt and clay	76
Swell index (lb/sq. ft.)	3000
PVC rating	3·8
PVC category	Marginal

WATSON SOIL SURVEY

TEST RESULTS

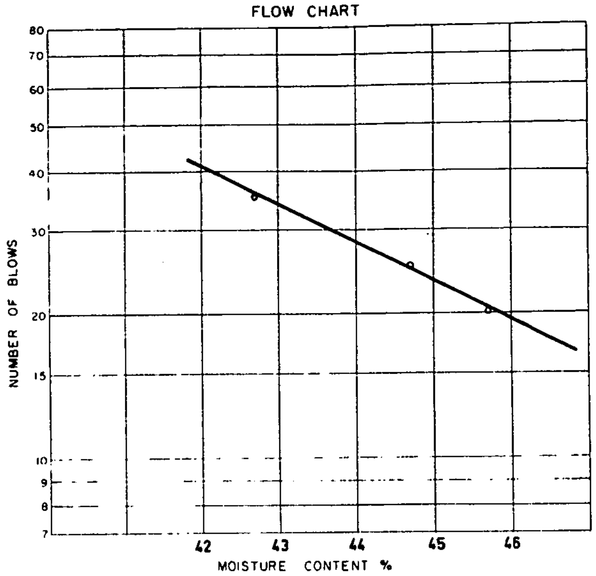
PARTICLE SIZE ANALYSIS

DISTRIBUTION CHART

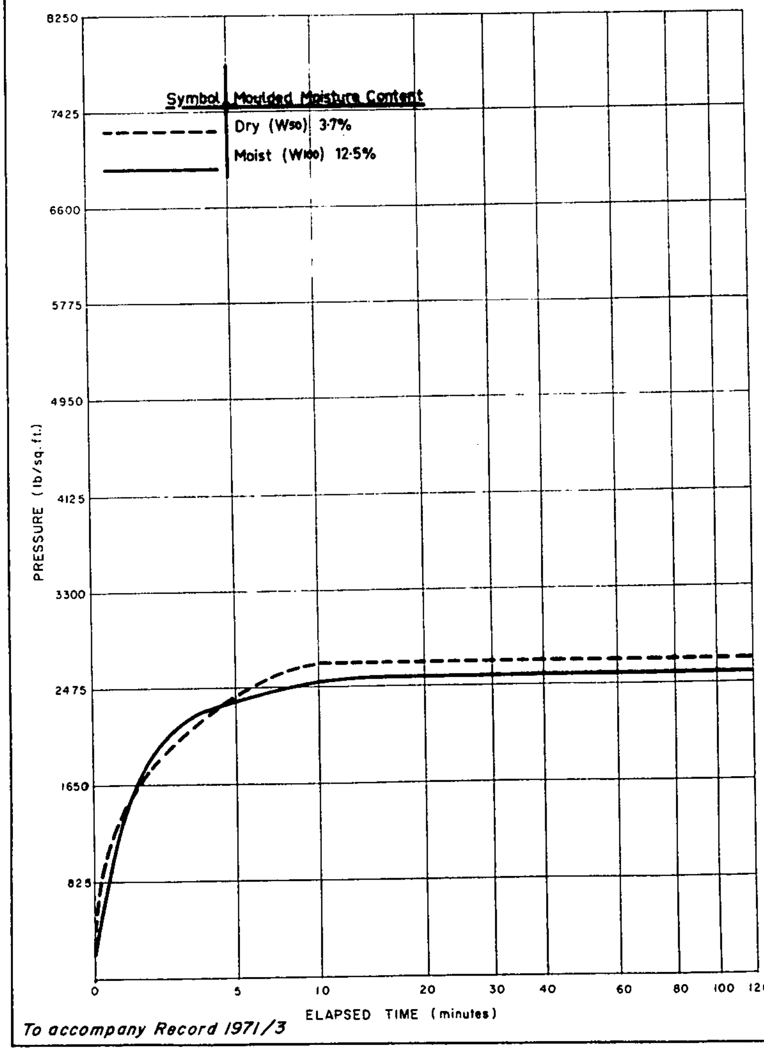


ATTERBERG LIMIT

FLOW CHART



POTENTIAL VOLUME CHANGE



SAMPLE No. 4C(ii)

SOIL TYPE 4

SUMMARY

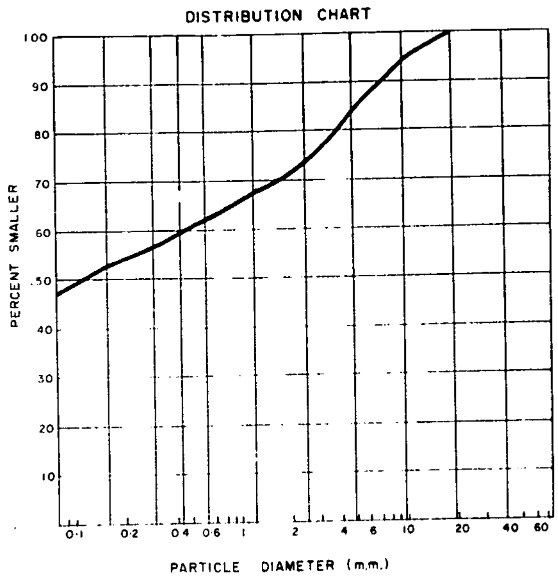
Lower liquid limit	45
Lower plastic limit	17
Plasticity index	28
Linear shrinkage	13
Percent gravel	5
Percent sand	24
Percent silt and clay	71
Swell index (lb/sq.ft.)	2600
PVC rating	3·2
PVC category	Marginal

To accompany Record 1971/3

WATSON SOIL SURVEY

TEST RESULTS

PARTICLE SIZE ANALYSIS



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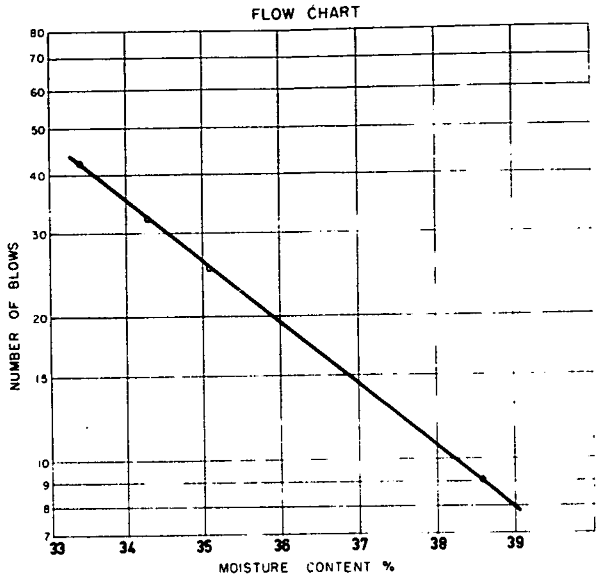
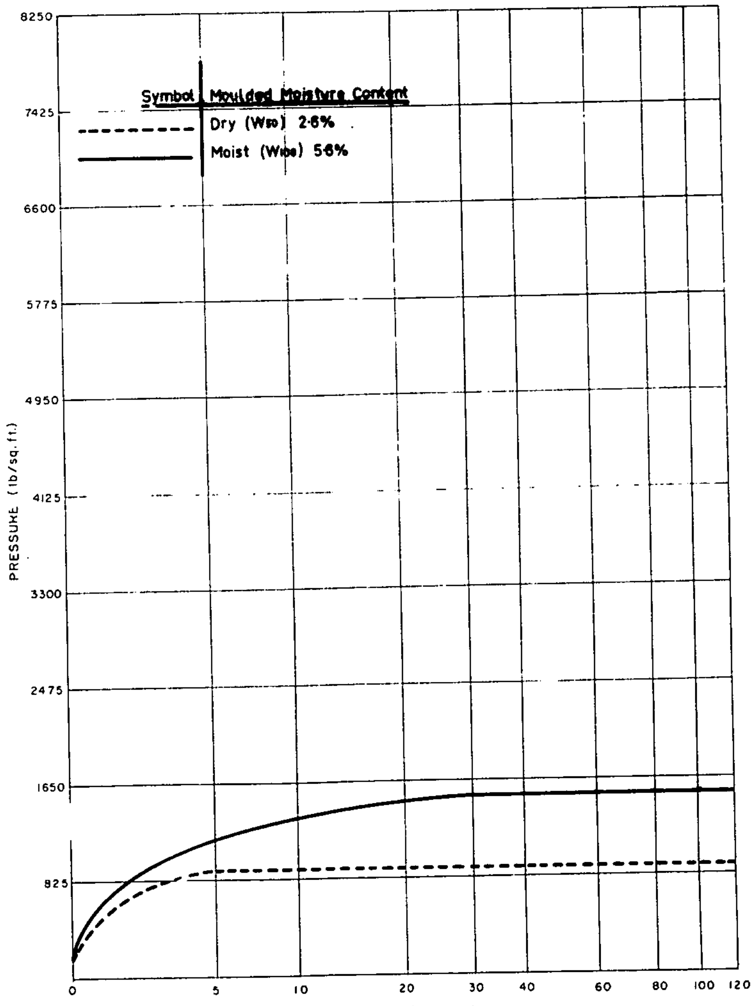


POTENTIAL VOLUME CHANGE



SAMPLE No. 5B

SOIL TYPE 5

SUMMARY

Lower liquid limit	35
Lower plastic limit	17
Plasticity index	18
Linear shrinkage	9
Percent gravel	27
Percent sand	26
Percent silt and clay	47
Swell index (lb/sq.ft.)	1250
PVC rating	1·4
PVC category	Non Critical

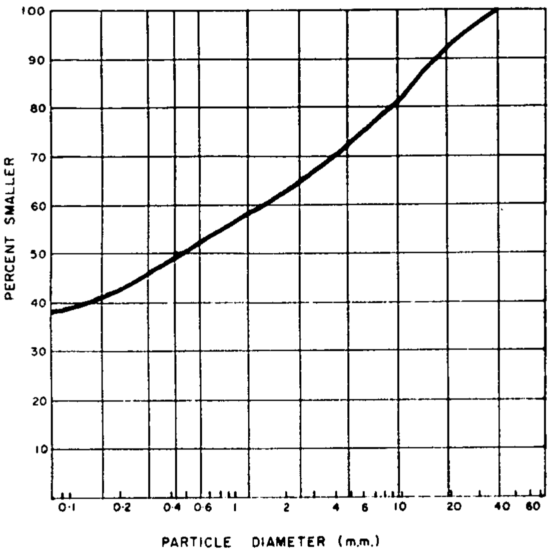
To accompany Record 1971/3

WATSON SOIL SURVEY

TEST RESULTS

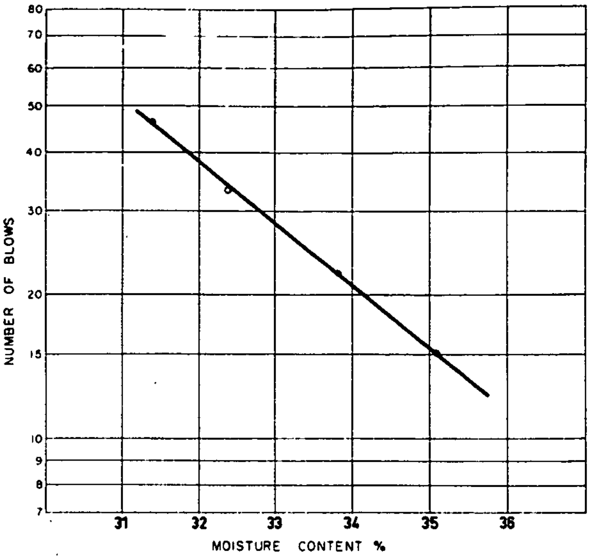
PARTICLE SIZE ANALYSIS

DISTRIBUTION CHART

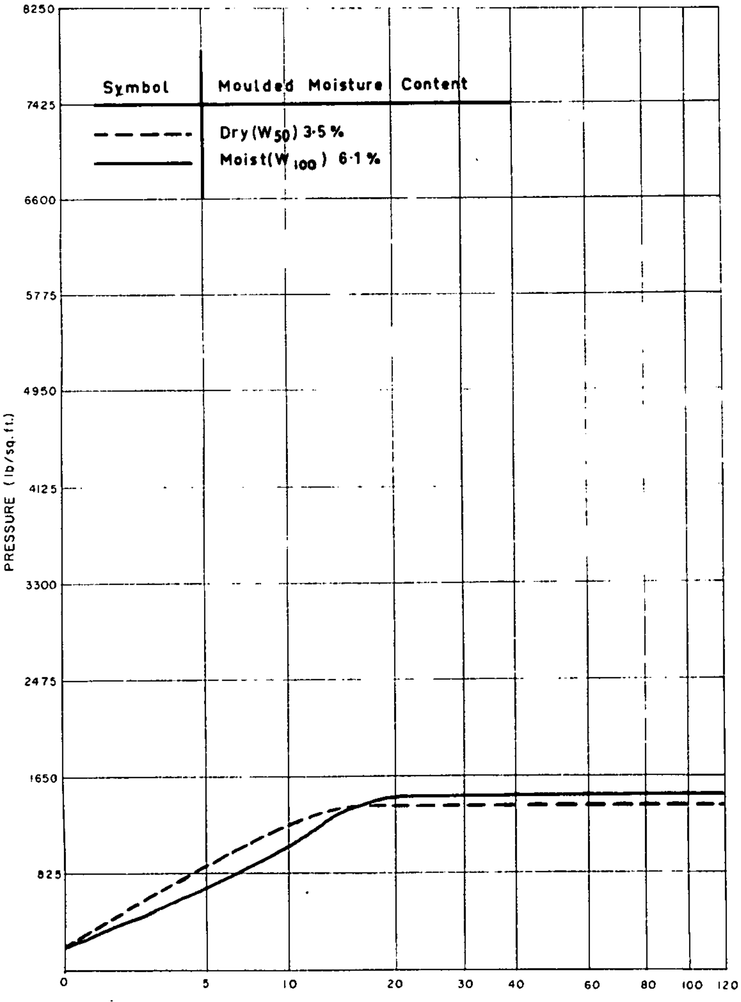


ATTERBERG LIMIT

FLOW CHART



POTENTIAL VOLUME CHANGE



SAMPLE No. 5C

SOIL TYPE 5

SUMMARY

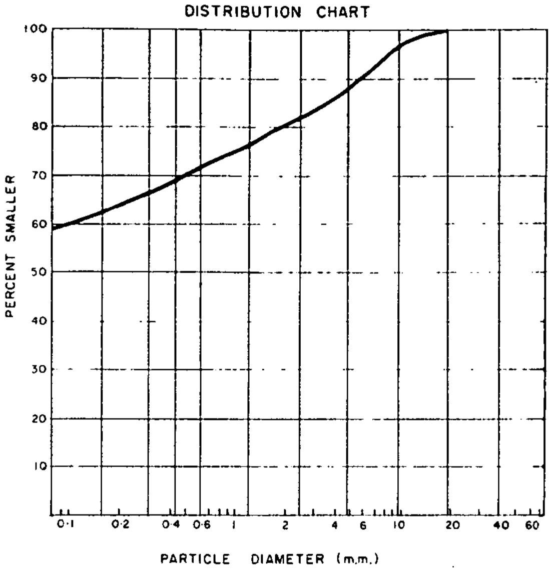
Lower liquid limit	33
Lower plastic limit	16
Plasticity index	17
Linear shrinkage	9
Percent gravel	36
Percent sand	26
Percent silt and clay	38
Swell index (lb/sq.ft.)	1450
PVC rating	1·7
PVC category	Non Critical

To accompany Record 1971/3

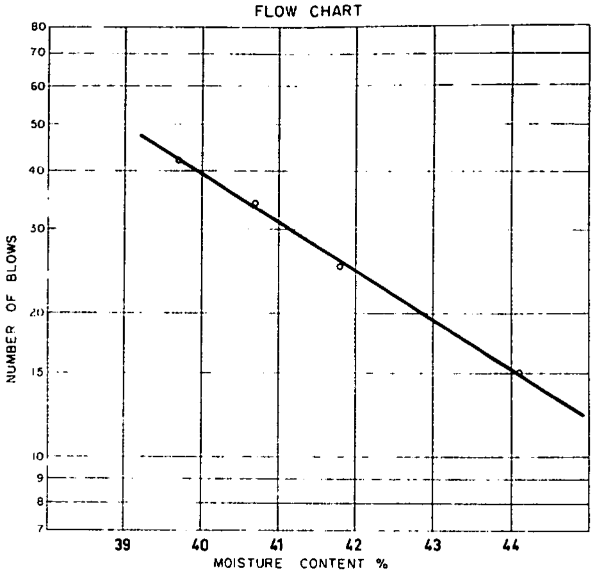
WATSON SOIL SURVEY

TEST RESULTS

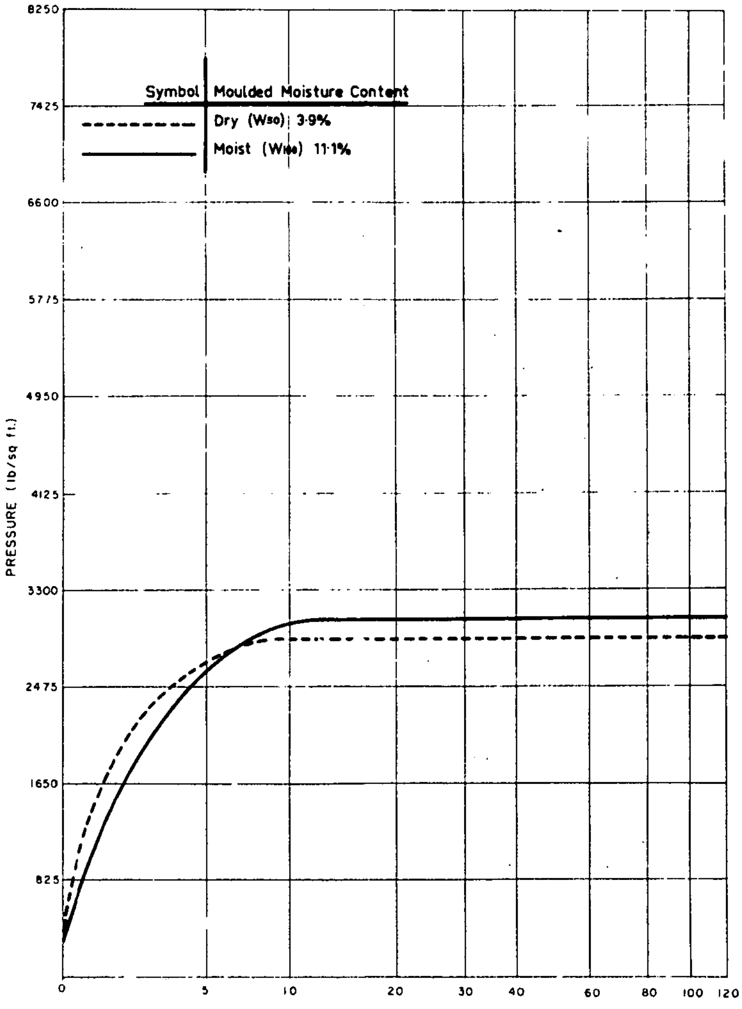
PARTICLE SIZE ANALYSIS



ATTERBERG LIMIT



POTENTIAL VOLUME CHANGE



SAMPLE No. 6B(i)

SOIL TYPE 6

SUMMARY

Lower liquid limit	42
Lower plastic limit	19
Plasticity index	23
Linear shrinkage	11
Percent gravel	18
Percent sand	23
Percent silt and clay	59
Swell index (lb/sq.ft.)	2950
PVC rating	3·7
PVC category	Marginal

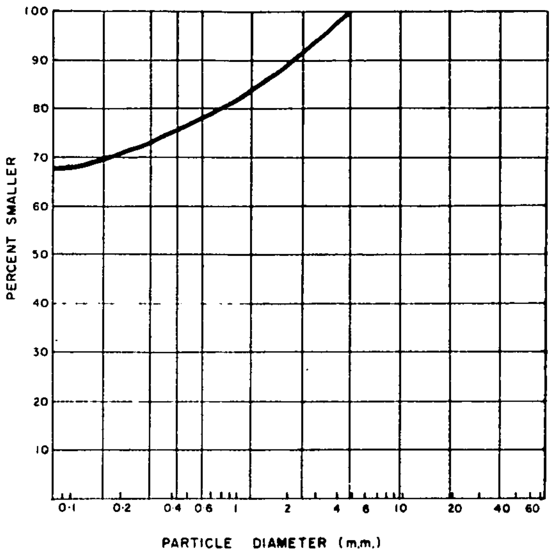
To accompany Record 1971/3

WATSON SOIL SURVEY

TEST RESULTS

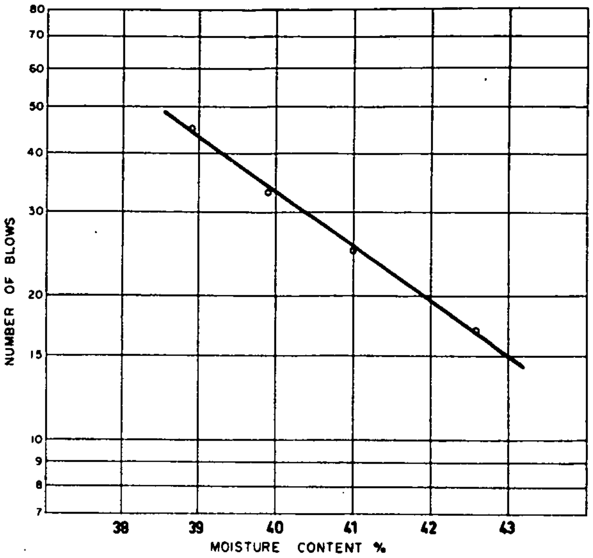
PARTICLE SIZE ANALYSIS

DISTRIBUTION CHART

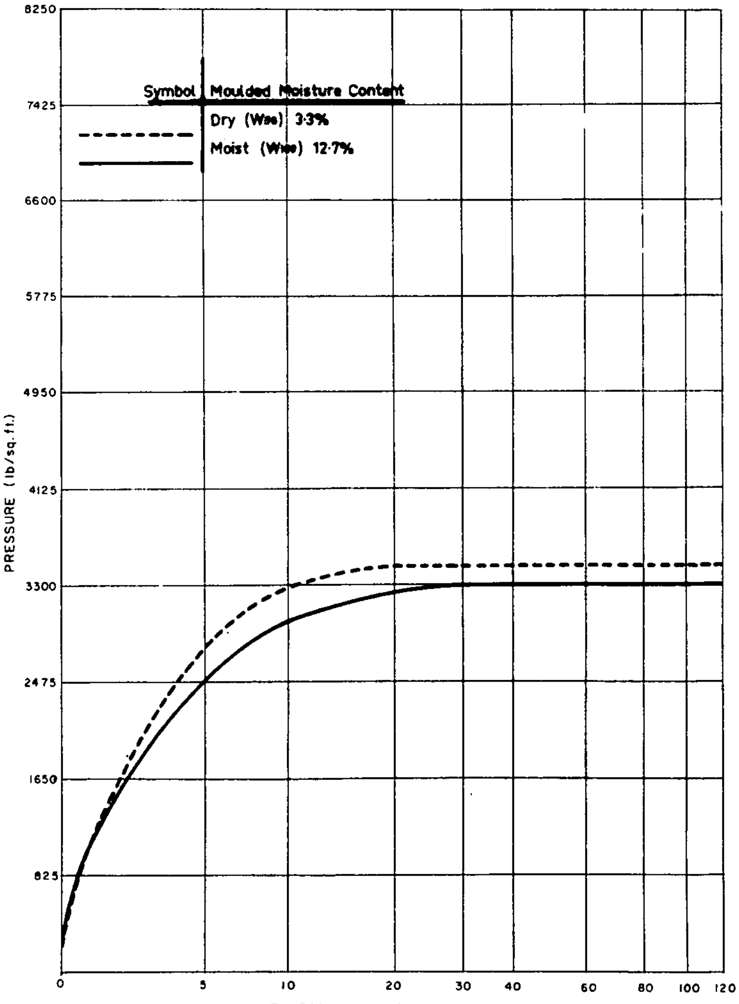


ATTERBERG LIMIT

FLOW CHART



POTENTIAL VOLUME CHANGE



SAMPLE No. 6B(ii)

SOIL TYPE 6

SUMMARY

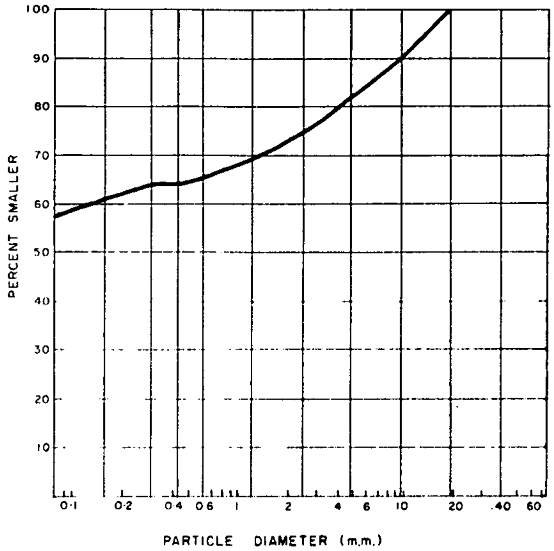
Lower liquid limit	41
Lower plastic limit	16
Plasticity index	25
Linear shrinkage	11
Percent gravel	8
Percent sand	24
Percent silt and clay	68
Swell index (lb/sq.ft.)	3400
PVC rating	4·3
PVC category	Critical

WATSON SOIL SURVEY

TEST RESULTS

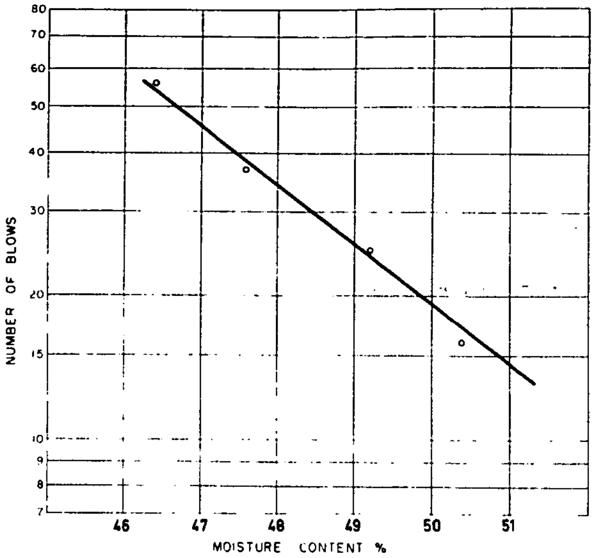
PARTICLE SIZE ANALYSIS

DISTRIBUTION CHART

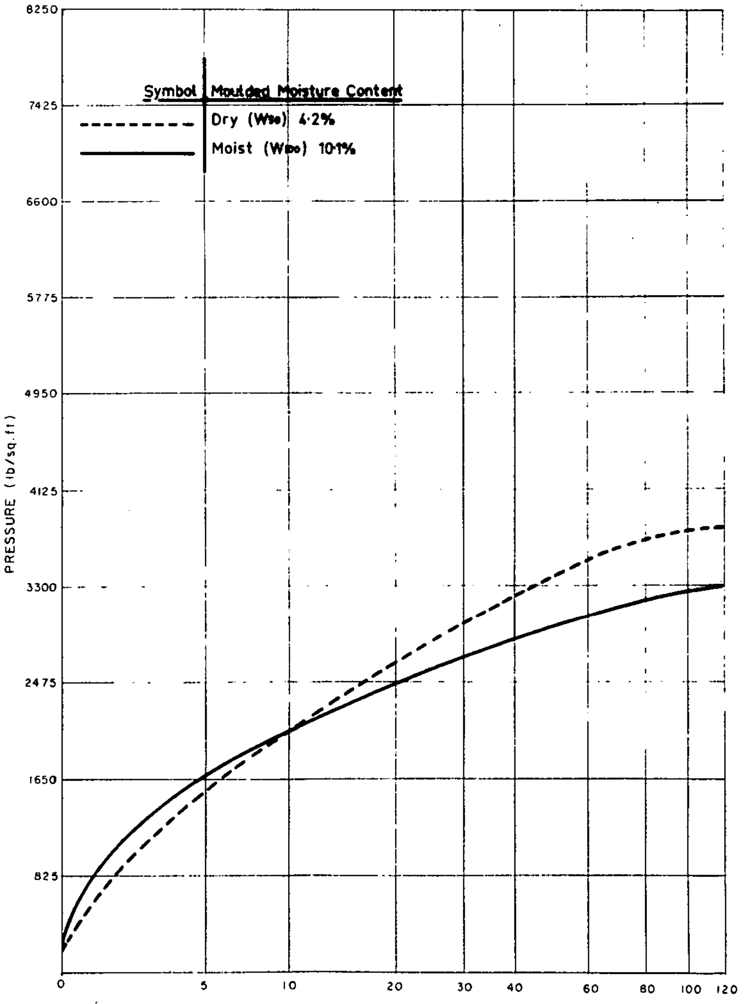


ATTERBERG LIMIT

FLOW CHART



POTENTIAL VOLUME CHANGE



SAMPLE No. 6C

SOIL TYPE 6

SUMMARY

Lower liquid limit	49
Lower plastic limit	22
Plasticity index	27
Linear shrinkage	13
Percent gravel	25
Percent sand	18
Percent silt and clay	57
Swell index (lb/sq. ft.)	3550
PVC rating	4·5
PVC category	Critical

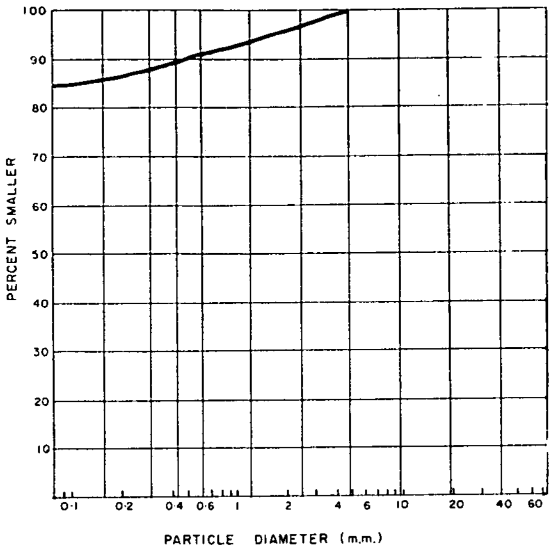
To accompany Record 1971/3

WATSON SOIL SURVEY

TEST RESULTS

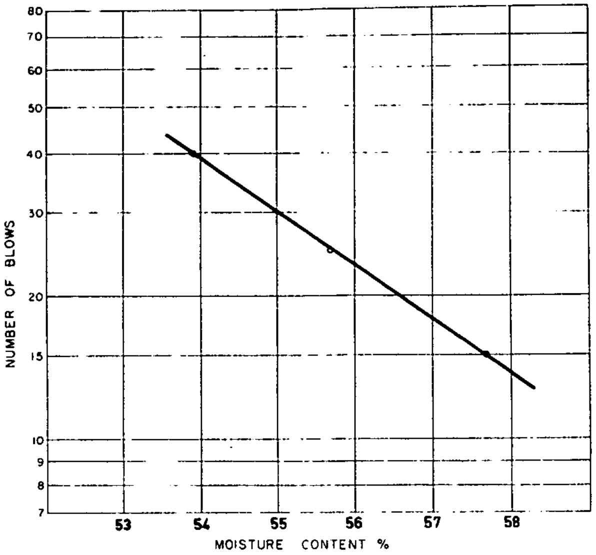
PARTICLE SIZE ANALYSIS

DISTRIBUTION CHART

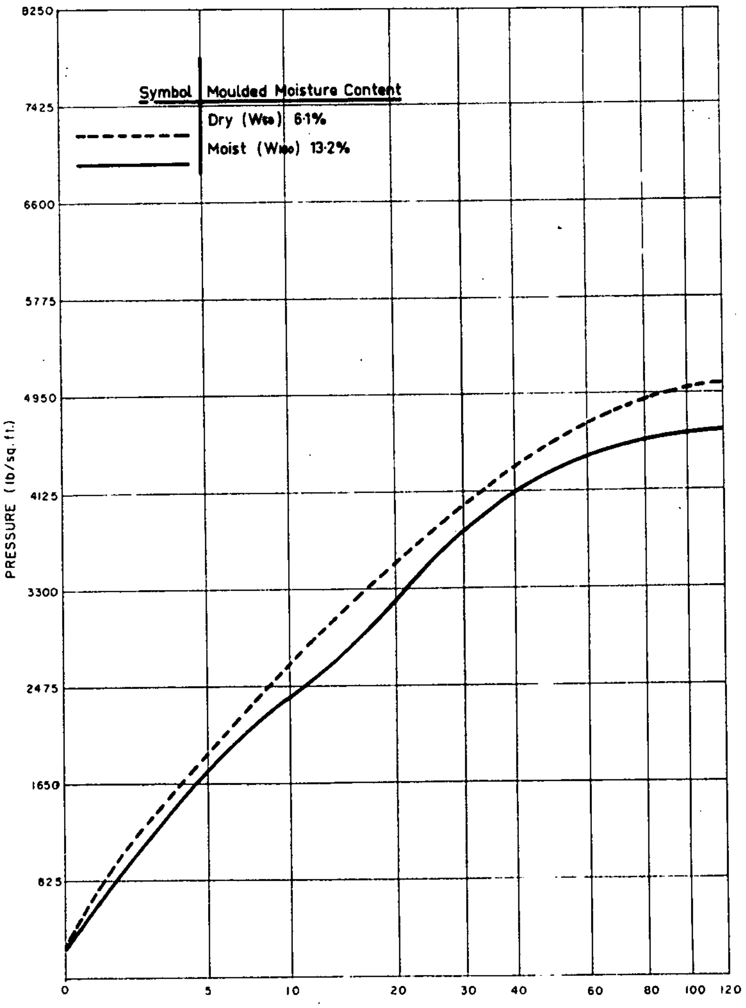


ATTERBERG LIMIT

FLOW CHART



POTENTIAL VOLUME CHANGE



SAMPLE No. 6D(i)

SOIL TYPE 6

SUMMARY

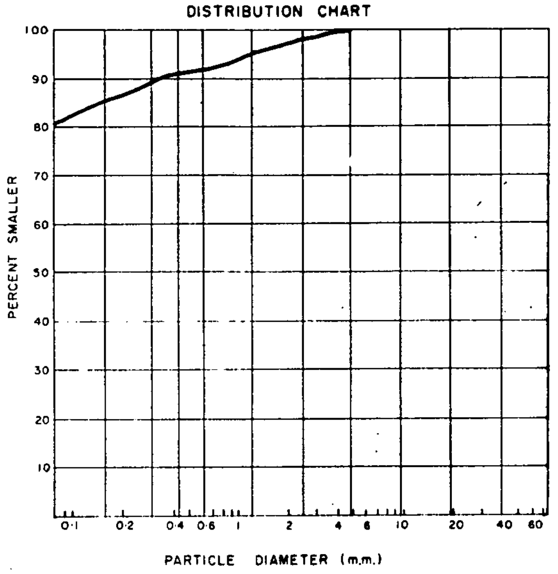
Lower liquid limit	56
Lower plastic limit	19
Plasticity index	37
Linear shrinkage	16
Percent gravel	3
Percent sand	12
Percent silt and clay	85
Swell index (lb/sq.ft.)	4800
PVC rating	6·1
PVC category	Very Critical

To accompany Record 1971/3

WATSON SOIL SURVEY

TEST RESULTS

PARTICLE SIZE ANALYSIS



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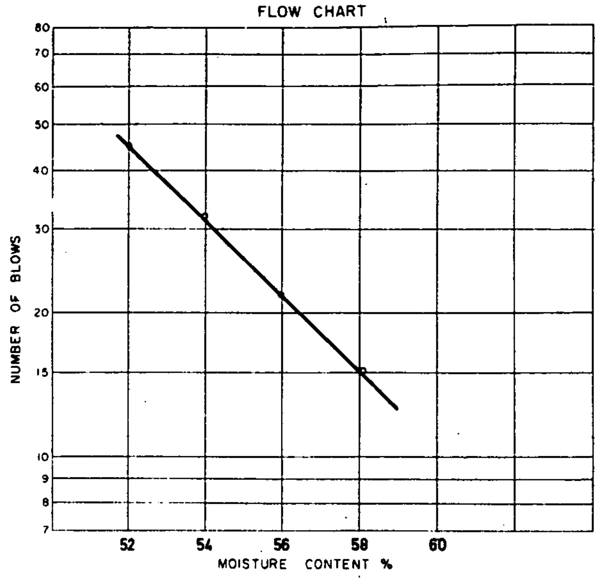
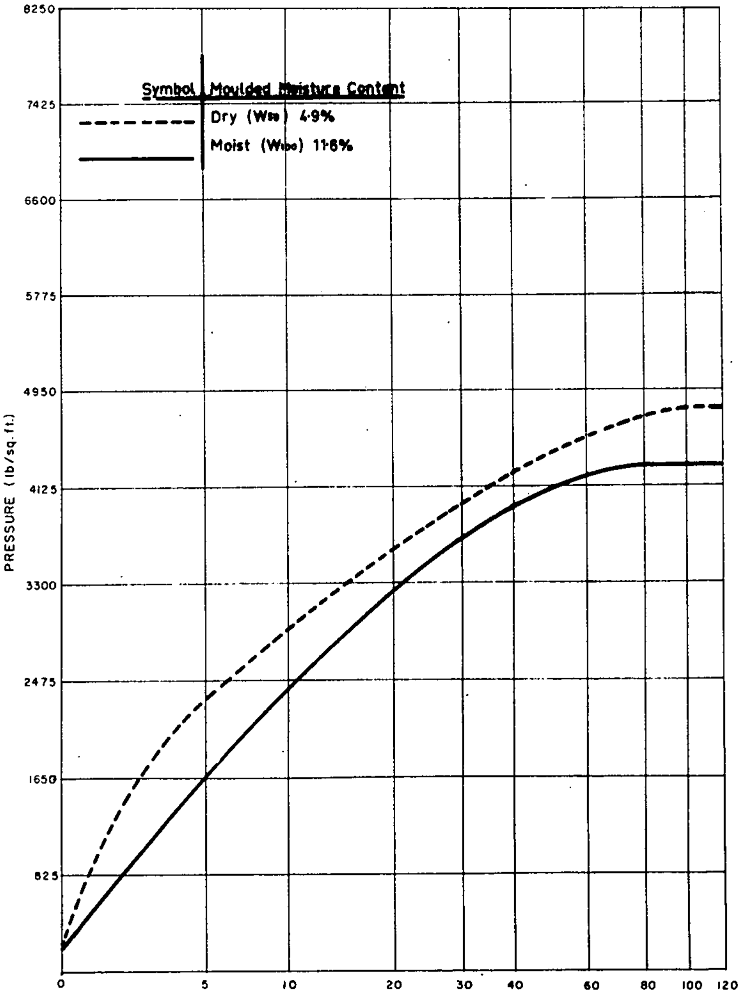


POTENTIAL VOLUME CHANGE



SAMPLE No. 6D(ii)

SOIL TYPE 6

SUMMARY

Lower liquid limit	55
Lower plastic limit	19
Plasticity index	36
Linear shrinkage	15
Percent gravel	2
Percent sand	17
Percent silt and clay	81
Swell index (lb/sq.ft.)	4500
PVC rating	5·7
PVC category	Critical

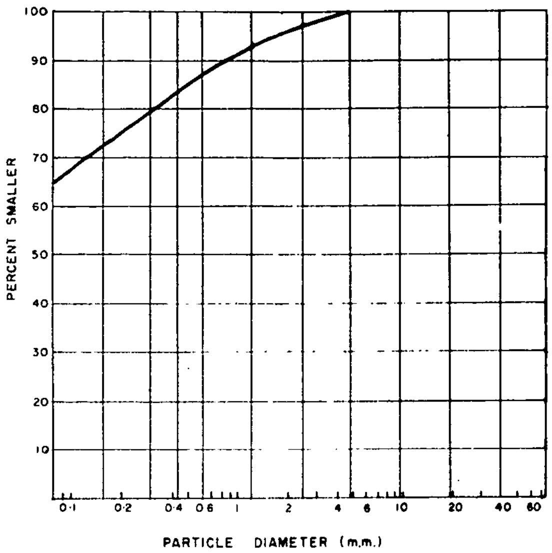
To accompany Record 1971/3

WATSON SOIL SURVEY

TEST RESULTS

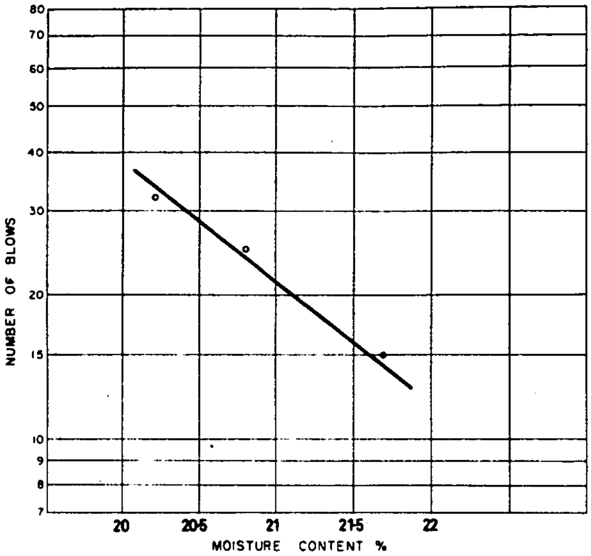
PARTICLE SIZE ANALYSIS

DISTRIBUTION CHART

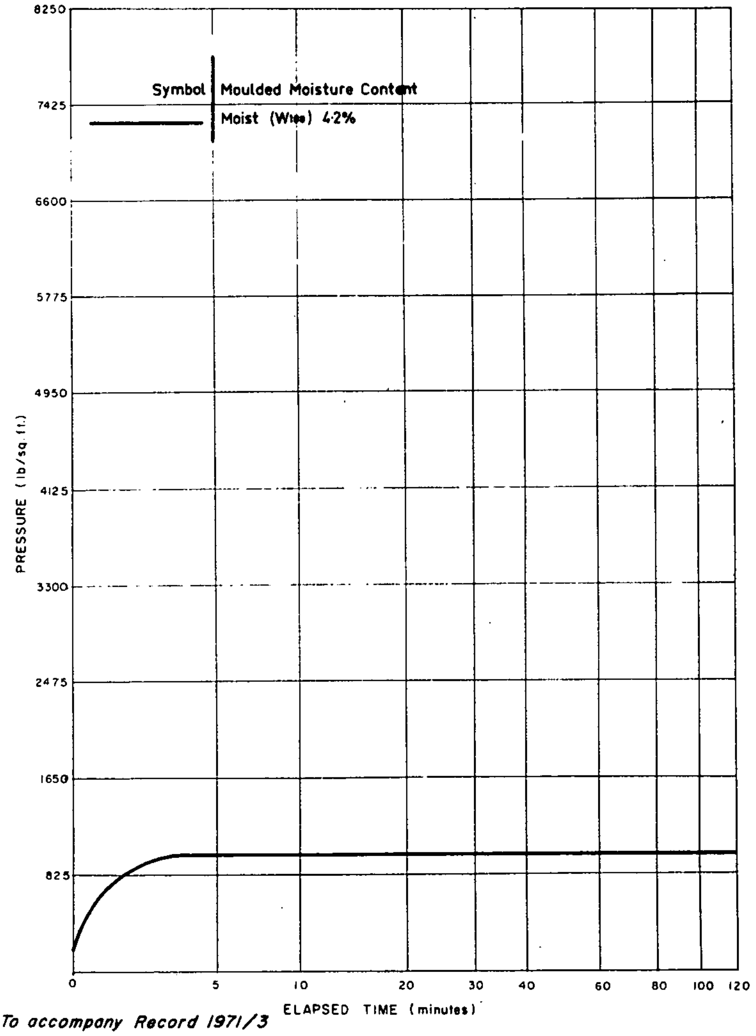


ATTERBERG LIMIT

FLOW CHART



POTENTIAL VOLUME CHANGE



SAMPLE No. 7A

SOIL TYPE 7

SUMMARY

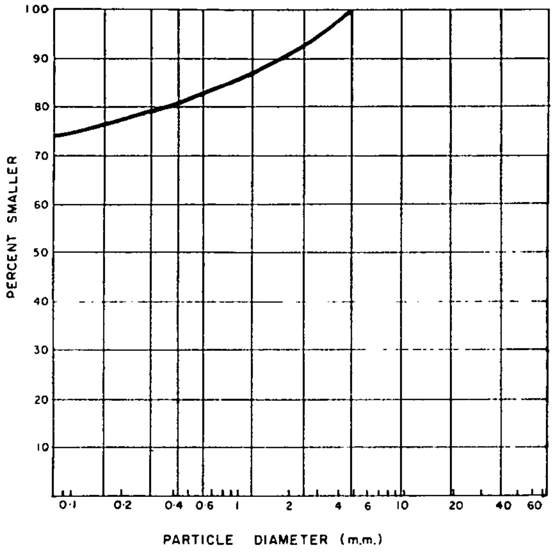
Lower liquid limit	21
Lower plastic limit	16
Plasticity index	5
Linear shrinkage	3
Percent gravel	2
Percent sand	33
Percent silt and clay	65
Swell index (lb/sq. ft.)	1000
PVC rating	1·0
PVC category	Non Critical

WATSON SOIL SURVEY

TEST RESULTS

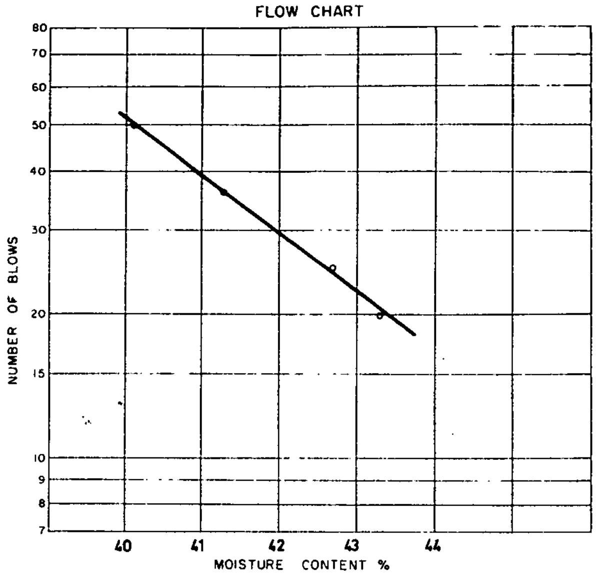
PARTICLE SIZE ANALYSIS

DISTRIBUTION CHART

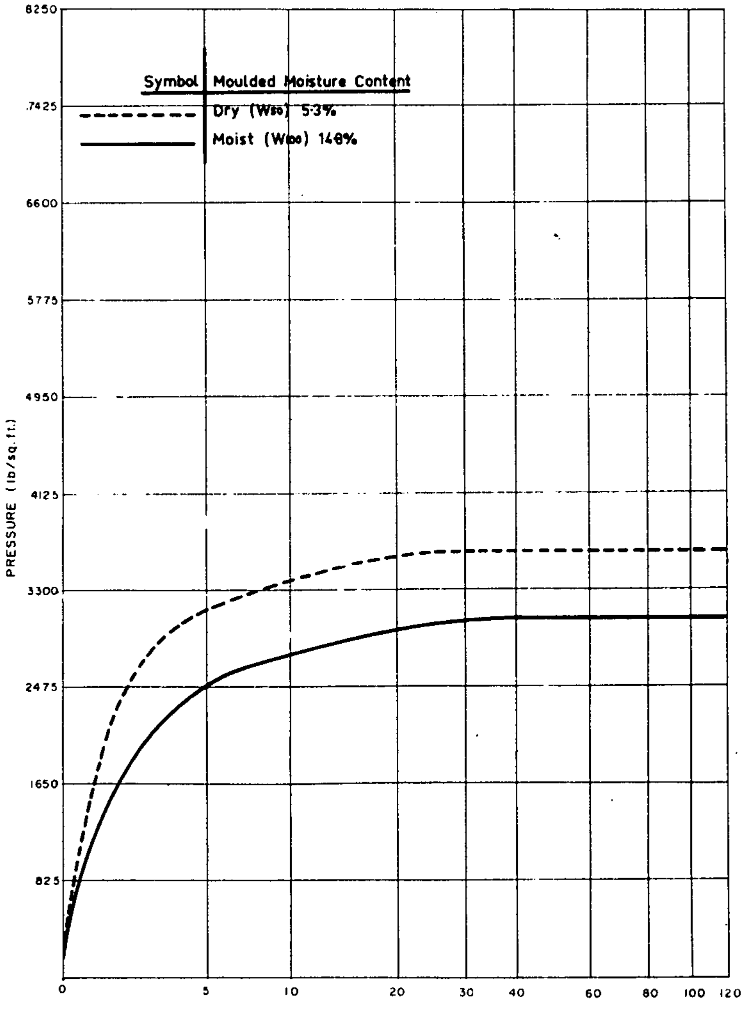


ATTERBERG LIMIT

FLOW CHART



POTENTIAL VOLUME CHANGE



SAMPLE No. 7B

SOIL TYPE 7

SUMMARY

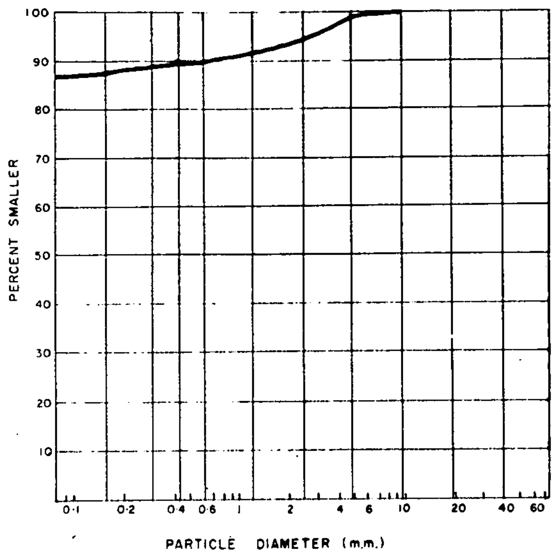
Lower liquid limit	43
Lower plastic limit	18
Plasticity index	25
Linear shrinkage	13
Percent gravel	7
Percent sand	19
Percent silt and clay	74
Swell index (lb/sq. ft.)	3350
PVC rating	4·2
PVC category	Critical

WATSON SOIL SURVEY

TEST RESULTS

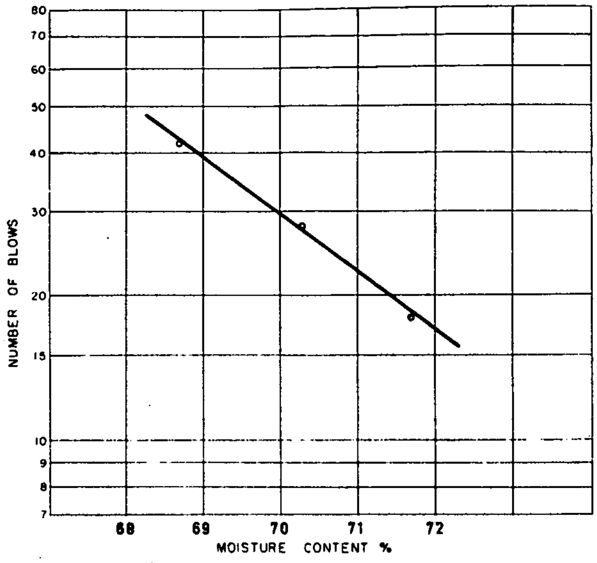
PARTICLE SIZE ANALYSIS

DISTRIBUTION CHART

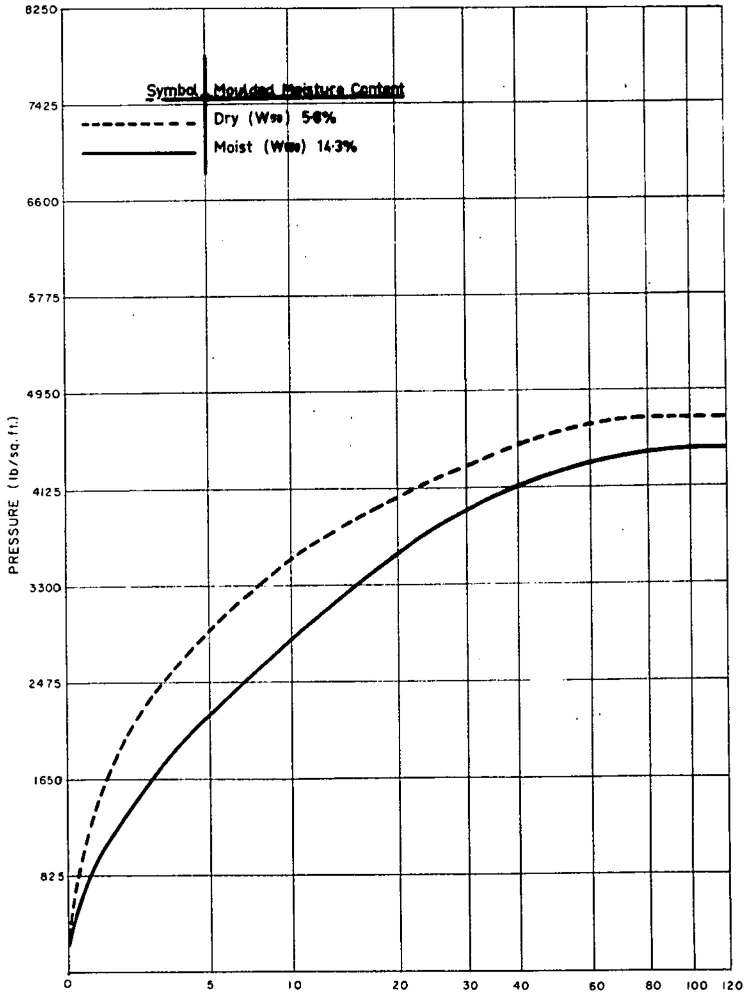


ATTERBERG LIMIT

FLOW CHART



POTENTIAL VOLUME CHANGE



SAMPLE No. 7 C

SOIL TYPE 7

SUMMARY

Lower liquid limit	71
Lower plastic limit	27
Plasticity index	44
Linear shrinkage	18
Percent gravel	6
Percent sand	7
Percent silt and clay	87
Swell index (lb/sq.ft.)	4550
PVC rating	5·8
PVC category	Critical

To accompany Record 1971/3

I55/A16/705

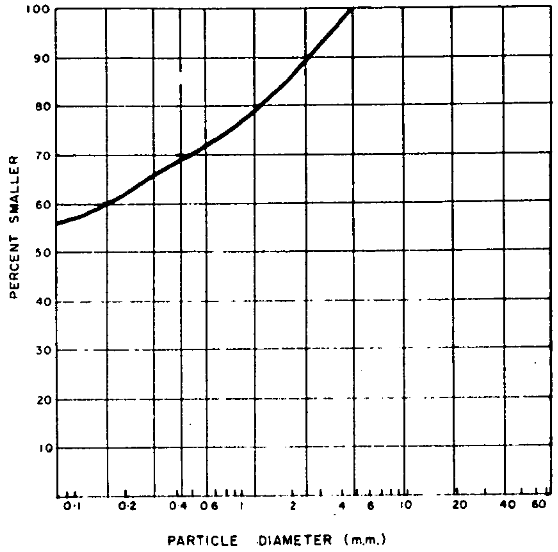
M (Pf) 121

WATSON SOIL SURVEY

TEST RESULTS

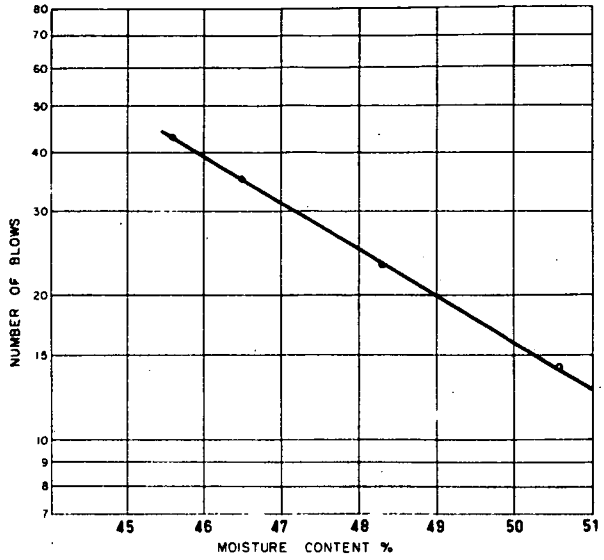
PARTICLE SIZE ANALYSIS

DISTRIBUTION CHART

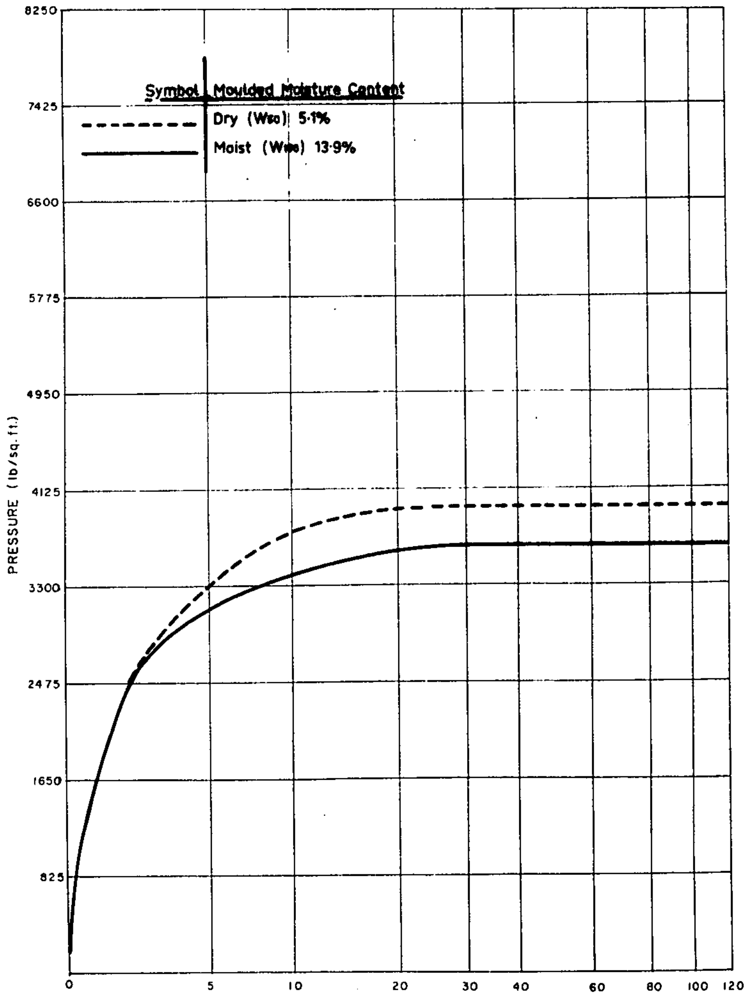


ATTERBERG LIMIT

FLOW CHART



POTENTIAL VOLUME CHANGE



SAMPLE No. 8 B

SOIL TYPE 8

SUMMARY

Lower liquid limit	48
Lower plastic limit	19
Plasticity index	29
Linear shrinkage	13
Percent gravel	10
Percent sand	34
Percent silt and clay	56
Swell index (lb/sq.ft.)	3800
PVC rating	4·8
PVC category	Critical

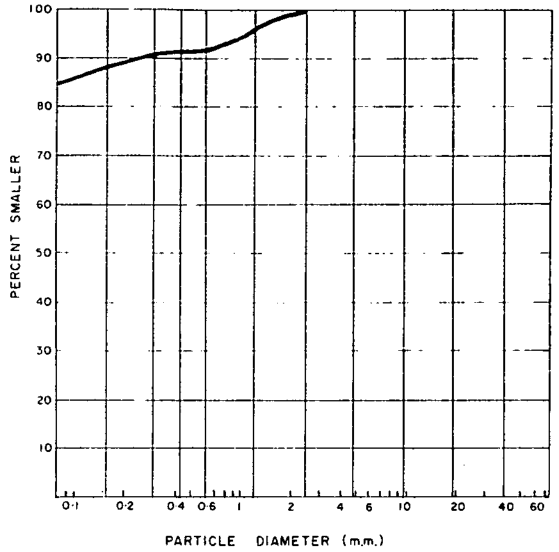
To accompany Record 1971/3

WATSON SOIL SURVEY

TEST RESULTS

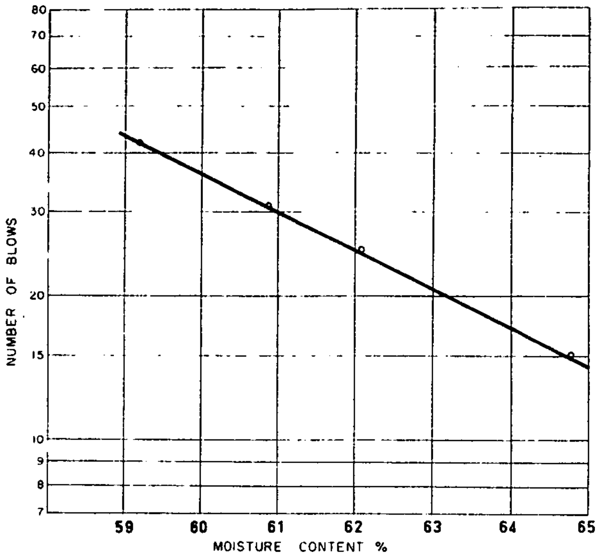
PARTICLE SIZE ANALYSIS

DISTRIBUTION CHART

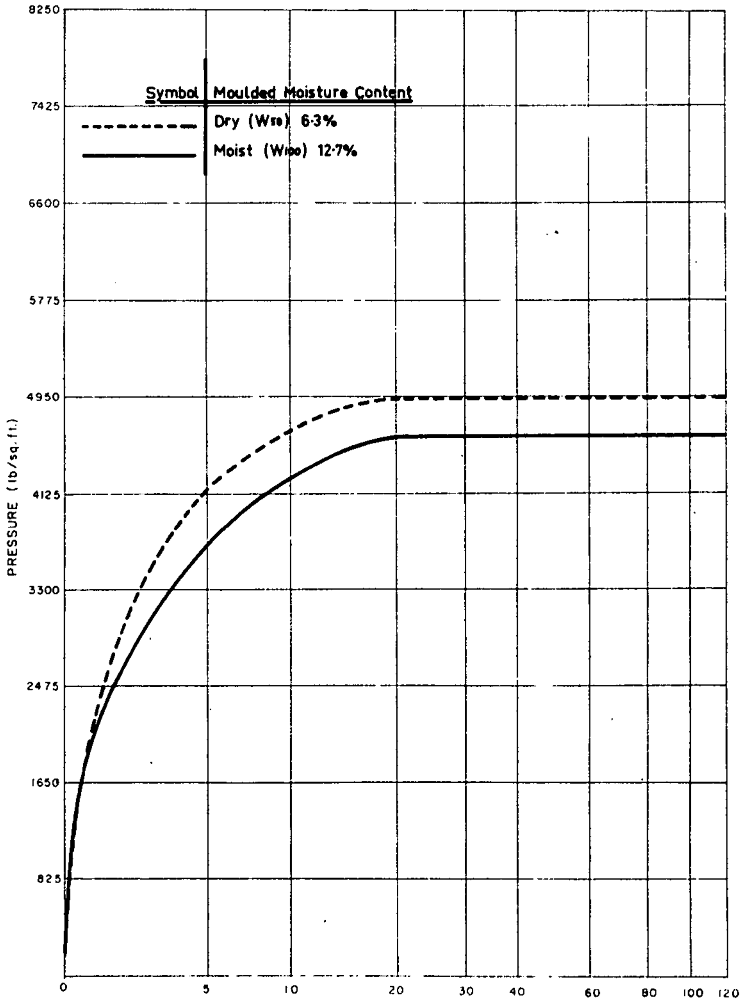


ATTERBERG LIMIT

FLOW CHART



POTENTIAL VOLUME CHANGE



SAMPLE No. 8 C

SOIL TYPE 8

SUMMARY

Lower liquid limit	62
Lower plastic limit	23
Plasticity index	39
Linear shrinkage	15
Percent gravel	NIL
Percent sand	15
Percent silt and clay	85
Swell index (lb/sq.ft.)	4800
PVC rating	6·1
PVC category	Very Critical

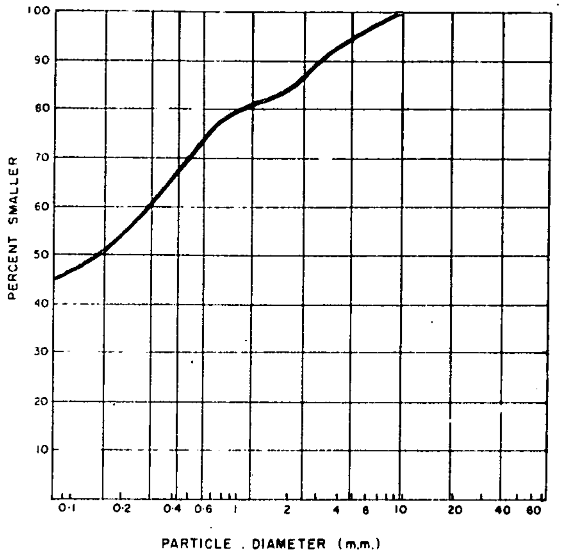
To accompany Record 1971/3

WATSON SOIL SURVEY

TEST RESULTS

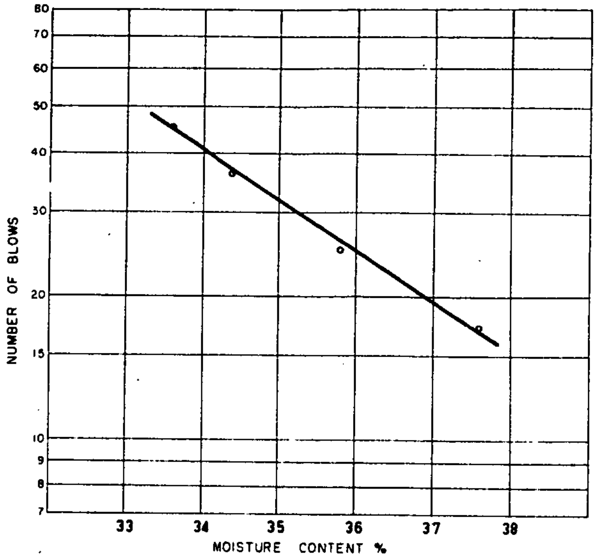
PARTICLE SIZE ANALYSIS

DISTRIBUTION CHART

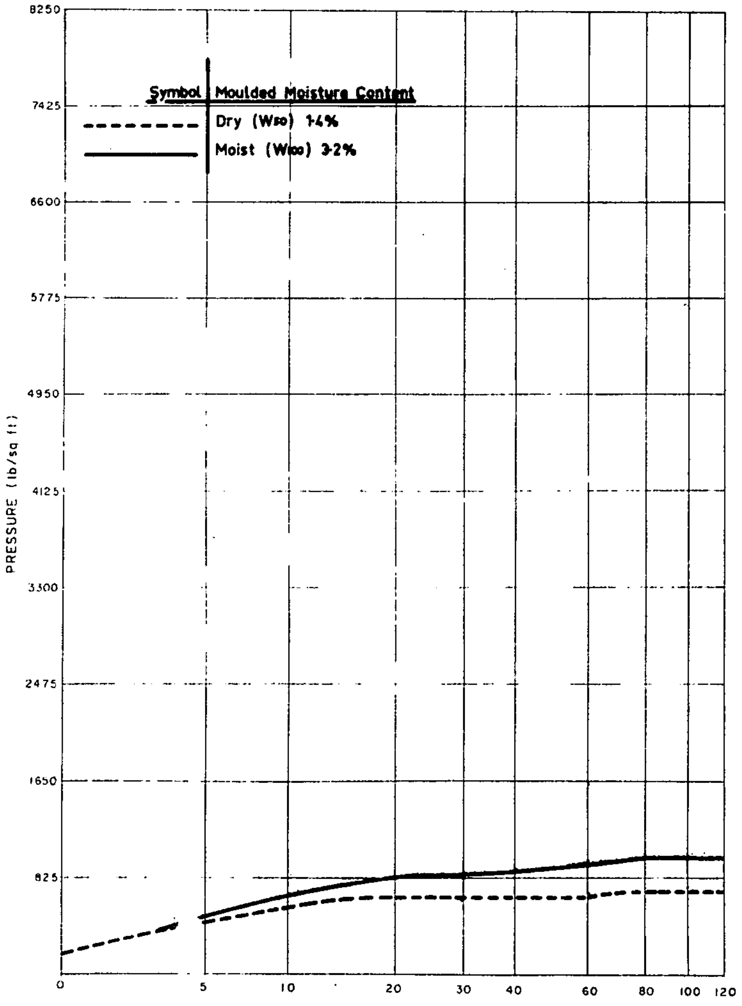


ATTERBERG LIMIT

FLOW CHART



POTENTIAL VOLUME CHANGE



SAMPLE No. 8 D

SOIL TYPE 8

SUMMARY

Lower liquid limit	36
Lower plastic limit	18
Plasticity index	18
Linear shrinkage	9
Percent gravel	14
Percent sand	41
Percent silt and clay	45
Swell index (lb/sq.ft.)	800
PVC rating	0·8
PVC category	Non Critical

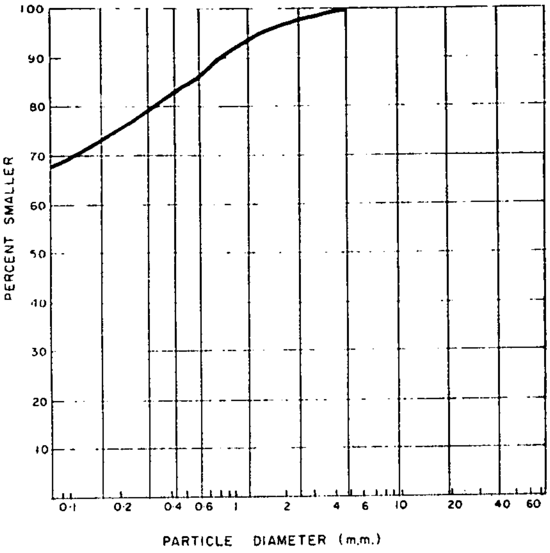
To accompany Record 1971/3

WATSON SOIL SURVEY

TEST RESULTS

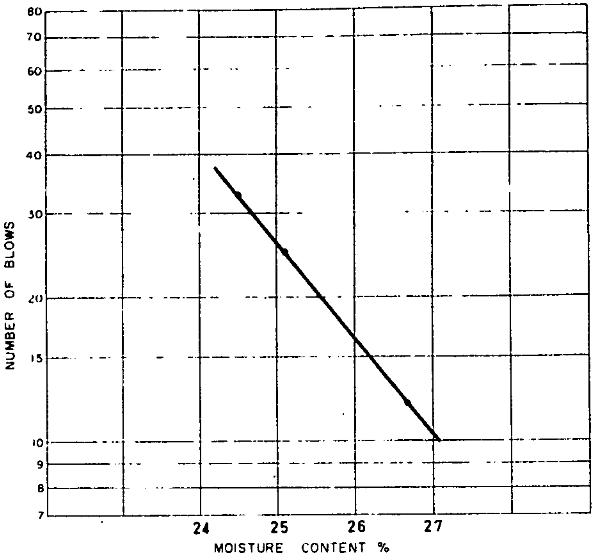
PARTICLE SIZE ANALYSIS

DISTRIBUTION CHART

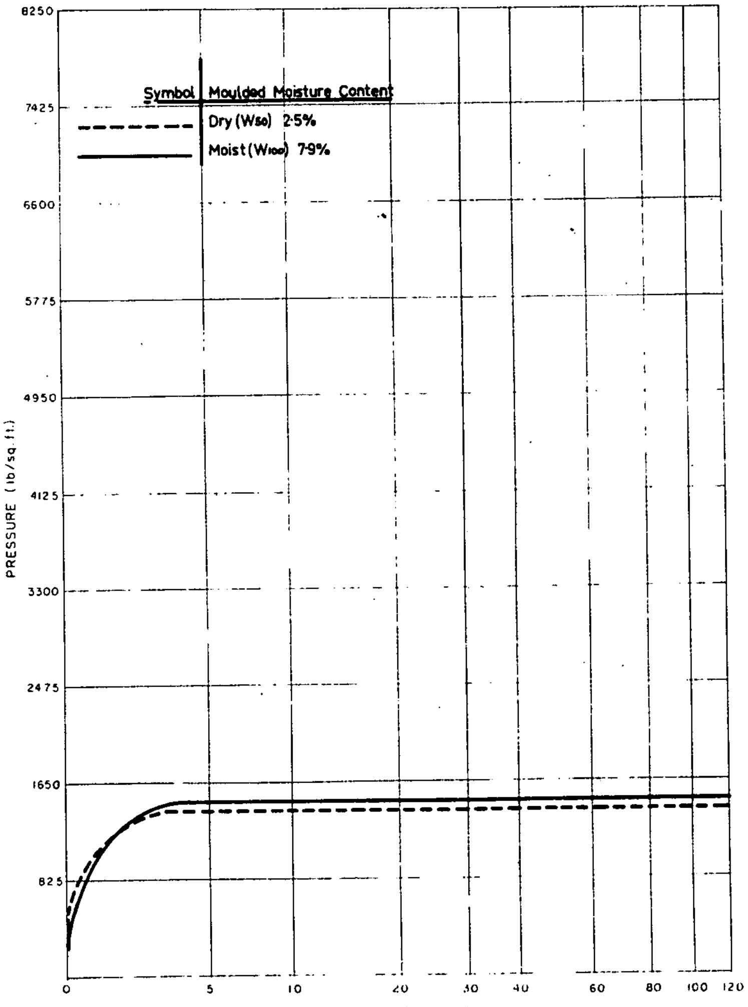


ATTERBERG LIMIT

FLOW CHART



POTENTIAL VOLUME CHANGE



SAMPLE No. 9 A

SOIL TYPE 9

SUMMARY

Lower liquid limit	25
Lower plastic limit	16
Plasticity index	9
Linear shrinkage	4
Percent gravel	2
Percent sand	30
Percent silt and clay	68
Swell index (lb/sq.ft.)	1450
PVC rating	1·7
PVC category	Non Critical

To accompany Record 1971/3

I55/A16/709

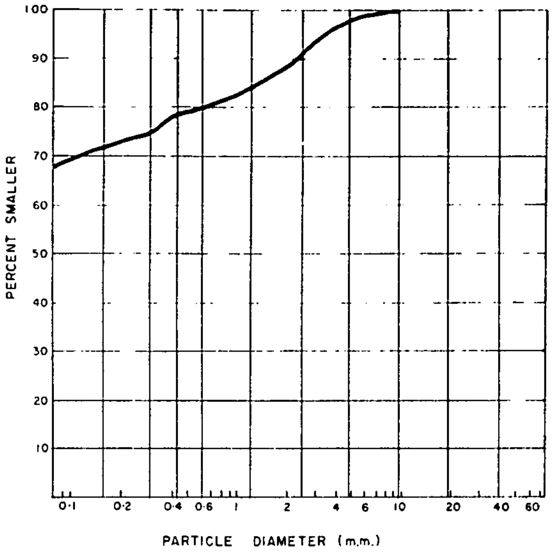
M (Pt) 121

WATSON SOIL SURVEY

TEST RESULTS

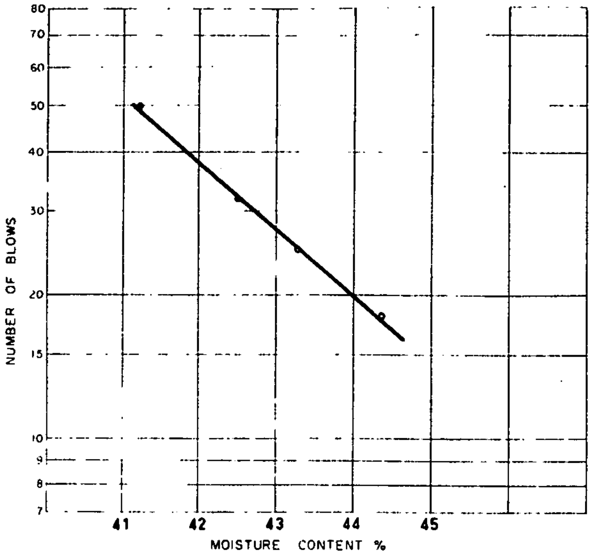
PARTICLE SIZE ANALYSIS

DISTRIBUTION CHART

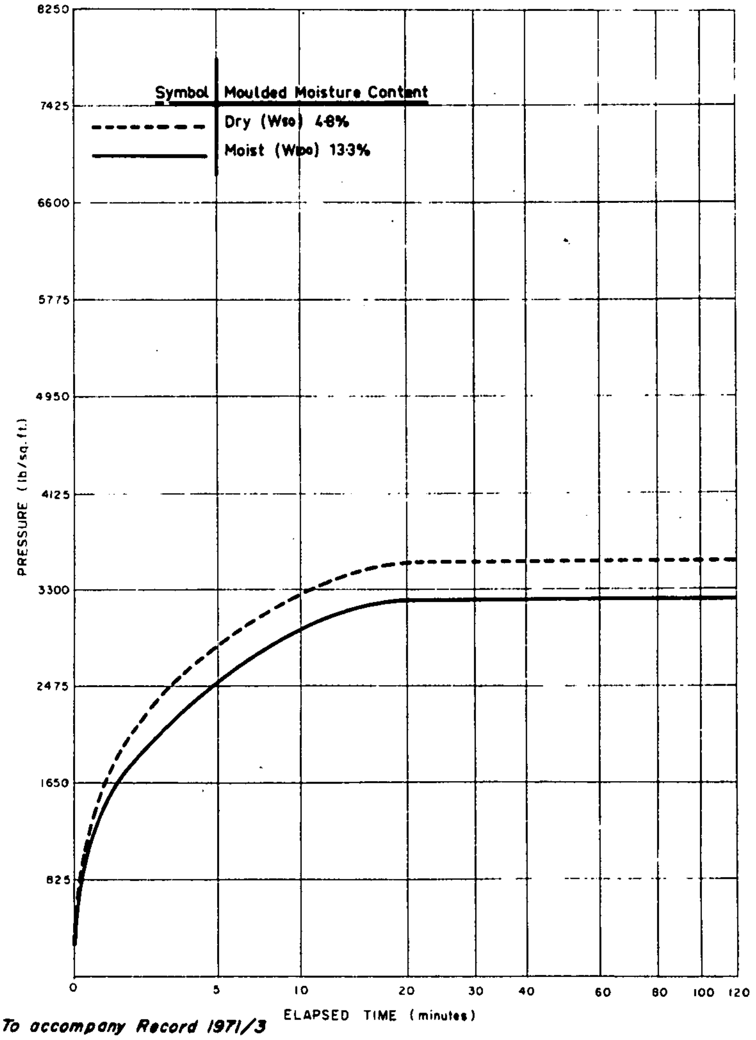


ATTERBERG LIMIT

FLOW CHART



POTENTIAL VOLUME CHANGE



SAMPLE No. 9 B

SOIL TYPE 9

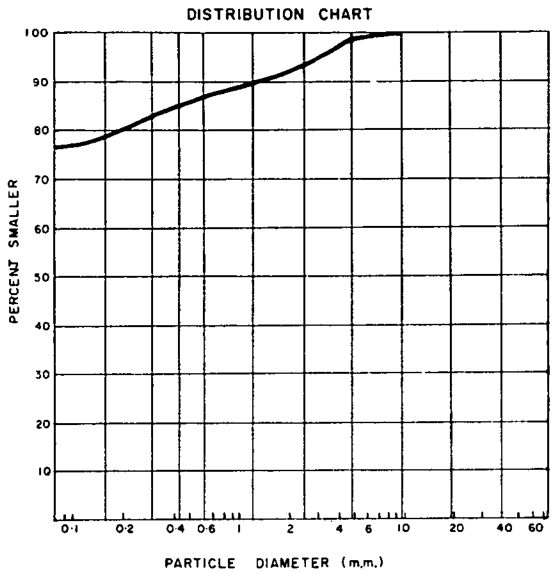
SUMMARY

Lower liquid limit	43
Lower plastic limit	16
Plasticity index	27
Linear shrinkage	12
Percent gravel	9
Percent sand	23
Percent silt and clay	68
Swell index (lb/sq.ft.)	3400
PVC rating	4·3
PVC category	Critical

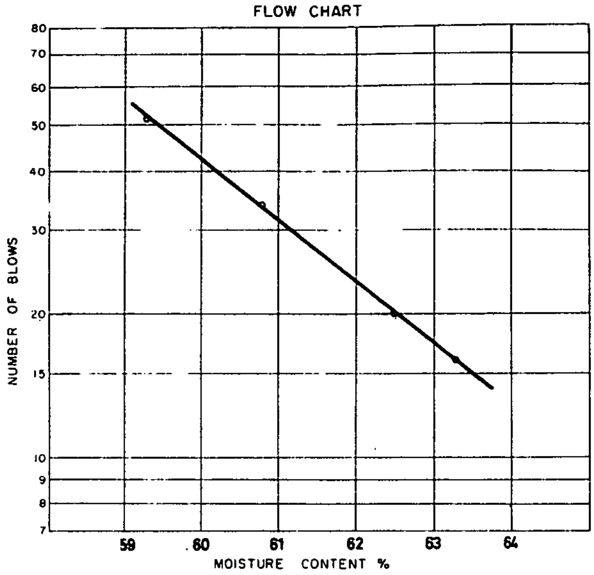
WATSON SOIL SURVEY

TEST RESULTS

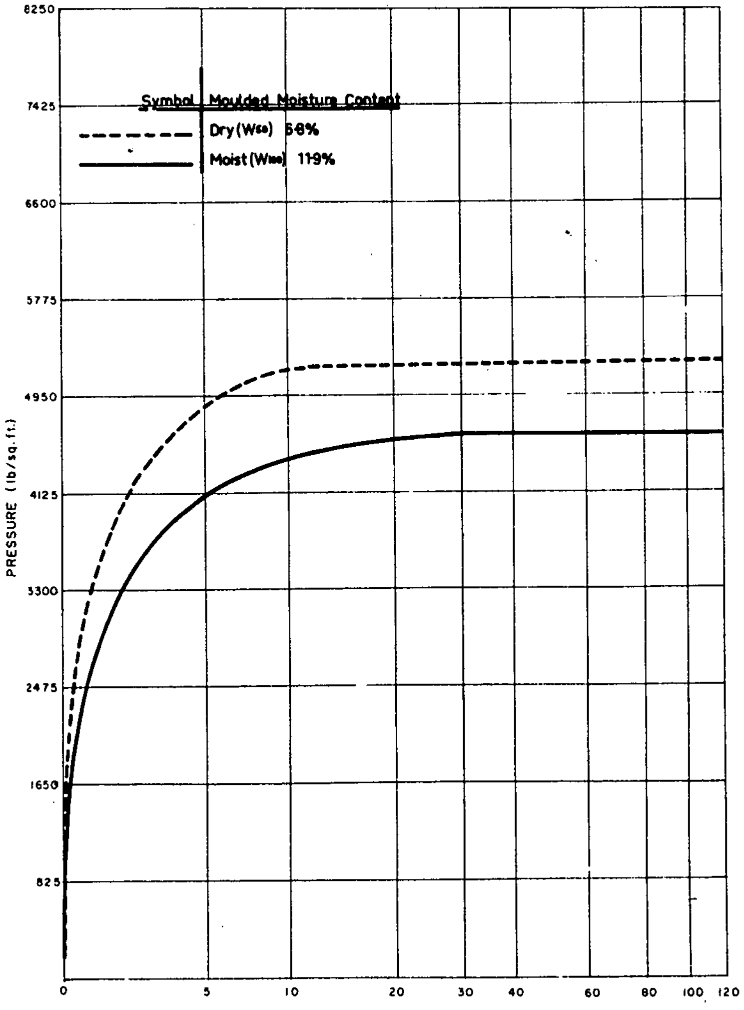
PARTICLE SIZE ANALYSIS


DISTRIBUTION CHART

ATTERBERG LIMIT


FLOW CHART

POTENTIAL VOLUME CHANGE



SAMPLE No. 9C

SOIL TYPE 9

SUMMARY

Lower liquid limit	62
Lower plastic limit	25
Plasticity index	37
Linear shrinkage	16
Percent gravel	7
Percent sand	16
Percent silt and clay	77
Swell index (lb/sq. ft.)	4900
PVC rating	6·2
PVC category	Very Critical

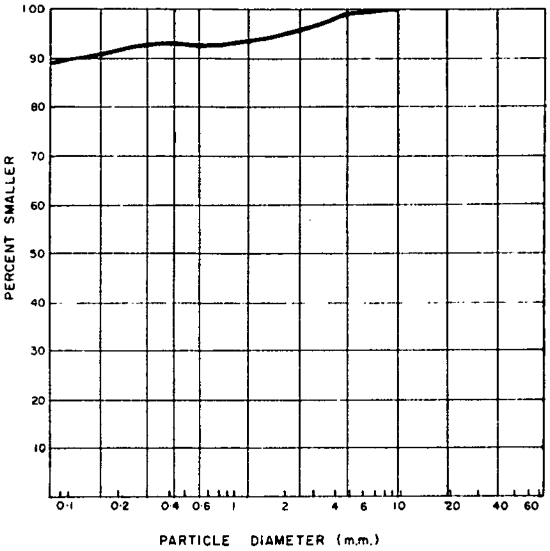
To accompany Record 1971/3

WATSON SOIL SURVEY

TEST RESULTS

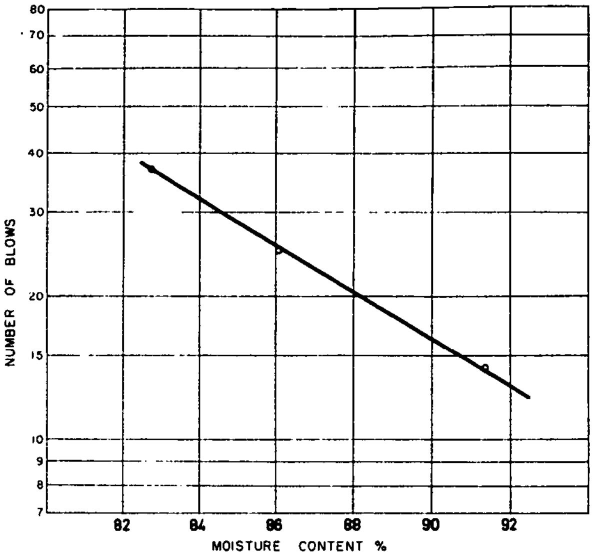
PARTICLE SIZE ANALYSIS

DISTRIBUTION CHART

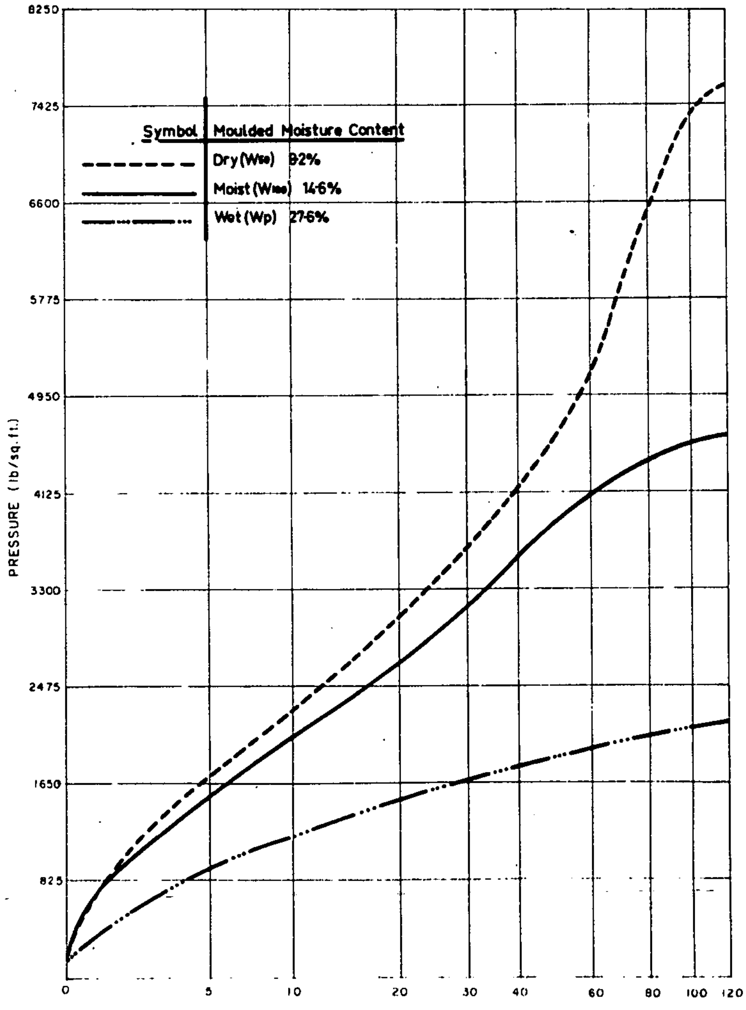


ATTERBERG LIMIT

FLOW CHART



POTENTIAL VOLUME CHANGE



To accompany Record 1971/3

SAMPLE No. 9D(i)

SOIL TYPE 9

SUMMARY

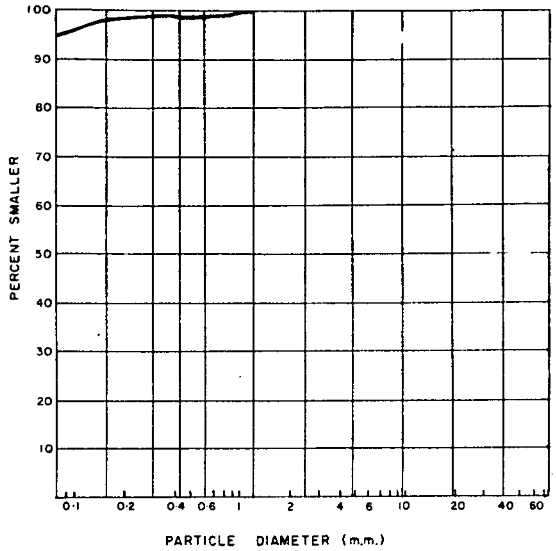
Lower liquid limit	86
Lower plastic limit	27
Plasticity index	59
Linear shrinkage	20
Percent gravel	4
Percent sand	7
Percent silt and clay	89
Swell index (lb/sq.ft.)	6050
PVC rating	7·6
PVC category	Very Critical

WATSON SOIL SURVEY

TEST RESULTS

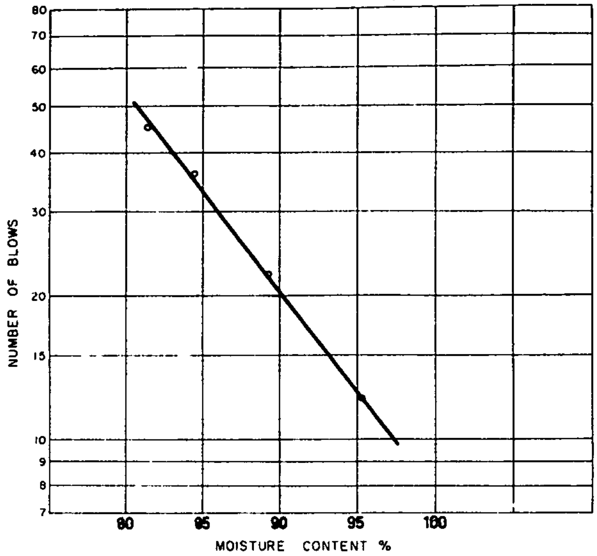
PARTICLE SIZE ANALYSIS

DISTRIBUTION CHART

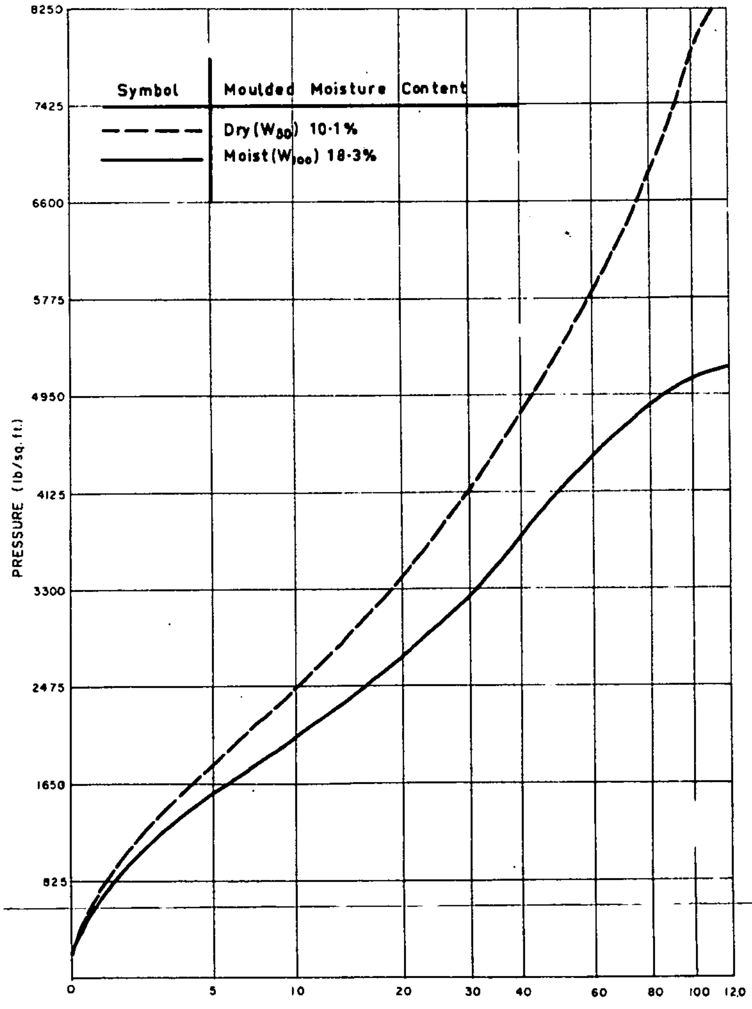


ATTERBERG LIMIT

FLOW CHART



POTENTIAL VOLUME CHANGE



SAMPLE No. 9D(ii)

SOIL TYPE 9

SUMMARY

Lower liquid limit	88
Lower plastic limit	30
Plasticity index	58
Linear shrinkage	17
Percent gravel	NIL
Percent sand	5
Percent silt and clay	95
Swell index (lb/sq.ft.)	6750
PVC rating	8·1
PVC category	Very Critical

APPENDIX 3

Potential Volume Change Meter

APPENDIX 3

The 'Potential Volume Change Meter'

Description

The Potential Volume Change Meter was developed by Lambe (1960) at the request of the U.S. Federal Housing Authority for the purpose of identifying potentially expansive foundation soils.

The apparatus (Figure 1) consists essentially of a consolidometer which measures the pressure exerted as the sample swells against the resistance of a proving ring. The proving ring deflects 0.0001 inch per 3-4 lb applied force and the dial reads 0.0001 inch per division. The diameter of the sample , which is that of the consolidometer ring, is 2.750 inches and its thickness is 0.625 inches.

Test Procedure

Samples are compacted dynamically in consolidometer rings at three different 'relative water contents'*, for which a correlation between swell index and potential volume change has been established. The three relative water contents at which samples are tested are termed dry, moist and wet and are equal to the following:

Dry (W_{50}) = water content at 50 percent relative humidity

Moist (W_{100}) = water content at 100 percent relative humidity

Wet (W_p) = water content at plastic limit.

The compaction procedures used are shown below, together with the compactive efforts and their relation to Standard and Modified AASHO** Compaction:

* The relative water content of a sample of soil refers to the relation between the actual water content of the sample and the water contents (which might be called 'standard' water contents) at which the soil exhibits certain well-defined properties (such as at the liquid limit, the plastic limit, the shrinkage limit, or the field moisture equivalent) or is in equilibrium with moist air having a certain relative humidity (such as 100 percent relative humidity or 50 percent relative humidity)

** American Association of State Highway Officials.

Relative Water Content	No. of Layers	No. of Blows per Layer	Compactive Energy (ft lb/cu.ft)
Dry	3	7	55 000 (Modified AASHO)
Moist	3	4	31 000 (½ Modified AASHO)
Wet	1	5	13 000 (Standard AASHO)

The two exposed faces of the compacted soil are covered with porous stones and the enclosed sample is attached to a base plate. Water is added until the sample is completely immersed and resultant swell pressures are recorded by the proving ring dial.

Presentation of Results

The pressure computed from the dial reading is termed the 'swell index'. The Swell Index test is essentially a measurement of the pressure exerted by the sample of compacted soil when it swells against the restraining force (proving ring) after being wetted. The value of pressure (lb/sq.ft) 2 hours after adding the water is the swell index of the soil.

Lambe correlated the swell index with potential volume change through his 'PVC rating'; this is a numerical rating which provides a qualitative measure of the magnitude of the potential volume changes in soils. It was derived from results of laboratory testing of five soil parameters:-

Heave from air-dried condition (Holtz and Gibbs, 1956)

Plasticity index (Holtz and Gibbs, 1956; Holtz, 1959)

Water content at 85 percent relative humidity (De Bruyn, Collins and Williams, 1956)

Plasticity index and activity (Williams, 1957)

Linear shrinkage - Field moisture equivalent to shrinkage limit (Altmeyer, 1956).

The volume change potential of a soil can be readily assessed by inspection of a plot (Fig. 2) of swell index versus PVC Rating. Fig. 2 shows, also, Lambe's four 'PVC Categories', which represent the severity of the potential volume change as reflected in the damage which has been observed in structures founded on soils.

REFERENCES

ALTMEYER, W.T., 1956 - Discussion of Paper 2814. Trans. American Society of Civil Engineers, Vol. 121, page 666.

DE BRUYN, C.M.A., COLLINS, L.E. and WILLIAMS, A.A.B. 1956 - "The specific surface, water affinity and potential expansiveness of clay", Clay Minerals Bulletin, Vol. 3, No. 17.

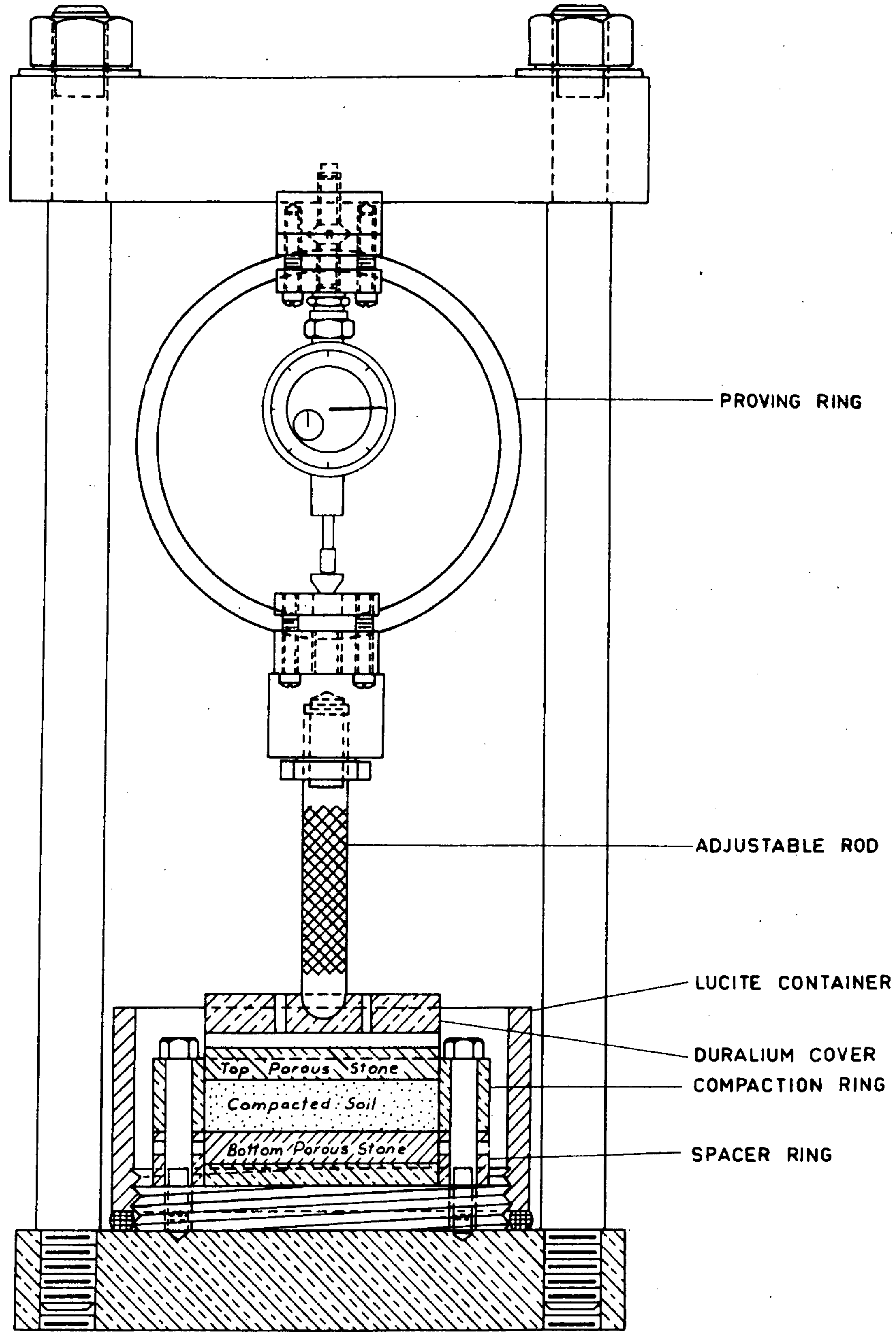
HOLTZ W.G. 1959 - "Expansive clays - properties and problems", Quarterly of the Colorado School of Mines, Vol. 54, No. 4, page 89.

HOLTZ W.G. and GIBBS , H.J. 1956 - "Engineering properties of expansive clays", Trans. American Society of Civil Engineers, Vol. 121, page 641.

LAMBE, T.W. 1960 - Soil PVC Meter. Technical Studies Report, FHA-701, Federal Housing Administration, Washington, D.C.

WILLIAMS, A.A.B. 1957 - Discussion of Jennings and Knight, (1957). South African Institute of Civil Engineers, Symposium on expansive clays, page 57.

FIG 1



(After, Lambe, 1960)

SOIL PVC METER

To accompany Record 1971/3

I55/A16/736

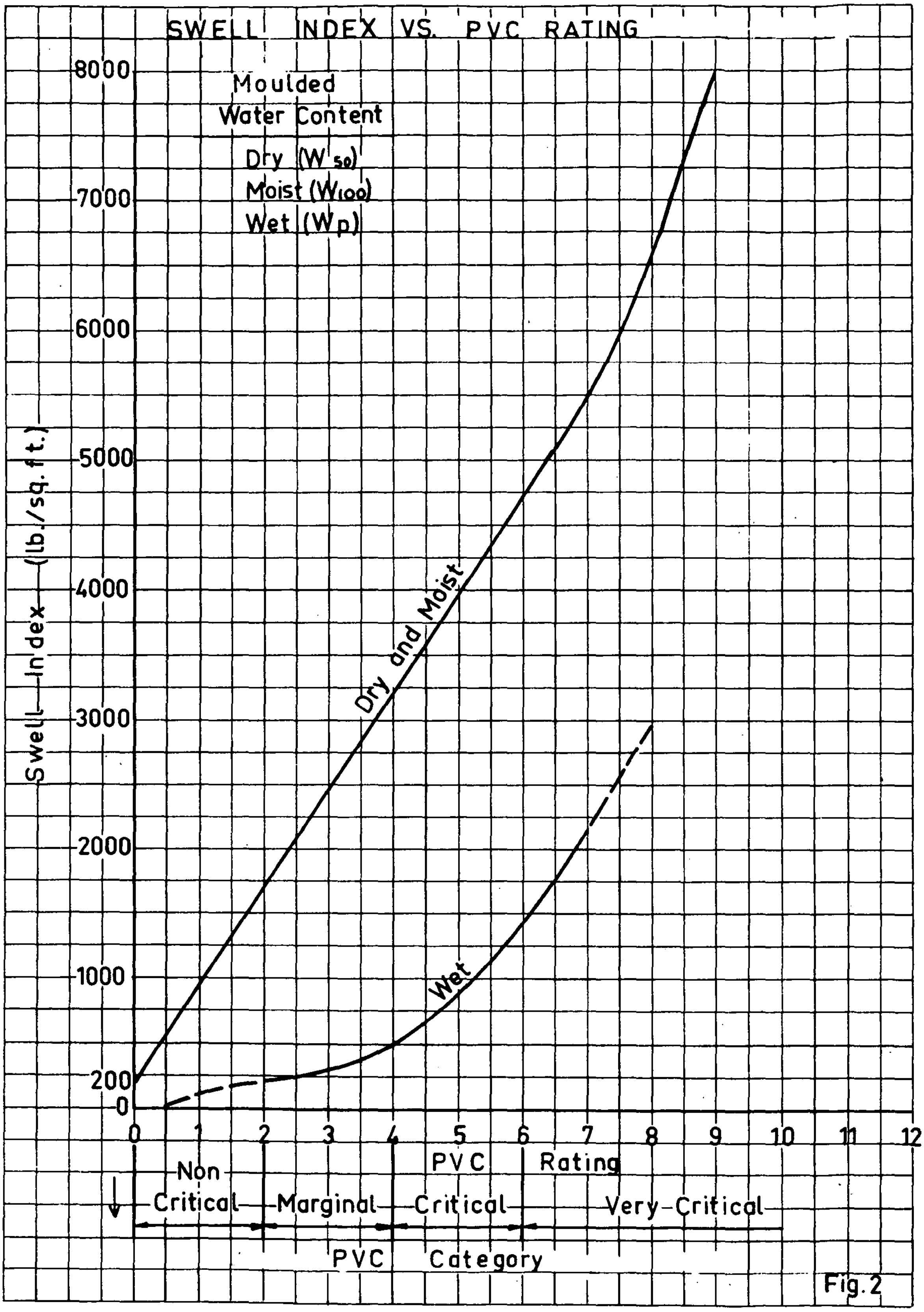


Fig. 2

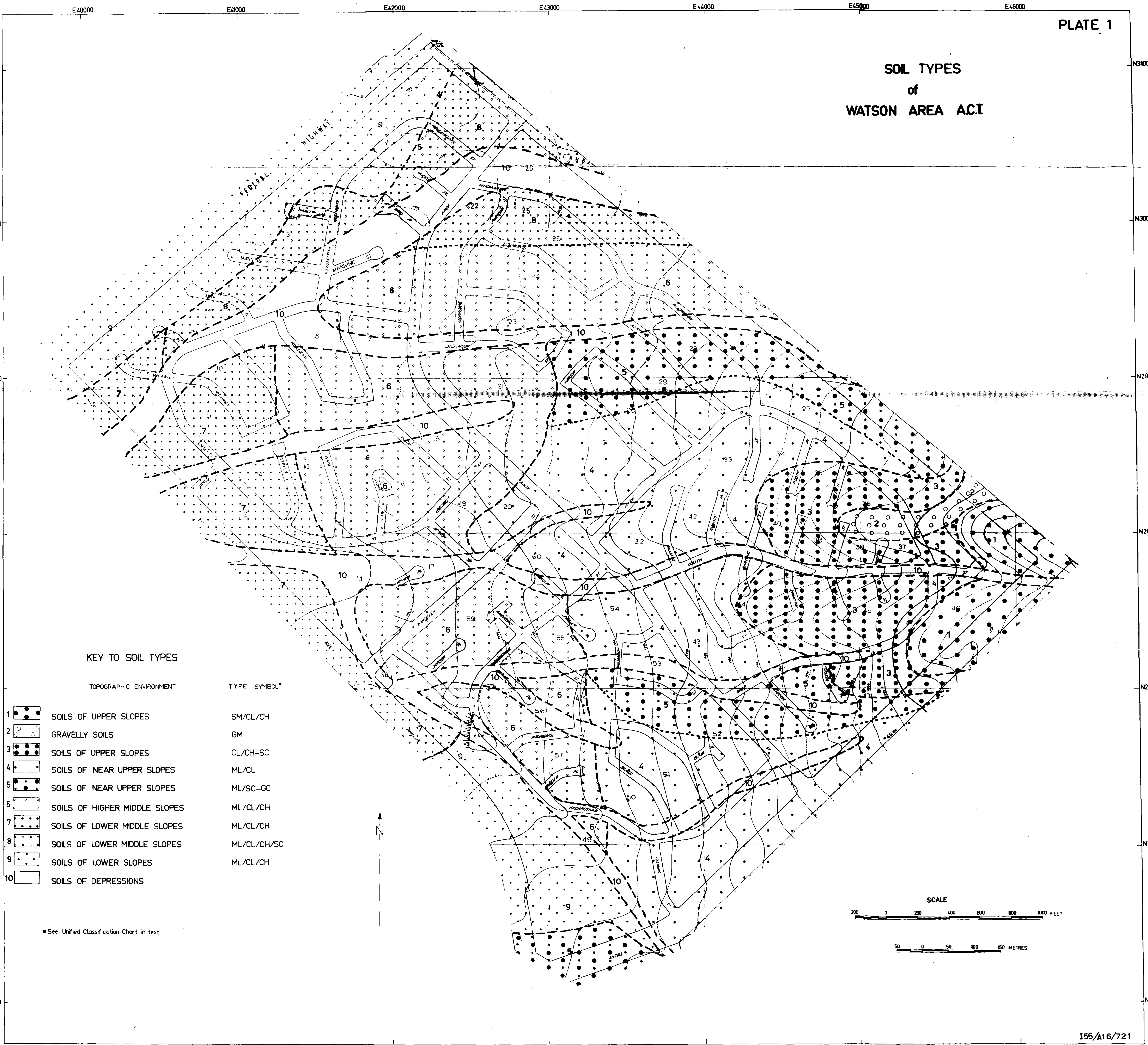
To accompany Record 1971/3

(After, Lambe, 1960)

I55/A16/737

PLATE 1

SOIL TYPES
of
WATSON AREA A.C.T.



KEY TO SOIL TYPES

	TOPOGRAPHIC ENVIRONMENT	TYPE SYMBOL*
1	SOILS OF UPPER SLOPES	SM/CL/CH
2	GRAVELLY SOILS	GM
3	SOILS OF UPPER SLOPES	CL/CH-SC
4	SOILS OF NEAR UPPER SLOPES	ML/CL
5	SOILS OF NEAR UPPER SLOPES	ML/SC-GC
6	SOILS OF HIGHER MIDDLE SLOPES	ML/CL/CH
7	SOILS OF LOWER MIDDLE SLOPES	ML/CL/CH
8	SOILS OF LOWER MIDDLE SLOPES	ML/CL/CH/SC
9	SOILS OF LOWER SLOPES	ML/CL/CH
10	SOILS OF DEPRESSIONS	

*See Unified Classification Chart in text

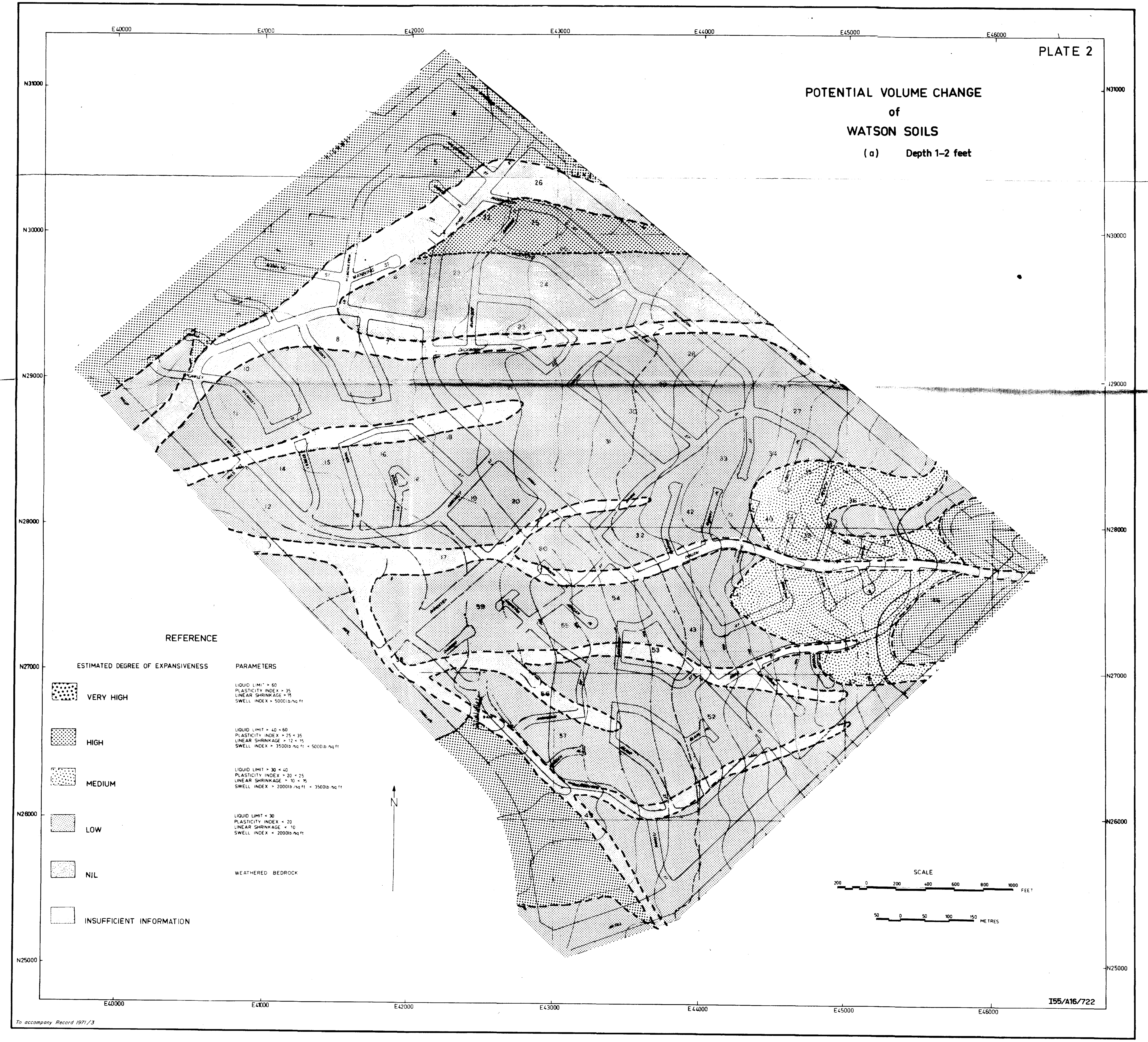
I55/A16/721

To accompany Record 1971/3

PLATE 2

POTENTIAL VOLUME CHANGE
of
WATSON SOILS

(a) Depth 1–2 feet



REFERENCE

ESTIMATED DEGREE OF EXPANSIVENESS	PARAMETERS
▨ VERY HIGH	LIQUID LIMIT > 60 PLASTICITY INDEX > 35 LINEAR SHRINKAGE > 15 SWELL INDEX > 5000lb/sq ft
▨ HIGH	LIQUID LIMIT > 40 < 60 PLASTICITY INDEX > 25 < 35 LINEAR SHRINKAGE > 12 < 15 SWELL INDEX > 3500lb/sq ft < 5000lb/sq ft
▨ MEDIUM	LIQUID LIMIT > 30 < 40 PLASTICITY INDEX > 20 < 25 LINEAR SHRINKAGE > 10 < 15 SWELL INDEX > 2000lb/sq ft < 3500lb/sq ft
▨ LOW	LIQUID LIMIT < 30 PLASTICITY INDEX < 20 LINEAR SHRINKAGE < 10 SWELL INDEX < 2000lb/sq ft
▨ NIL	WEATHERED BEDROCK
☐ INSUFFICIENT INFORMATION	

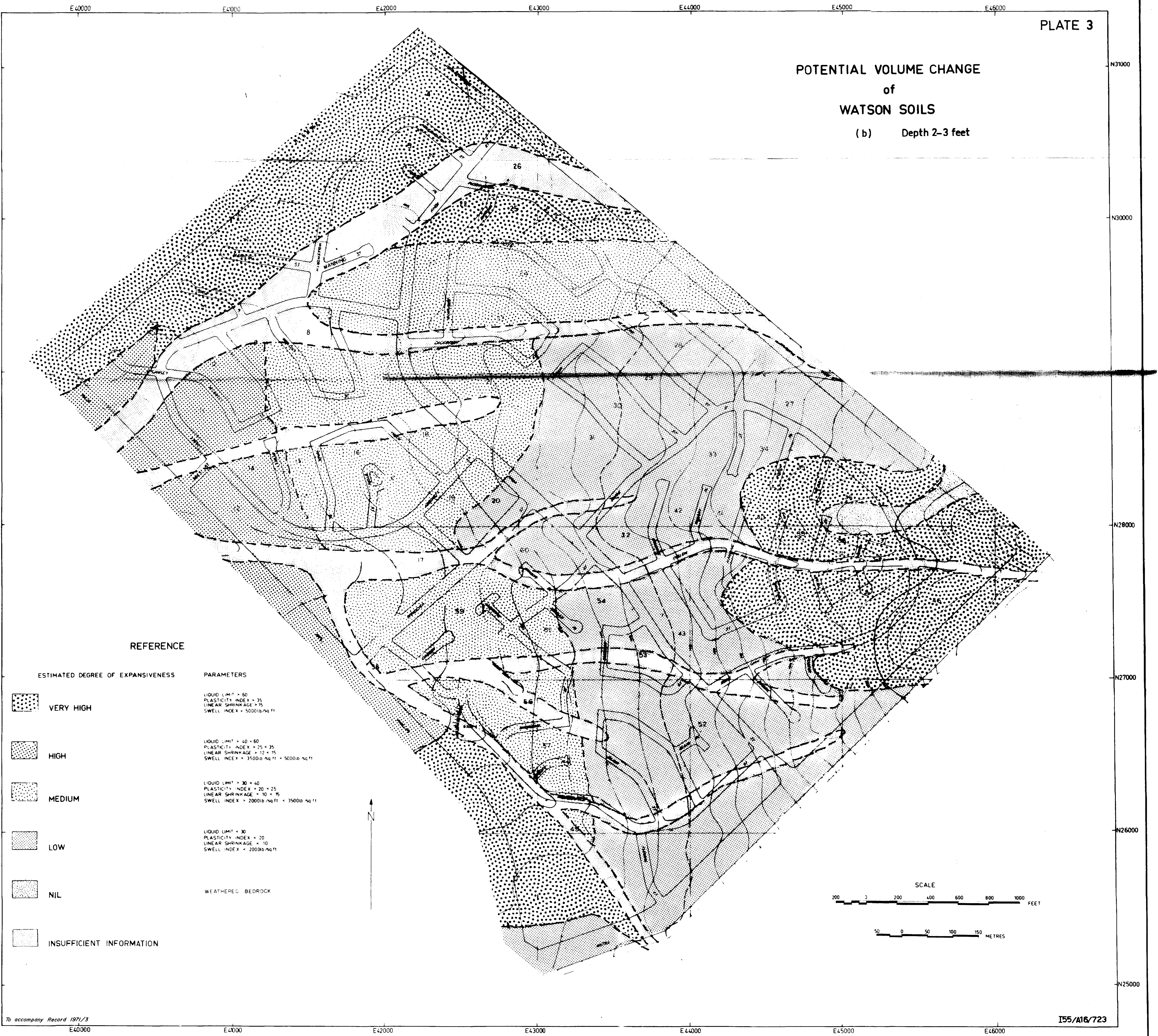
I55/A16/722

To accompany Record 1971/3

PLATE 3

POTENTIAL VOLUME CHANGE
of
WATSON SOILS

(b) Depth 2–3 feet



REFERENCE

ESTIMATED DEGREE OF EXPANSIVENESS		PARAMETERS
●	VERY HIGH	LIQUID LIMIT > 60 PLASTICITY INDEX > 35 LINEAR SHRINKAGE > 15 SWELL INDEX > 5000lb/sq ft
▨	HIGH	LIQUID LIMIT > 40 < 60 PLASTICITY INDEX > 25 < 35 LINEAR SHRINKAGE > 12 < 15 SWELL INDEX > 3500lb/sq ft < 5000lb/sq ft
▨	MEDIUM	LIQUID LIMIT > 30 < 40 PLASTICITY INDEX > 20 < 25 LINEAR SHRINKAGE > 10 < 15 SWELL INDEX > 2000lb/sq ft < 3500lb/sq ft
▨	LOW	LIQUID LIMIT < 30 PLASTICITY INDEX < 20 LINEAR SHRINKAGE < 10 SWELL INDEX < 2000lb/sq ft
▨	NIL	WEATHERED BEDROCK
☐	INSUFFICIENT INFORMATION	

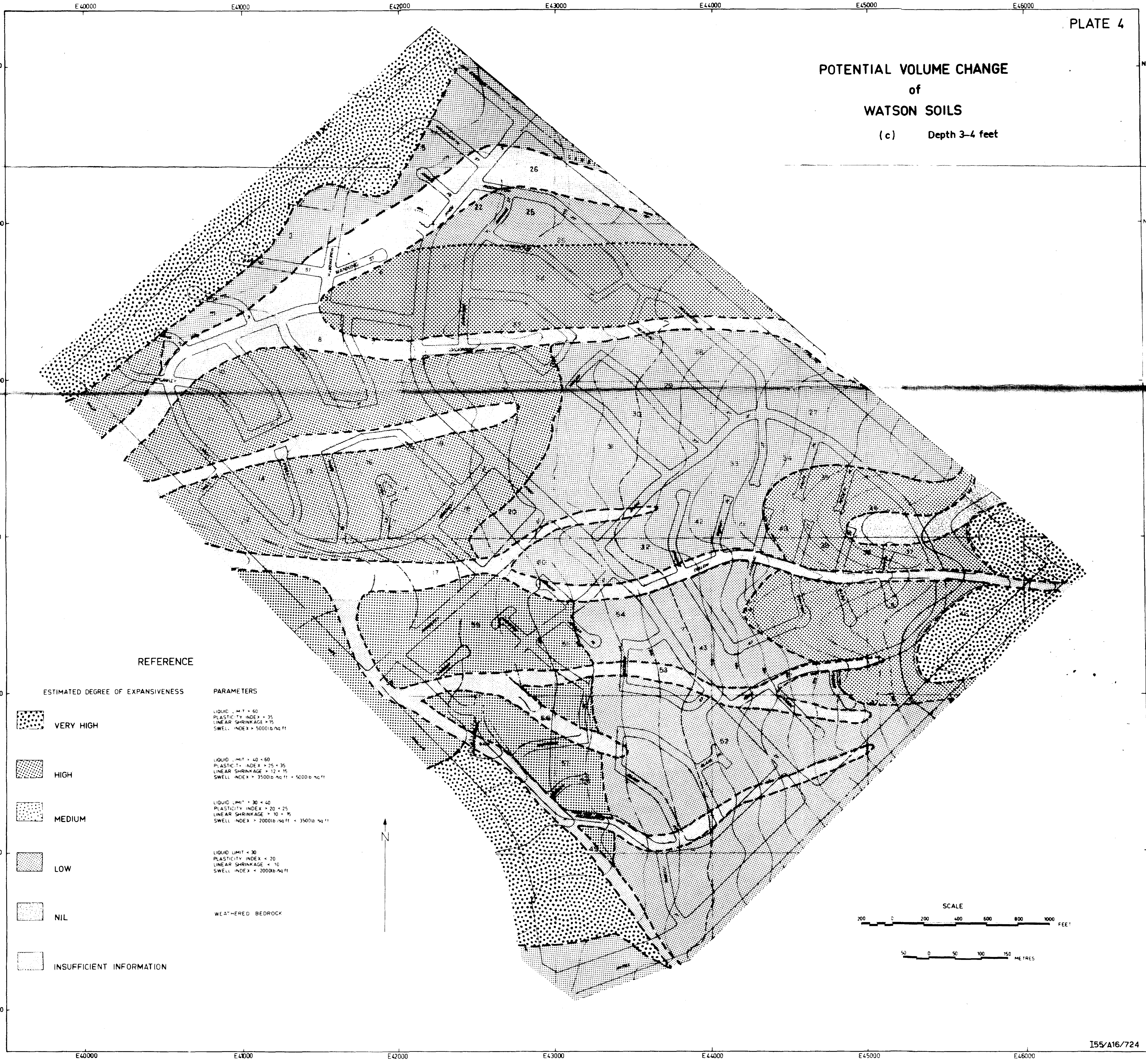
To accompany Record 1971/3

I55/A16/723

PLATE 4

POTENTIAL VOLUME CHANGE
of
WATSON SOILS

(c) Depth 3–4 feet



REFERENCE

ESTIMATED DEGREE OF EXPANSIVENESS		PARAMETERS
▦	VERY HIGH	LIQUID LIMIT > 60 PLASTICITY INDEX > 35 LINEAR SHRINKAGE > 15 SWELL INDEX > 5000lb/sq ft
▦	HIGH	LIQUID LIMIT > 40 < 60 PLASTICITY INDEX > 25 < 35 LINEAR SHRINKAGE > 12 < 15 SWELL INDEX > 3500lb/sq ft < 5000lb/sq ft
▦	MEDIUM	LIQUID LIMIT > 30 < 40 PLASTICITY INDEX > 20 < 25 LINEAR SHRINKAGE > 10 < 15 SWELL INDEX > 2000lb/sq ft < 3500lb/sq ft
▦	LOW	LIQUID LIMIT < 30 PLASTICITY INDEX < 20 LINEAR SHRINKAGE < 10 SWELL INDEX < 2000lb/sq ft
▦	NIL	WEATHERED BEDROCK
☐	INSUFFICIENT INFORMATION	

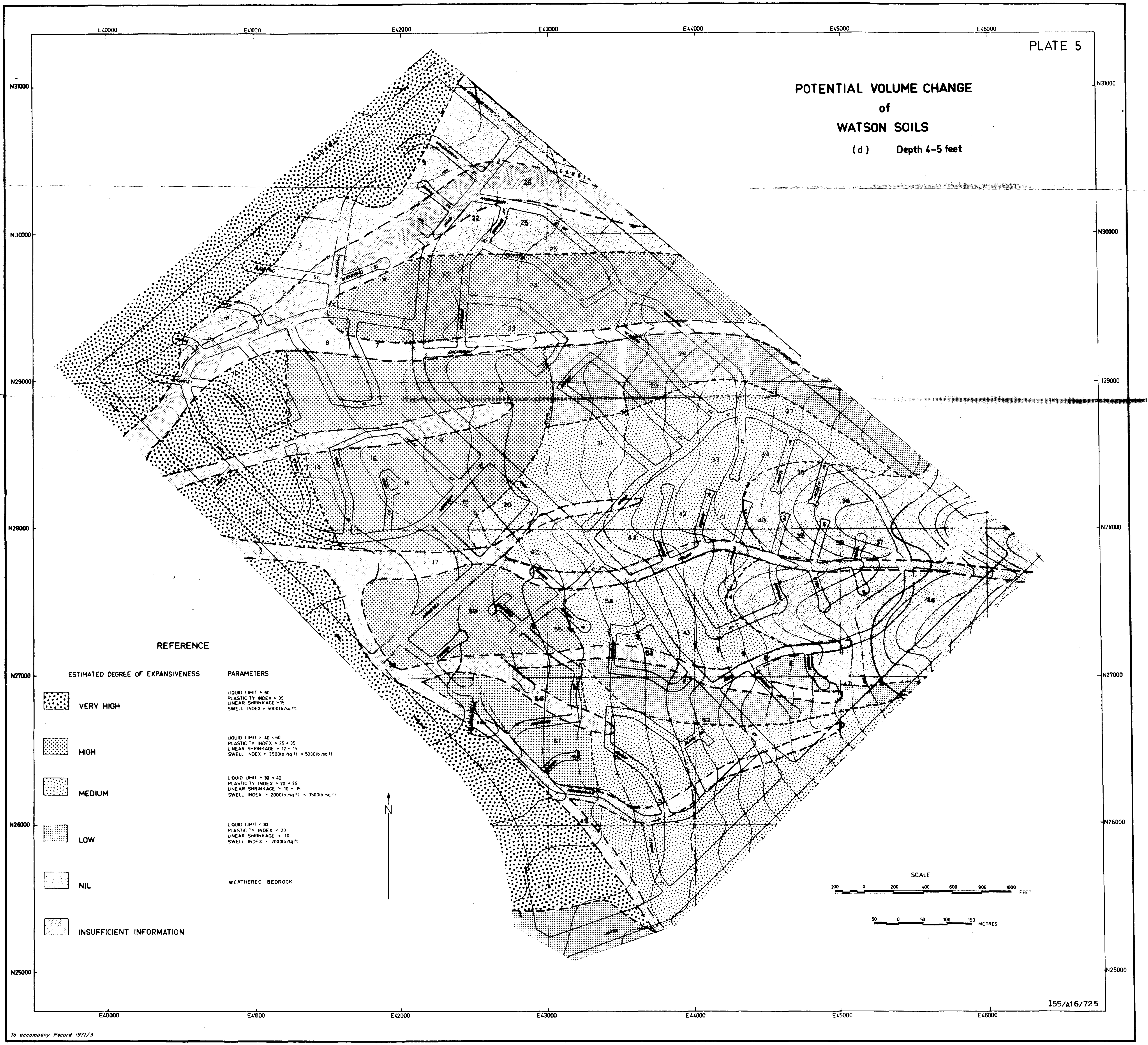
I55/A16/724

To accompany Record 1971/3

PLATE 5

POTENTIAL VOLUME CHANGE
of
WATSON SOILS

(d) Depth 4-5 feet



REFERENCE

ESTIMATED DEGREE OF EXPANSIVENESS		PARAMETERS
⁘	VERY HIGH	LIQUID LIMIT > 60 PLASTICITY INDEX > 35 LINEAR SHRINKAGE > 15 SWELL INDEX > 5000lb/sq ft
⁘	HIGH	LIQUID LIMIT > 40 < 60 PLASTICITY INDEX > 25 < 35 LINEAR SHRINKAGE > 12 < 15 SWELL INDEX > 3500lb/sq ft < 5000lb/sq ft
⁘	MEDIUM	LIQUID LIMIT > 30 < 40 PLASTICITY INDEX > 20 < 25 LINEAR SHRINKAGE > 10 < 15 SWELL INDEX > 2000lb/sq ft < 3500lb/sq ft
▦	LOW	LIQUID LIMIT < 30 PLASTICITY INDEX < 20 LINEAR SHRINKAGE < 10 SWELL INDEX < 2000lb/sq ft
░	NIL	WEATHERED BEDROCK
░	INSUFFICIENT INFORMATION	

To accompany Record 1971/3

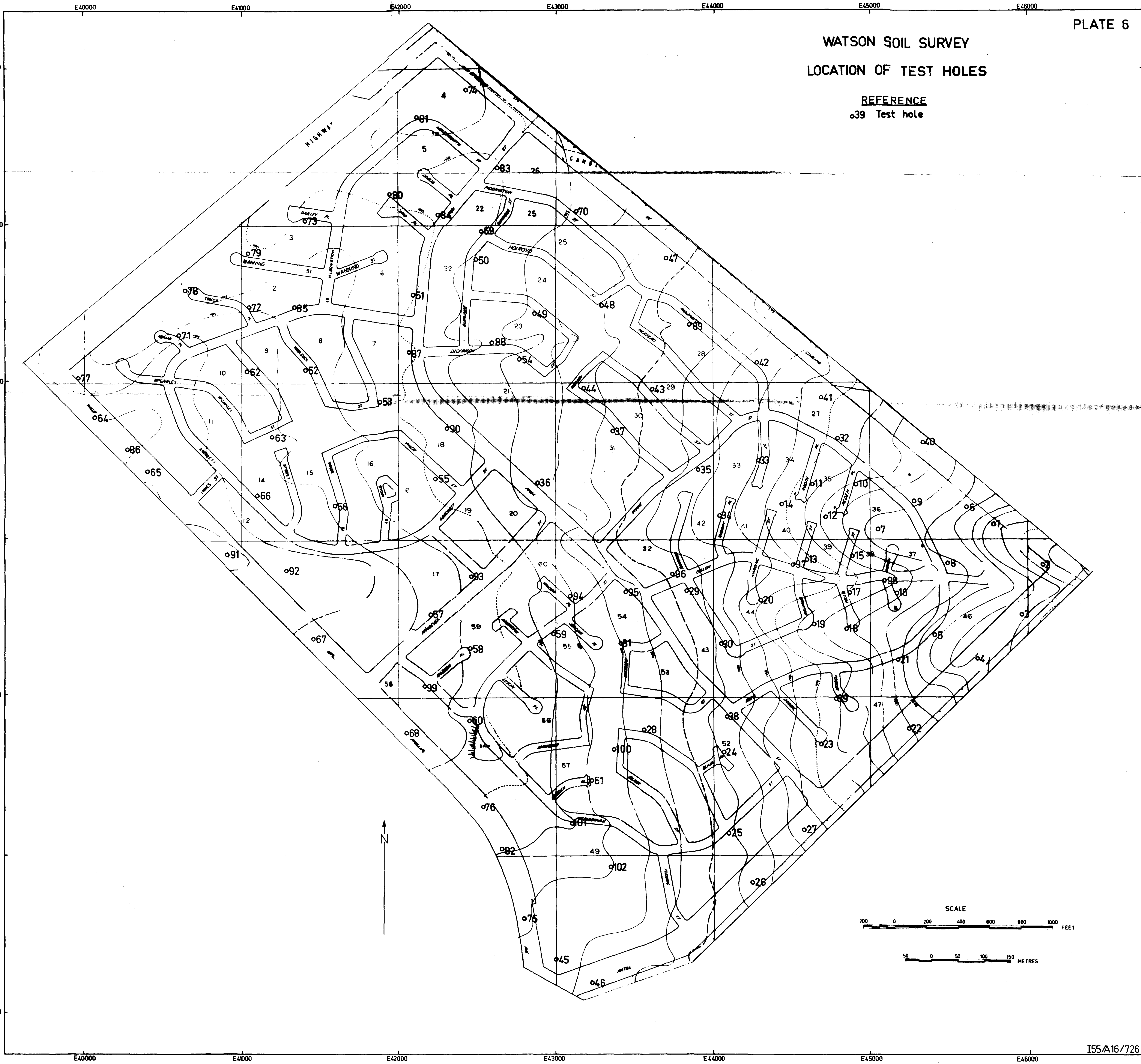
PLATE 6

WATSON SOIL SURVEY

LOCATION OF TEST HOLES

REFERENCE

o39 Test hole



SCALE

200 0 200 400 600 800 1000 FEET

50 0 50 100 150 METRES

I55/A16/726

To accompany Record 1971/3