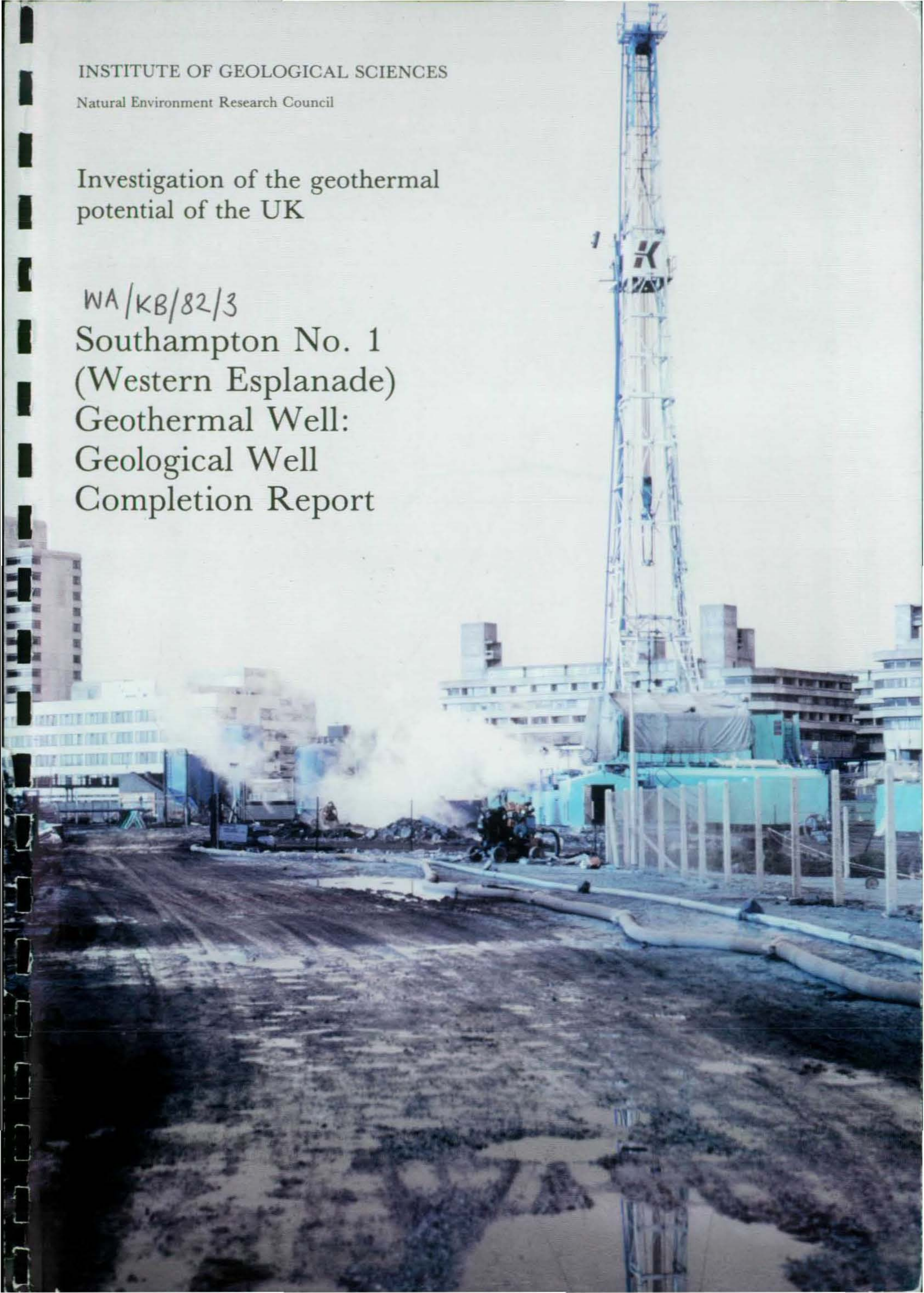
INSTITUTE OF GEOLOGICAL SCIENCES

Natural Environment Research Council

Investigation of the geothermal potential of the UK

WA/KB/82/3

Southampton No. 1 (Western Esplanade) Geothermal Well: Geological Well Completion Report



PROGRAMME DIRECTOR C

INSTITUTE OF GEOLOGICAL SCIENCES
Environmental and Deep Geology Division

Investigation of the geothermal potential of the UK

Southampton No. 1 (Western Esplanade) Geothermal Well: Geological Well Completion Report

L. P. Thomas and D. W. Holliday

with contributions by
G. A. Kirby, M. Kubala, R. Lamb, M. J. Bird,
E. C. Freshney

(Deep Geology Unit Report No. 82/3)

This work was supported by the Department of Energy in association with Southampton City Council and the Geothermal Development Programme of the Commission of the European Communities.

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Cover Photo Testing a geothermal well in the centre of Southampton.
Photo by M. Price, IGS.

FOREWORD

The Southampton No. 1(Western Esplanade) Borehole was the first geothermal demonstration well to be drilled in the United Kingdom. It was sponsored by the Department of Energy in association with Southampton City Council and the Geothermal Development Programme of the Commission of the European Communities. The borehole was drilled by the Institute of Geological Sciences on behalf of the Department of Energy, site geology being the responsibility of the Deep Geology Unit. This well completion report has been compiled by Drs L. P. Thomas and D. W. Holliday and includes contributions from G. A. Kirby, M. Kubala and R. Lamb (Deep Geology Unit), M. J. Bird (Hydrogeology Unit) and E. C. Freshney (SW England Unit).

5 August 1982 Institute of Geological Sciences

SOUTHAMPTON NO. 1

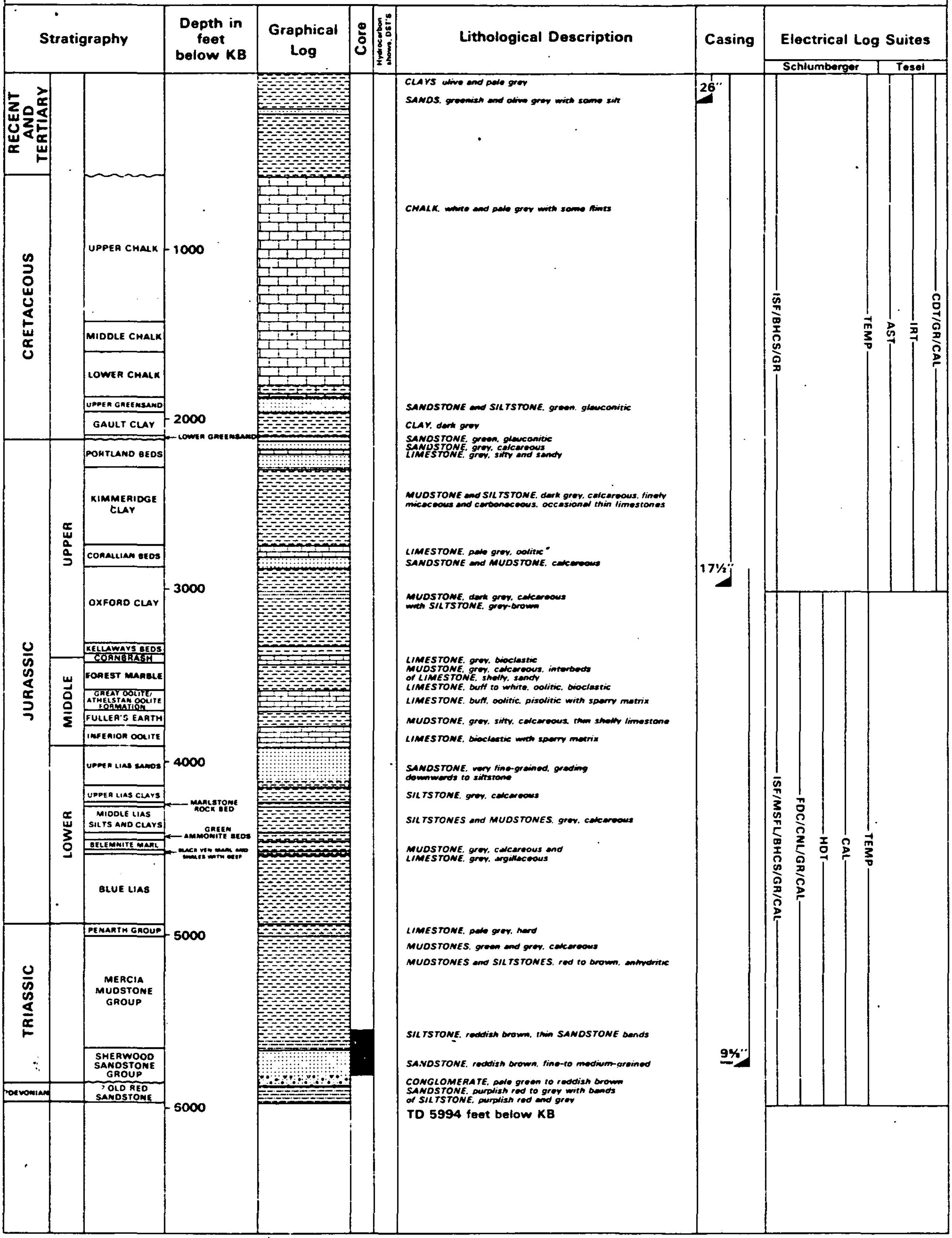
SUMMARISED WELL LOG

LOCATION

Latitude 50° 54' 24" N

Longitude 1° 24' 33" W

Grid Reference SU 41559 12018



CONTENTS

Page

1 **GENERAL**

1.1	Well Data	1
1.2	Location Map	3
1.3	Background Information	4
1.4	Bouguer Anomaly Map	5
1.5	Summary	6

2 **GEOLOGY**

2.1	Formation Tops	9
2.2	Stratigraphy and Lithology	11
2.3	Core description	23
2.4	Graphical log of cored section	26
2.5	Dipmeter results	27
2.6	Hydrocarbon Indications	28

3 **LOGGING DATA**

3.1	Mud Logging	29
3.2	Wireline Logging	29

4 **RESULTS OF CORE ANALYSIS FOR POROSITY, PERMEABILITY AND GRAIN DENSITY** 31

5 **LIST OF ENCLOSURES** 41

1 GENERAL

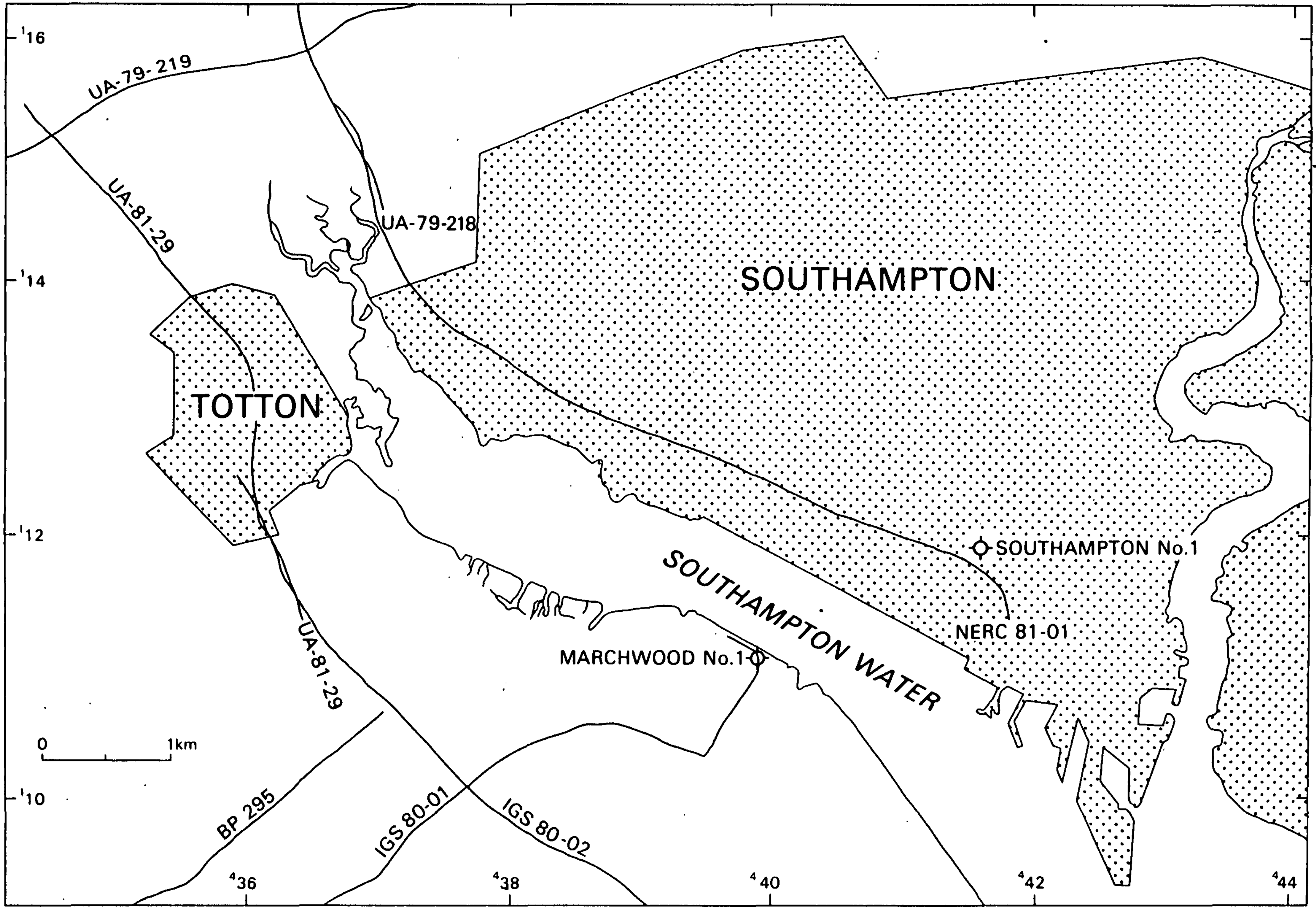
1.1 Well Data

Well Name:	Southampton No. 1 (Western Esplanade)
Type:	Geothermal Development
Location:	Western Esplanade, Southampton National Grid Reference: SU 41559 12018 Latitude: 50° 54' 24" N Longitude: 1° 24' 33" W
Hydrocarbon Exploration Licence:	Amoco/Ultramar XL 138
Client and operator:	Department of Energy and Institute of Geological Sciences (NERC)
Drilling Contractor:	Kenting Drilling Services Ltd
Rig:	Kenting No. 12
Spud Date:	26 September 1981
TD Reached:	20 November 1981
Final Status:	Capped and completed for further tests
KB Elevation:	24.92 ft AOD
Ground Level:	10.96 ft AOD
Terminal Depth:	5994 ft below Kelly Bushing
Hole Diameter (depth below KB):	26 inch to 165 ft 17½ inch to 3005 ft 12½ inch to 5994 ft
Casing and completion depths (below KB):	20 inch 158 ft 13⅜ inch 2995 ft 9⅝ inch liner hung from 2826 ft to 5635 ft

Cored Interval (Drillers depth below KB) 5588 - 5814 ft

Core 1	5588 to 5649 ft	(100% recovery)
Core 2	5649 to 5708 ft	(97%)
Core 3	5708 to 5726 ft	(89%)
Core 4	5726 to 5744 ft	(95%)
Core 5	5744 to 5804 ft	(93%)
Core 6	5804 to 5814 ft	(100%)
Total Core:	226 ft	

Wireline Logs:	Schlumberger Inland Services Inc., Tesel Well Services Ltd
Mud Logging:	Exploration Logging (UK) Ltd
Cementing:	Dowell-Schlumberger
Velocity Survey:	Seismograph Services Ltd
Mud Engineering:	Dresser Europe S.A., Magcobar Group
Coring:	Diamant-Boart S.A.
Site Geology:	Deep Geology Unit and SW England Unit, Institute of Geological Sciences
Hydrogeology:	Hydrogeology Unit, Institute of Geological Sciences
Log Analysis and Supervision:	PED, Department of Energy; Applied Geophysics Unit, Institute of Geological Sciences
Drilling Superintendent:	Mr D. McIntyre, Drilcon Ltd



1.2 Location Map

1.3 Background Information

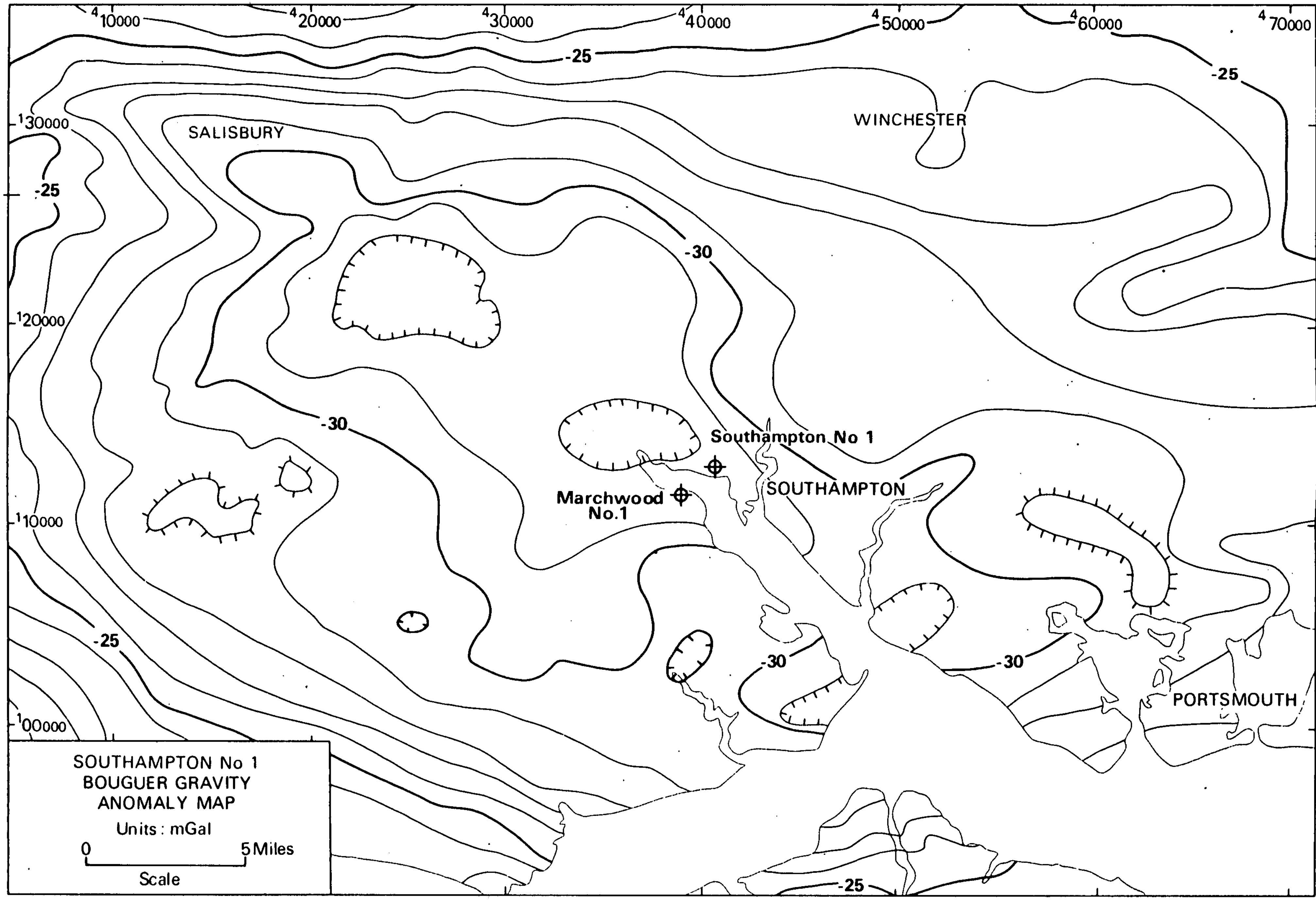
Southampton No 1 (Western Esplanade) was drilled as a geothermal development well, on behalf of the Department of Energy in association with Southampton City Council, following the successful testing of Marchwood No 1 Borehole and studies of the geothermal potential of the Wessex Basin area by the Institute of Geological Sciences.

The site was selected near Southampton city centre, with the aim of providing space heating for the proposed Western Esplanade development area. The nearby Marchwood No 1 Borehole is situated 1.8 km to the south-west, and the south-east part of NERC 81-1 seismic line is adjacent to the site (Figure 1.2). Southampton No 1 is situated in an area of negative gravity anomaly as indicated on the regional Bouguer anomaly map (Figure 1.4).

The primary objective was to drill to the known aquifer, the Triassic Sherwood Sandstone, and to carry out hydrogeological and geothermal tests. The whole of the Sherwood Sandstone was cored for geological and hydro-geological analysis.

Samples additional to those required by IGS for stratigraphical purposes, were collected for thermal conductivity determinations and for organic geochemical studies on the Jurassic part of the sequence.

1.4 Bouguer Anomaly Map



1.5 Summary

Southampton No 1 spudded into Made Ground and Quaternary deposits on 26th September 1981. 20 inch casing was set at 158 ft, 13 3/8 inch casing was set at 2995 ft, and 9 5/8 inch casing at 5635 ft. The hole terminated at a depth of 5994 ft below Kelly Bushing on 20 November 1981.

The Quaternary sediments are 41 ft thick at this locality and are composed of made ground and buried channel deposits, consisting of silty peaty clay, peat and a basal flint gravel. The Tertiary sequence was entered at a lower stratigraphical level than at Marchwood No 1, in the Bracklesham Formation, which together with the London Clay Formation and Reading Formation consisted of grey to brown silty clays, grey to green sands and some lignite. A glauconitic sand marked the base of the Tertiary rocks which was penetrated at a depth of 598 ft.

The underlying Cretaceous sequence is closely similar to that proved in Marchwood No 1 with Upper, Middle and Lower Chalk being present. The base of the Lower Chalk occurred at 1888 ft and is marked by a glauconitic sand. Below are various units of the Lower Cretaceous, namely the Upper Greensand, Gault Clay and Lower Greensand in descending order. The base of the Cretaceous was proved at 2140 ft.

The highest Jurassic strata are those of the Portland Stone (53 ft thick) and Portland Sand (66 ft thick). These formations were not present in Marchwood No 1, where as a result of the late Kimmerian transgression, Lower Cretaceous rocks rest on Kimmeridge Clay. Beneath the Portland Beds, the Kimmeridge Clay, predominantly grey and brown calcareous mudstones and siltstones, extends down to 2745 ft. Below are limestones and siltstones referred to the Corallian Beds, which pass downwards into the mudstones and siltstones of the Oxford Clay and the Kellaways Beds below, the base of which is at 3381 ft. The Middle Jurassic strata comprise Cornbrash limestones, Forest Marble mudstones and limestones, overlying oolitic limestones of the Great Oolite. These in turn overlie calcareous mudstones of the Fuller's Earth, and oolitic limestones of the Inferior Oolite which mark the base of the Middle Jurassic at 3909 ft.

The Lower Jurassic strata conform with those observed in Marchwood No 1, namely a descending sequence of Bridport Sands (Upper Lias Sands), Upper Lias Clays, the Marlstone Rock Bed limestone resting on Middle Lias calcareous mudstones and siltstones. These are underlain by the Lower Lias mudstones, passing downwards in the lower part, into alternations of mudstone and limestone. The base of the Lower Lias is at 4951 ft.

At the top of the Triassic sequence are the Penarth Group (Rhaetic) limestones and mudstones which rest on the green and grey siltstones of the Blue Anchor Formation (Tea Green Marl and Grey Marl) underlain, in turn, by red siltstones and mudstones of the Mercia Mudstone Group (Keuper Marl). The Mercia Mudstone Group is divisible as at Marchwood No 1 into several, widely recognisable, lithostratigraphical units. The basal unit is the equivalent of the Keuper Waterstones which, in the Southampton No 1 Borehole, exhibits an increase in grain size downwards and grades into the underlying Sherwood Sandstone. The base of the Keuper Waterstones is taken at 5674 ft.

The Sherwood Sandstone Group here is divisible into an upper, predominantly sandstone sequence ('Bunter Sandstone'), and a lower, predominantly conglomeratic unit ('Bunter Pebble Beds'). The Sherwood Sandstone Group is made up of a number of fining-upwards depositional phases, the coarsest detritus occurring in the lower part, where pebbles of quartzite and sandstone exhibit a high degree of roundness. The base of the Sherwood Sandstone Group is taken at 5894 ft.

As in Marchwood No 1, below the known Triassic sediments, lies a series of red sandstones, siltstones and mudstones, more indurated and tectonically disturbed than the sediments above. It is suggested that these sediments may be of Old Red Sandstone (Devonian) age although no age determinations have been possible. These sediments were present to the terminal depth of 5994 ft.

2 GEOLOGY

2.1 Formation Tops

		Depth below KB ft	Depth below OD ft	Thick-ness ft
QUATERNARY		14	11+OD	38
TERTIARY				
Bracklesham Formation	(Wittering Member	52	27	160
London Clay Formation	(Whitecliff Sand (Member	212	187	10
	(London Clay (undivided	222	197	292
Reading Formation		514	489	84
CRETACEOUS				
	Upper Chalk	598	573	847
	Middle Chalk	1445	1420	176
	Lower Chalk	1621	1596	267
	Upper Greensand	1888	1863	98
	Gault	1986	1961	130
	Lower Greensand	2116	2091	24
JURASSIC				
	Portland Beds	2140	2115	160
	Kimmeridge Clay	2300	2275	445
	Corallian	2745	2720	135
	Oxford Clay	2880	2855	442
	Kellaways Beds	3322	3297	59
	Cornbrash	3381	3356	47
	Forest Marble	3428	3403	153
	Great Oolite/Athelstan Oolite Formation	3581	3556	120
	Fuller's Earth	3701	3676	95
	Inferior Oolite	3796	3771	113
	Upper Lias Sands	3909	3884	228
	Upper Lias Clay	4137	4112	109
	Marlstone Rock Bed	4246	4221	9
	Middle Lias Silts and Clays	4255	4230	166
	Green Ammonite Beds	4421	4396	39
	Belemnite Marl	4460	4435	60
	Black Ven Marl and Shales with Beef?	4520	4495	26
	Blue Lias	4546	4521	405

TRIASSIC				
Penarth Group	Langport Member	4951	4926	33
	Cotham Member	4984	4959	15
	Westbury Formation	4999	4974	19
Mercia Mudstone Group	Blue Anchor Formation	5018	4993	64
	Variegated Marl	5082	5057	45
	Upper Red Marl	5127	5102	129
	Anhydritic Siltstone	5258	5233	92
	Saliferous Marl	5350	5325	148
	Lower Red Marl	5498	5473	55
	"Waterstones" Equivalent	5553	5528	121
Sherwood Sandstone	'Bunter' Sandstone	5674	5649	124
	'Bunter' Pebble Beds	5798	5773	96
?DEVONIAN				
	?Old Red Sandstone	5894	5869	100+
	Terminal Depth	5994	5969	

2.2 Stratigraphy and Lithology

QUATERNARY 11-52 ft

Made ground above buried channel deposits consisting of silty peaty clay, peat, and a basal flint gravel.

TERTIARY

Bracklesham Formation

Wittering Member 52-212 ft

Clay, olive green to greyish brown, interlaminated with glauconitic silt to fine sand grade layers and partings. Sands, olive grey with olive grey clay layers and laminae. Lignite is common particularly in upper part. Marcasite is also common. A coarse-to medium-grained sand occurs between 173 ft and 205 ft.

London Clay Formation

Whitecliff Sand Member 212-222 ft

Sand, grey, medium-grained.

London Clay Formation, undivided 222-514 ft

Clay, slightly micaceous, olive grey, sandy to extremely sandy, with clayey fine silty sands arranged in four coarsening-upwards cycles. Calcareous siltstones present at about 370 ft and 500 ft. Shelly material, mainly bivalves and gastropods appears at 230 ft and becomes fairly common below 320 ft. Lignitic debris, marcasite, and calcite are also fairly common.

Reading Formation 514-598 ft

Clay, grey with reddish brown mottling; variable but generally with low silt and fine sand content. Sand, medium-grained is present between 575-585 ft. A flint gravel with glauconitic sand matrix occurs in the lowest 1-2 ft.

UPPER CRETACEOUS

Upper Chalk 598-1445 ft

This is a white to pale cream chalky wackestone, and ranges from moderately soft to moderately hard. Flints are abundant and range from pale to dark brownish-grey and from opaque to translucent. The gamma ray curve is remarkably constant throughout at about 7 API units. The sonic velocity of this division increases in the basal 75 ft, indicating increasing lithification.

Middle Chalk 1445-1621 ft

The Middle Chalk is a white chalky wackestone, contains scattered shell debris, and ranges from moderately soft to moderately hard. Flints are generally absent. Gamma ray values are again very constant throughout. Harder chalk in the basal 60 ft is marked by higher sonic velocities than those above and below.

Lower Chalk 1621-1888 ft

At the top of this division are the Plenus Marls, alternations of soft, white and silty, and clayey chalk, which are characterised by an increase in gamma ray and decrease in sonic velocity between 1621 and 1643 ft. These are underlain by pale to dark grey silty and argillaceous chalk. Flints are absent throughout. Gamma ray values increase slowly downwards and a basal glauconitic, phosphatic and calcareous sandstone (equivalent to the 'Chloritic Marl') from 1881-1888 ft is indicated by a marked peak in the gamma ray log.

LOWER CRETACEOUS

Upper Greensand 1888-1986 ft

The upper 40 ft comprise medium grey to greyish green, very fine- to fine-grained, moderately to poorly sorted, calcareous and glauconitic sandstones. The remainder consists of pale to medium grey, occasionally greyish brown, very fine- to coarse-grained calcareous and clayey siltstone ranging from moderately soft to moderately hard. Gamma ray values are higher than in the Chalk, averaging 30 API units but show little variation. The more highly cemented zones (mostly calcareous but also siliceous cements) are marked by sharp increases in sonic velocity.

Gault Clay 1986-2116 ft

This is predominantly a medium grey, silty and locally sandy, calcareous, soft and sticky mudstone, the top and bottom of the formation having a more silty aspect. Accessory pyrite, glauconite and shell fragments are common throughout. Gamma ray values increase rapidly from 35 to 55 API units at 2050 ft thereafter remaining fairly constant at this higher value. The sonic velocity also decreases rapidly to a minimum at 2030 ft returning to higher values below.

Lower Greensand 2116-2140 ft

The top of this unit is marked by a shape decrease in gamma ray values and an increase in sonic velocities. It is a friable, dark greyish green, fine-to medium-, occasionally coarse-grained, glauconitic sandstone, with moderately sorted, subrounded grains.

JURASSIC

Portland Beds 2140-2300 ft

The top of these beds is marked by a decrease in gamma ray values and sonic velocity. The topmost 40 ft comprise medium brown to grey, very fine- to fine-, occasionally coarse-grained, moderately to poorly sorted and poorly calcareous sandstones with subangular to subrounded grains. From 2180 to 2220 ft there are hard, pale to medium grey, silty and sandy wackestones interbedded with pale to medium grey very fine-grained calcareous and glauconitic sandstones and coarse-grained siltstones. These sandstones continue to the base of this formation and become siltier and more clayey downwards. Below the limestones, gamma ray values increase and sonic velocities decrease steadily into the underlying Kimmeridge Clay, indicating the transitional nature of this boundary.

Kimmeridge Clay 2300-2745 ft

The Kimmeridge Clay consists of medium brown to grey, very silty, fissile, moderately hard calcareous mudstones with shell debris, carbonaceous streaks and accessory pyrite. These mudstones grade into siltstones at intervals throughout the formation. Below 2600 ft there are several thin medium to dark brown very fine- to fine-grained calcareous sandstones. The Kimmeridge Clay is characterised by high gamma (55 API units) and low sonic velocity values with a moderately 'spikey' signature. Although the Portland Beds are present in the borehole, the Kimmeridge Clay is much thinner than expected. Geophysical markers in the top half of the Kimmeridge Clay in other nearby wells (e.g. Arreton No 2) appear to be absent at Southampton suggesting that here part of the formation is missing.

Corallian Beds 2745-2880 ft

The top of the Corallian is marked by a sudden decrease in gamma ray values and an increase in sonic velocities, indicating the incoming of a grey rubbly or oolitic grainstone with thin argillaceous partings. This is thought to be equivalent to the Osmington Oolite and extends to 2783 ft with a sandy base. Below this there are interbedded white to pale grey, very fine- to fine-grained, moderately sorted, calcareous, moderately hard sandstones, with subrounded subspherical grains, medium greyish-brown clayey siltstones and silty mudstones. Accessory pyrite is common throughout. Around 2855 ft there are two thin limestones. Below these, a downwards gradation into the Oxford Clay, from sandstone through siltstones to mudstones, takes place. This also is marked by a steady increase in gamma ray values and a decrease in sonic velocities.

Oxford Clay and Kellaways Beds 2880-3381 ft

Down to 3030 ft there are pale grey, calcareous, moderately soft silty mudstones with accessory pyrite and some shell debris. A shift to lower gamma ray and higher sonic velocities below the depth of 3030 ft marks the incoming of medium greyish-brown, calcareous, moderately hard siltstones which are thinly laminated, locally lignitic and contain shell debris. These extend downards to approximately 3160 ft where they grade into mudstones similar to those at the top of the Oxford Clay. Below 3230 ft there are interbedded brownish-greyish bituminous and weakly calcareous mudstones. The Kellaways Rock extends from 3322 to 3364 ft and comprises white, very fine- to fine-grained, moderately friable calcareous sandstone, with subrounded to subangular grains, grading to coarse-grained siltstone. This is marked by a distinct peak in the sonic and gamma ray curves. The underlying Kellaways Clay consists of grey-brown silty, calcareous and locally carbonaceous mudstones with high gamma ray values and low sonic velocities.

Cornbrash 3381-3428 ft

Limestones, pale grey to white skeletal grainstones are the dominant lithology, with minor amounts of sandy limestone. Some grey (?)pisoliths were also recorded. The Cornbrash limestones are distinguished from the subjacent Forest Marble limestones by their lower sonic and gamma ray values.

Forest Marble 3428-3581 ft

Pale grey calcareous mudstones with thin sandy and shelly limestone interbeds dominate the shaly unit above 3487 ft. Below 3487 ft limestones predominate. These are generally buff to white, hard, oolitic and skeletal grainstones, with subordinate wackestones with scattered skeletal debris. Echinoid spines and bivalve shells are abundant at various levels.

Great Oolite/Athelstan Oolite Formation 3581-3701 ft

The top of this unit is marked by a character change in sonic and density logs and the incoming of ooliths and oolitic limestone in the cuttings. Poorly sorted pale greyish white ooliths from fine- to coarse-sand size are common; minor quantities of oolitic grainstone, some with an apparent bimodality in oolith size population, were also recorded. Sandy limestones are developed below 3690 ft. The relationship of this unit with the Frome Clay/Fuller's Earth of Dorset remains unresolved, as in the Marchwood Borehole.

Fuller's Earth 3701-3796 ft

Medium to dark grey, silty, calcareous mudstone with carbonaceous streaks dominate this unit. Thin sandy and argillaceous limestone interbeds are well developed, particularly in the middle part. This formation may correlate with all or part of the Lower Fuller's Earth of Dorset.

Inferior Oolite 3796-3909 ft

The top of the Inferior Oolite is marked by a strong change in the character of the sonic and density logs. Limonitic ooliths are present near the top of this interval, and pale grey to white sparry wackestones with scattered shells and oolites predominate down to 3826 ft. These are referred to the Upper Inferior Oolite. Pale grey limestones, generally grainstones with sucrosic texture and minor quantities of very fine-grained quartz sand, are developed between 3826-3870 ft. These may belong to either the Lower or Middle Inferior Oolite. Oolitic and skeletal limestones characterise the lower part of this interval (Lower Inferior Oolite) with sandy and ferruginous limestones predominating below 3890 ft.

Upper Lias Sands 3909-4137 ft

A marked increase in gamma ray values and a slight increase in the interval transit time from the sonic log define the top of this unit. Sandstones, pale greyish white, very fine-grained, grading to coarse siltstone, moderately sorted, with subangular grains are the dominant lithology. An argillaceous matrix is common, and a calcite cement locally developed. Accessory minerals include mica and rare (?)chamosite.

Sample quality deteriorated after a circulation loss at 4020 ft, but the formation appears to become increasingly silty and argillaceous with depth. Traces of ironstone and sandy limestone were also recorded. Dipmeter results show a low dip, wih high azimuth variation, which may be due to the bioturbation commonly seen in this unit and observed in cores taken at Marchwood No 1.

Upper Lias Clay 4137-4246 ft

Medium grey siltstones, medium-grained, argillaceous, calcareous and micaceous, which grade to silty mudstones, are the dominant lithology. The passage from the overlying sands is gradational; the junction is marked by a slight increase in gamma ray and resistivity log values. Dip values from the HDT results appear to be relatively constant at 2° to 4° to the south.

Middle Lias

Marlstone Rock Bed equivalent 4246-4255 ft

This marker beds is characterised by a pronounced change in gamma, sonic and density log values. It comprises limestone, buff to white sparry to micritic wackestone with scattered ooliths and shell debris, and some very fine-grained quartz sand.

Middle Lias Silts and Clays 4255-4421 ft

Grey argillaceous siltstones and calcareous silty mudstones make up the bulk of this unit with some thin argillaceous limestones near the top. The lithological homogeneity of the unit is strikingly similar to the equivalent strata in Marchwood No 1. Dipmeter patterns reveal a shift in azimuth to the east with dips averaging 2°.

Lower Lias

Green Ammonite Beds 4421-4460 ft

This uppermost subdivison of the Lower Lias has no distinctive log marker at the top; it has been taken at a slight density change. Grey micaceous siltstones and silty mudstones are the dominant lithology.

Belemnite Marl 4460-4520 ft

Medium grey, argillaceous and calcareous siltstones and silty mudstones are the dominant lithological components of this unit. Geophysically the unit is characterised by lower gamma and interval transit time values due to the high carbonate content of the mudstones. A belemnite fragment was identified at 4470 ft.

Black Ven Marl and Shales with Beef 4520-4546 ft

Grey calcareous siltstone and silty mudstone were recorded in this interval.

Blue Lias 4546-4951 ft

This unit consists of alternation of grey fissile, occasionally micaceous and carbonaceous mudstone and pale grey argillaceous limestones, usually micro-crystalline grainstones. The beds give rise to highly characteristic serrated geophysical log signatures. Dipmeter results show a persistent 'green' pattern of dips at 2^{o} to 4^{o} to the north-east.

TRIASSIC

Penarth Group

Langport Member 4951-4984 ft

The Langport Beds (White Lias) form an excellent marker bed, with a highly distinctive lithology which produces strong changes in the gamma, sonic and density log values. It generally consists of pale grey to white limestone, a hard microcrystalline grainstone with sucrosic texture, but locally is a micritic packestone with some argillaceous partings.

Cotham Member 4984-4999 ft

Grey and greenish grey mudstones make up the bulk of this unit, with a thin argillaceous limestone at 4992 ft.

Westbury Formation 4999-5018 ft

Fissile, dark grey to black pyritic mudstones are the dominant lithology, with subordinate thin argillaceous limestone interbeds.

Mercia Mudstone Group

Blue Anchor Formation 5018-5082 ft

Silty mudstones and argillaceous siltstones of grey to greyish-green colour are the dominant lithology.

Variegated Marl 5082-5127 ft

This is a lithologically variable unit comprising greyish green micro-micaceous mudstones and reddish brown argillaceous, micaceous, siltstone. Trace amounts of anhydrite appear at this level.

Upper Red Marl 5127-5258 ft

Predominantly mudstones, reddish brown, silty, soft and slightly calcareous, with subordinate reddish brown argillaceous siltstone, blocky, occasionally micaceous, with pale green reduction spots. Traces of anhydrite are present throughout. Dipmeter results show a tectonic dip of 2° to the north-east.

Anhydritic Siltstone 5258-5350 ft

Although not easily distinguished on lithological grounds alone, the characteristic geophysical log signatures make this division a prominent marker in the middle of the Mercia Mudstone Group. The unit consists of soft, reddish brown mudstone and reddish brown argillaceous siltstone, with abundant anhydrite between 5270-5300 ft. The dipmeter results are of relatively poor quality at this level which may be caused by bad hole conditions.

Saliferous Marl (Equivalent) 5350-5498 ft

This interval comprises reddish brown mudstone, silty, with occasional matrix-supported sand grains. Minor amounts of white, calcareous very fine-grained sandstone are also present and give strong resistivity peaks at 5360 and 5410 ft. The halite equivalent identified at Marchwood No 1 is present between 5380-5425 ft. Structural dip remains in a north-north-easterly direction although the results are of poor quality.

Lower Red Marl 5498-5553 ft

Reddish brown, soft mudstones with matrix-supported sand grains are the dominant lithology, with traces of argillaceous siltstone and anhydrite.

"Waterstones" (equivalent) 5553-5674 ft (see also section 2.3)

Siltstone, reddish brown, fine- to coarse-grained, argillaceous, with occasional thin, very fine-grained sandstone interbeds makes up the bulk of this unit. The proportion of sandstone and sandstone bed thickness increases with depth; fining-upwards grain-size profiles are well developed in the core. Some nodular anhydrite was also seen. Dipmeter results show a structural dip to the north of 2° - 4°; low-dipping indistinct bedding was seen in the core.

Sherwood Sandstone Group

"Bunter" Sandstone 5674-5798 ft (see Section 2.3)

The top of the unit is marked by an abrupt change from sandy siltstone to sandstone in the core, together with a decrease in gamma and interval transit time values, and a resistivity change. The main rock type is sandstone, reddish brown, fine- to medium-grained, subangular to subrounded grains, moderately to poorly sorted, with a locally developed dolomitic cement and some argillaceous matrix. Beds of reddish brown mudstone and siltstone account for less than 5 per cent of the formation which, essentially, consists of thin, fining-upwards sandstone units with erosive bases, and ranging between 0.5 and 5.0 ft in thickness. Pebbly beds and intraclastic breccio-conglomerates are common. Small to medium scale cross-beddding and water expulsion structures are developed at various levels.

"Bunter" Pebble Beds 5798-5894 ft (see Section 2.3)

Conglomerate, pale green to reddish brown, is the dominant lithology. Clasts range from pebble to cobble size, are well rounded, poorly sorted and show some evidence of corrosion or weathering. No fabric could be discerned but the part of the formation which was cored (to 5814 ft) had three very thin low-dipping sandstone beds. Purple sandstone, siltstone, white quartzite and quartz are present as clasts. The matrix consists of fine- to coarse-grained purplish red sandstone, poorly sorted, subangular grains with dolomitic cement. Log porosity values range from 6 to 10 per cent; the core appears to be impermeable throughout. The formation is characterised by low gamma ray values (40-45 API units). At the base there is thought to be a strong unconformity which is illustrated by an azimuth shift in the dipmeter results, although the rock types at this level produce poor quality dipmeter data.

(?)DEVONIAN

<u>(?)Old Red Sandstone</u> 5894-5994 ft

Two main rock types were identified in the cuttings. The dominant component is a purplish grey sandstone, very fine- to fine-grained, with subangular to angular, elongate to subspherical grains, generally poorly sorted, hard and tight with silica cement and patches of ferroan dolomite. Hematite staining is common. Siltstone, reddish brown, hard, with some matrix-supported sand grains and abundant hematite was the minor lithology. Traces of pale greenish white siliceous sandstone were also recorded. Gamma ray and density logs are the only geophysical logs available for the formation; the length of the ISF/sonic sonde precluded the possibility of logging to the bottom of the hole.

2.3 Core Description

Mercia Mudstone Group

'Waterstones' 5553-5674 ft (cored only from 5588 ft)

(Core 1 5588-5649 ft)

(Core 2 5649-5674 ft)

Predominantly (85%) siltstones grading to thin (6-12") sandstones; together form several fining-upward units, all having erosional bases.

Siltstones, reddish brown to mottled green (reduction spots), argillaceous, calcareous to dolomitic cement, poor visible porosity. Numerous laminae of very fine-to fine-grained sandstone and a reddish brown mudstone.

Sandstones, light to medium reddish brown, fine- to medium-grained, moderately sorted with angular to subrounded grains, calcareous, occasionally dolomitic, moderately to well cemented, very poor visible porosity, hard to very hard.

Anhydrite, pale pink to white, very fine to coarsely crystalline, sparry, brittle, locally occurring as bands and nodules in the siltstones, some nodules flattened parallel to bedding.

Sherwood Sandstone Group

'Bunter' Sandstone 5674-5798 ft

(Core 2 5674-5708 ft)

(Core 3 5708-5726 ft)

(Core 4 5726-5744 ft)

(Core 5 5744-5798 ft)

Comprises a sequence of conglomerate, sandstone, siltstone and mudstone, in fining-upwards units of variable thickness and completeness, with erosive contacts.

(a) Interval 5674-5735 ft

Conglomerate, intraclasts of reddish brown sandstone, siltstone and mudstone, poor visible porosity and little fracturing; in addition at 5720 ft, 5723 ft, 5726-5730 ft, clasts of vein quartz; medium-to coarse-grained sandstone matrix, very poorly sorted, calcareous cement, moderately hard to friable, moderate visible porosity; the sonic, density and neutron logs indicate a porous zone at 5725-5729 ft.

Sandstone, pale pink to reddish brown, sporadically mottled green, very fine-to coarse-grained, moderately to poorly sorted, subangular to subrounded grains, moderately to well cemented, calcareous, traces of mica and anhydrite. Cross bedding in some units, loading common at mudstone/sandstone bed contacts. Coarse-to very coarse-grained sandstone is present in the interval 5732.5 to 5734.5 ft, with intraclasts of sandstone, siltstone and anhydrite, exhibiting total bed disruption as a result of dewatering and loading.

Siltstone, reddish brown, argillaceous, calcareous, poor visible porosity.

Mudstone, reddish brown and green, argillaceous, calcareous. Sporadic thin laminae of very fine-grained sandstone.

(b) Interval 5735-5757 ft

Dominated by sandstone light to dark reddish brown, medium-to very coarse-grained, subangular to subrounded grains, moderately to poorly cemented, calcareous and anhydritic, argillaceous and micaceous, clasts of red to greyish green siltstone, also mudstone clasts towards base, heavily fractured, friable, moderate to good visible porosity. Sonic, neutron and density logs indicate porous zones between 5739 and 5741 ft and between 5748 and 5751 ft.

Minor siltstone at 5744 ft, purplish to reddish brown, fine-to coarse- grained, very argillaceous and heavily fractured.

Loading and water expulsion structures are present.

(c) Interval 5757-5798 ft

Intraformational conglomerate, clasts well rounded to subangular, pebble grade, of reddish brown, greyish green sandstone, siltstone and mudstone; fining-upward into attenuated sequences of sandstone, siltstone and mudstone. Sandstones, pale to dark reddish brown, some mottling, very fine- to very coarse-grained, moderately to poorly sorted, subangular to subrounded grains, moderately to well cemented, calcareous, occasionally dolomitic, poor visible porosity. Load structures common. Siltstones, purplish to reddish brown, fine to coarse-grained, micaceous, argillaceous, with minor very fine-grained sandstone laminae and with a dolomitic cement.

Mudstones, (subordinate) reddish brown, micaceous, argillaceous, calcareous.

"Bunter" Pebble Beds 5798-5894 ft (cored only to 5814 ft)

(Core 5 5798-5804 ft)

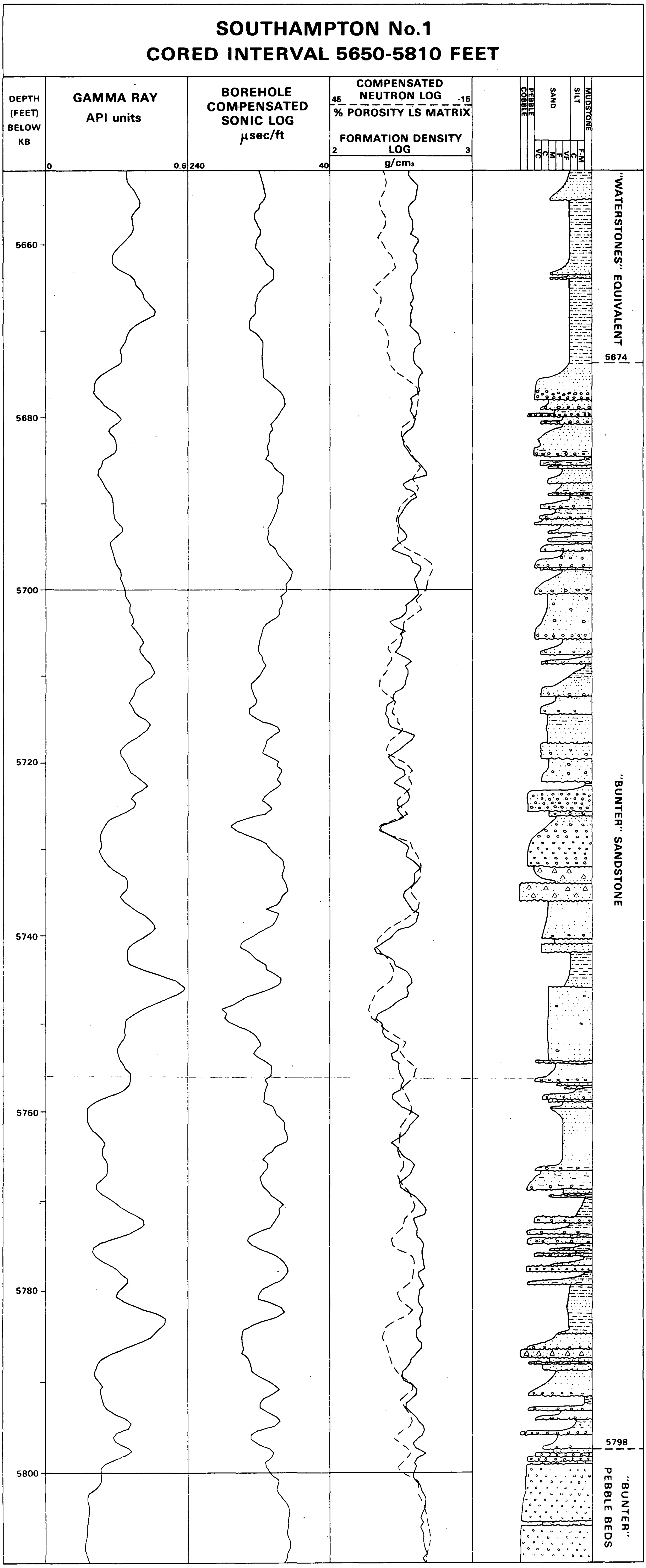
(Core 6 5804-5814 ft)

In the cored interval, conglomerate units (1-6 ft) predominate with thin intervening (3-6") sandstones.

Conglomerate, polymict, poorly sorted with a coarse reddish brown sandstone matrix, calcareous, well cemented, poor visible porosity, little fracturing. Clasts in the conglomerate are well rounded to slightly elongated pebbles and cobbles of reddish brown sandstone and siltstone, milky quartz, quartzite, and chert. Other clasts are tabular and angular to subrounded, including minor reddish brown mudstone.

Sandstone, reddish brown, medium- to coarse-grained, moderately to well cemented, calcareous. Compaction by overlying beds has produced flame and drape structures (eg. at 5806 ft).

2.4 Graphical Log of Cored Section



2.5 Dipmeter Results

Mercia Mudstone Group

'Waterstones' 5553-5674 ft

The tadpole plot on a 2 ft interval and 2 ft step gives a basically 'green' pattern with maximum variation at the base, dip values ranging between 3° and 5°. A nose plot for this interval gives a 360° to 030° direction for the structural dip.

Sherwood Sandstone Group

'Bunter' Sandstone 5674-5798 ft

The tadpole plot shows a division into three parts. The upper part, 5674-5706 ft, shows a fairly random 'bag of nails' scatter plot, with average dip values ranging between 3° and 10°. The middle part, 5706-5755 ft, shows again a 'bag of nails' scatter, but with dip values falling into two groups, those between 3° and 7° and those between 15° and 30°. The lower part, 5755-5798 ft, shows again a 'bag of nails' scatter but as in the upper part, values are almost entirely between 2° and 10°.

The two sets of dip values in the middle section may represent structural dip (low values) and sedimentary bedding dip (high values). Because of the random orientation of the plots the direction of structural dip was not readily determined.

'Bunter' Pebble Beds 5798-5894 ft

Tadpole plots show a random 'bag of nails' scatter with a wide range in the amount of dip in the top 40 ft from 2° to 35°. In the bottom 50 ft, the values are all in the 20° to 40° range. The latter values may indicate the development of large cross-beds in the lower conglomerates.

2.6 Hydrocarbon Indications

Continuous total gas, chromatograph and cuttings analyses were carried out by Exploration Logging and presented on the Formation Evaluation Log. No indications of oil were found at any level.

Insignificant amounts of gas were recorded in the beds above the Oxford Clay. In the Oxford Clay a maximum of 750 ppm (0.075%) total gas was recorded at 3040 ft. In the Upper Lias Sands a value of 100 ppm total gas was recorded at 4020 ft. Other peaks occurred in the Blue Lias where values of 84 ppm (4560 ft) and 300 ppm (4710 ft) were recorded. Below this depth only traces of gas were observed to terminal depth.

3. LOGGING DATA

3.1 Mud Logging

Exploration Logging provided a standard unit with following conventional logging services .

1) Continuous mud-gas detector and gas chromatograph for total hydrocarbons.
2) Record mud temperature and weight.
3) Dual Pump Stroke counter and totaliser with strokes per minute recorder.
4) Drilling and penetration rate recorder giving total depth and kelly position.
5) Cuttings blender.

Samples were collected at 10 ft intervals, for analysis on site and at IGS laboratories. Wet, bulk samples were collected for organic geochemistry of the Jurassic part of the sequence by Amoco. Samples were also collected at 30 ft intervals for thermal conductivity determinations by Imperial College, London.

3.2 Wireline Logging

Schlumberger and Tesel carried out the wireline logging; Seismograph Services Ltd the velocity survey. All logs were referenced from Kelly Bushing. A summary of the logs is given below.

Run 1 Schlumberger 0 to 3000 ft

ISF/BHCS/GR (9/10/81)

Tesel 0 to 3000 ft

AST (Sonic))

IRT (Induction)) (9/10/81)

CDT/GR/CAL)

Run 2 Schlumberger 3000 ft to T.D.

ISF/MSFL/BHCS/GR/CAL (17/11/81)

FDC/CNL/GR/CAL 3010 to 5626 ft (18/11/81)

FDC/CNL/GR/CAL 5625 ft to T.D. (6/12/81)

HDT (27/11/81)

CAL (1/12/81)

Temperature (6/12/81)

CIS (Seismograph Services Ltd)

Copies of the logs are available at 1:500 and 1:200 scales.

4. RESULTS OF CORE ANALYSIS FOR POROSITY, PERMEABILITY AND GRAIN DENSITY

Symbols :

g - Gas determined values

L - Liquid determined values

K - Hydraulic conductivity at 70°C

B - Dry bulk density (g cm^{-3})

G - Grain density (g cm^{-3})

n - Natural determination

A - Porosity (percent)

k - Permeability (millidarcies)

H - Horizontal plug

V - Vertical plug

- - Below range of liquid permeameter

* - Suspect result - mis-shapen plug

+ - Not tested for permeability

MERCIA MUDSTONE GROUP ("WATERSTONES" (equivalent))

Plug No	Depth (ft)	kg	kL	kg	KL	ρBn	ρBL	ρGn	ρGL	An	AL
1225-1V	5602' 5"	0.56	-	$9.2\text{x}10^{-4}$	-	2.439	2.440	2.743	2.736	11.09	10.83
-1H		0.64	-	$1.0\text{x}10^{-3}$	-	2.447	2.445	2.732	2.727	10.43	10.32
-2V	5614' 6"	0.03	-	$5.6\text{x}10^{-5}$	-	2.504	2.498	2.739	2.720	8.58	8.17
-2H1		0.2	14.72*	$3.0\text{x}10^{-5}$	$2.4\text{x}10^{-2}$*	2.523	2.502	2.743	2.725	8.04	8.21
-2H2		0.01	-	$2\text{x}10^{-5}$	-	-	2.547	-	2.721	-	6.38
-3V	5630' 4½"	-0.02	-	$2.5\text{x}10^{-5}$	-	2.493	2.481	2.749	2.729	9.31	9.09
-3H		0.06	-	$9.9\text{x}10^{-5}$	-	2.480	2.470	2.751	2.727	9.85	9.43
-4V	5643' 6½"	0.12	-	$2.0\text{x}10^{-4}$	-	2.441	2.425	2.706	2.703	9.81	10.27
-4H1		0.12	-	$2.9\text{x}10^{-4}$	-	2.447	2.432	2.706	2.702	9.56	9.97
-4H2		<0.01	-	$<2\text{x}10^{-5}$	-	-	2.443	-	2.709	-	9.84
-5V	5659' 6"	0.26	-	$4.2\text{x}10^{-4}$	-	2.391	2.391	2.735	2.733	12.58	12.51
-5H		0.10	-	$1.6\text{x}10^{-4}$	-	2.512	21.497	2.724	2.714	7.77	7.97
-6V	5673' 11"	0.08	-	$1.3\text{x}10^{-4}$	-	2.515	2.502	2.757	2.728	8.79	8.29
-6H		0.5	-	$7.7\text{x}10^{-5}$	-	2.508	2.500	2.764	2.736	9.26	8.60

SHERWOOD SANDSTONE GROUP ("BUNTER" SANDSTONE)

Plug No	Depth (ft)	kg	kL	Kg	KL	ρBn	ρBL	ρGn	ρGL	An	AL
1225-7V	5674' 5"	0.64	-	1.1×10^{-3}	-	2.417	2.408	2.701	2.695	10.53	10.66
-7H		8.17*	-	1.3×10^{-2}	-	2.417	2.404	2.700	2.693	10.49	10.71
-8V	5679' 4"	0.06	-	9.1×10^{-5}	-	2.551	2.550	2.739	2.728	6.85	6.55
-8H1		0.05	-	8.1×10^{-5}	-	2.552	2.549	2.720	2.710	6.17	5.96
-8H2		<0.01	-	$<2 \times 10^{-5}$	-	-	2.529	-	2.701	-	6.35
-9V	5684' 2"	0.11	-	1.9×10^{-4}	-	2.551	2.541	2.705	2.697	5.68	5.78
-9H		0.07	-	1.1×10^{-4}	-	2.534	2.533	2.704	2.698	6.28	6.11
-10V	5689' 2"	0.05	-	8.2×10^{-5}	-	2.514	2.519	2.706	2.703	7.12	6.81
-10H1		0.20	-	3.3×10^{-4}	-	2.476	2.480	2.713	2.712	8.74	8.55
-10H2		0.17	-	2.8×10^{-4}	-	-	2.375	-	2.684	-	11.51
-11V	5691' 7"	48.8	35.9	8.0×10^{-2}	5.9×10^{-2}	2.272	2.260	2.659	2.666	14.55	15.25
-11H1		76.8	71.1	1.3×10^{-1}	1.2×10^{-1}	2.272	2.261	2.659	2.666	14.54	15.20

SHERWOOD SANDSTONE GROUP ("BUNTER" SANDSTONE)

Plug No	Depth (ft)	kg	kL	Kg	KL	ρBn	ρBL	ρGn	ρGL	An	AL
1225-11H2		102.8	-	$1.7x10^{-1}$	-	-	2.262	-	2.662	-	15.01
-12V	5693' 11"	0.38	-	$6.3x10^{-4}$	-	2.551	2.546	2.683	2.674	4.92	4.77
-12H		0.64	-	$1.1x10^{-3}$	-	2.533	2.521	2.683	2.675	5.59	5.79
-13V	5696' 6"	0.05	-	$8.8x10^{-5}$	-	2.564	2.567	2.650	2.653	3.23	3.25
-13H1		0.74	-	$1.2x10^{-3}$	-	2.563	2.563	2.658	2.661	3.58	3.68
-13H2		6.1	-	$1.0x10^{-2}$	-	-	2.617	-	2.723	-	3.87
-14V	5698' 9½"	0.04	-	$7.0x10^{-5}$	-	2.593	2.596	2.674	2.677	3.03	3.02
-14H		0.02	-	$3.1x10^{-5}$	-	2.602	2.604	2.669	2.673	2.52	2.57
-15V	5701' 4½"	3.97	-	$6.5x10^{-3}$	-	2.420	2.425	2.649	2.660	8.65	8.86
-15H		0.63	-	$1.0x10^{-3}$	-	2.429	2.442	2.651	2.664	8.36	8.35
-16V	c.5702' 8"	26.2	1.14	$4.3x10^{-2}$	$1.9x10^{-3}$	2.425	2.425	2.634	2.646	7.92	8.37
-16H1		481*	143*	$7.9x10^{-1}$	$2.4x10^{-1}$	2.283	2.281	2.619	2.638	12.83	13.91

SHERWOOD SANDSTONE GROUP ("BUNTER" SANDSTONE)

Plug No	Depth (ft)	kg	kL	Kg	KL	ρBn	ρBL	ρGn	ρGL	An	AL
1225-16H2		91.1	-	$1.5x10^{-1}$	-	-	2.429	-	2.647	-	8.23
-17V	5705' 3"	35.4	7.11	$5.8x10^{-2}$	$1.2x10^{-2}$	2.102	2.101	2.610	2.699	19.45	20.53
-17H		33.4	23.1	$5.5x10^{2}$	$3.8x10^{-2}$	2.100	2.096	2.610	2.644	19.54	20.73
-18V	5705' 6½"	18.7	11.9	$3.1x10^{-2}$	$2.0x10^{-2}$	2.417	2.411	2.632	2.646	8.16	8.89
-18H1		409	173	$6.7x10^{-1}$	$2.9x10^{-1}$	2.326	2.318	2.623	2.639	11.31	12.17
-18H2		405	-	$6.7x10^{-1}$	-	-	2.393	-	2.644	-	9.50
-19V	5707' 6½"	<0.01	-	$<2x10^{-5}$	-	2.400	2.438	2.714	2.732	11.57	10.75
-19H1		0.44	-	$7.2x10^{-4}$	-	2.447	2.468	2.705	2.722	9.53	9.31
-19H2		0.13	-	$2.1x10^{-4}$	-	-	2.417	-	2.724	-	11.26
-20V	5709' 2½"	198	295	$3.3x10^{-1}$	$4.9x10^{-1}$	2.085	2.081	2.605	2.641	19.96	21.22
-20H1		357	440	$5.9x10^{-1}$	$7.2x10^{-1}$	2.111	2.107	2.606	2.639	19.03	20.15
-20H2		594	-	$9.8x10^{-1}$	-	-	2.091	-	2.640	-	20.80
-21V	5712' 6"	2.79	-	$4.6x10^{-3}$	-	2.405	2.403	2.628	2.651	8.47	9.36
-21H1		0.16	-	$2.6x10^{-4}$	-	2.556	2.558	2.656	2.666	3.78	4.04

SHERWOOD SANDSTONE GROUP ("BUNTER" SANDSTONE)

Plug No	Depth (ft)	kg	kL	Kg	KL	ρBn	ρBL	ρGn	ρGL	An	AL
1225-21H2		0.48	-	7.9×10^{4}	-	-	2.549	-	2.665	-	4.36
-22V	5715' 9"	2.70	1.42	4.4×10^{-3}	2.3×10^{-3}	2.345	2.348	2.651	2.670	11.53	12.09
-22H		18.3	19.6	3.0×10^{-2}	3.2×10^{-2}	2.007	2.008	2.607	2.651	23.01	24.25
-23V	5717' 7"	2.66	-	4.4×10^{-3}	-	2.478	2.483	1.648	2.662	6.43	6.73
-23H1		0.31	-	5.2×10^{-4}	-	2.490	2.489	2.649	2.666	5.98	6.65
-23H2		1.10	-	1.8×10^{-3}	-	-	2.483	-	2.667	-	6.91
-24V	5718' 3½"	846	757	1.39	1.24	1.906	1.916	2.539	2.625	24.94	27.00
-24H1		559	763	9.2×10^{-1}	1.25	1.911	1.920	2.539	2.625	24.73	26.84
-24H2		2798	-	4.60	-	-	1.974	-	2.629	-	24.91
-25V	5724' 6"	0.05	-	8.74×10^{-5}	-	2.396	2.442	2.657	2.722	9.80	10.29
-25H		0.12	-	2.0×10^{-4}	-	2.411	2.484	2.626	2.703	7.76	8.12
-26V	5725' 8½"	39.1	1.80	6.4×10^{-2}	3.0×10^{-3}	2.092	2.126	2.570	2.641	18.59	19.49
-26H1		1316	91	2.16	1.5×10^{-1}	1.956	1.976	2.551	2.629	23.32	24.82
-26H2		239	-	3.9×10^{-1}	-	-	2.068	-	2.637	-	21.56

SHERWOOD SANDSTONE GROUP ("BUNTER" SANDSTONE)

Plug No	Depth (ft)	kg	kL	Kg	KL	ρBn	ρBL	ρGn	ρGL	An	AL
1225 -27V	5726' 9"	+	+	+	+	2.413	2.446	2.634	2.680	8.37	8.71
-27H		+	+	+	+	2.214	2.240	2.600	2.662	14.85	15.84
-28V	5729' 10"	0.29	-	4.7×10^{-4}	-	2.530	2.569	2.623	2.668	3.57	3.70
-28H		7.46	6.82	1.2×10^{-2}	1.1×10^{-2}	2.479	2.513	2.609	2.654	4.96	5.31
-29V	5732' 1"	146	55.7	2.4×10^{-1}	9.2×10^{-2}	1.966	1.991	2.544	2.624	22.73	24.15
-29H1		569	608	9.4×10^{-1}	1.0	1.971	1.989	2.542	2.625	22.45	24.22
-29H2		0.14	-	2.3×10^{-4}	-	-	2.508	-	2.661	-	5.74
-30V	5734' 9½"	0.03	-	4.5×10^{-5}	-	2.539	2.565	2.656	2.632	4.40	2.53
-30H1		<0.01	-	$<2\times10^{-5}$	-	2.541	2.567	2.655	2.675	4.28	4.01
-30H2		0.1	-	2×10^{-5}	-	-	2.466	-	2.692	-	8.40
-31V	5737' 6"	244	314	4.0×10^{-1}	5.2×10^{-1}	1.983	1.998	2.537	2.626	21.84	23.93
-31H1		251	184	4.1×10^{-1}	3.0×10^{-1}	1.996	2.015	2.542	2.628	21.45	23.30
-31H2		283	-	4.7×10^{-1}	-	-	2.080	-	2.631	-	20.96

SHERWOOD SANDSTONE GROUP ("BUNTER" SANDSTONE)

Plug No	Depth (ft)	kg	kL	Kg	KL	ρBn	ρBL	ρGn	ρGL	An	AL
1225-32V	5739' 6"	11.3	5.67	1.9×10^{-2}	9.3×10^{-3}	2.335	2.335	2.586	2.644	9.73	10.91
-32H1		88.9	277	12.5×10^{-1}	4.6×10^{-1}	2.284	2.318	2.579	2.641	11.44	12.21
-32H2		1970	-	3.2	-	-	2.148	-	2.633	-	18.45
-33V	5743' 9"	0.07	-	1.1×10^{-4}	-	2.406	2.458	2.671	2.677	9.93	8.19
-33H		<0.01	-	$<2 \times 10^{-5}$	-	2.439	2.497*	2.683	2.571*	9.08	2.86*
-34V	5745' 4"	688	1260	1.1	2.07	1.894	1.912	2.515	2.612	24.69	26.80
-34H1		658	1405	1.1	2.31	1.896	1.909	2.515	2.615	24.63	26.99
-34H2		2144	-	3.5	-	-	1.912	-	2.609	-	16.70
-35V	5748' 10"	0.76	-	1.3×10^{-3}	-	2.442	2.474	2.598	2.655	6.00	6.81
-35H1		2.95	1.45	4.9×10^{-3}	2.4×10^{-3}	2.473	2.505	2.604	2.656	5.06	5.68
-35H2		2387	-	3.9	-	-	2.346	-	2.645	-	11.32
-36V	5753' 2"	51.1	40.0	8.5×10^{-2}	6.6×10^{-2}	2.280	2.307	2.589	2.644	11.92	12.76
-36H		1.5	-	2.5×10^{-3}	-	2.406	2.435	2.617	2.667	8.05	8.70
-37V	5756' 0"	26.0	16.1	4.3×10^{-2}	2.7×10^{-2}	2.220	2.235	2.580	2.647	13.98	15.56

SHERWOOD SANDSTONE GROUP ("BUNTER" SANDSTONE)

Plug No	Depth (ft)	kg	kL	Kg	KL	ρBn	ρBL	ρGn	ρGL	An	AL
1225-37H1		4.1	-	6.8×10^{-2}	-	2.371	2.401	2.609	2.662	9.12	9.81
-37H2		452	-	7.4×10^{-1}	-	-	2.209	-	2.639	-	16.29
-38V	5738' 3½"	0.08	-	1.4×10^{-4}	-	2.546	2.576	2.651	2.697	3.95	4.51
-38H		0.06	-	1.0×10^{-4}	-	2.551	2.583	2.654	2.699	3.86	4.29
-39V	5763' 0"	1.00	-	1.6×10^{-3}	-	2.340	2.362	2.630	2.692	11.05	12.27
-39H1		2.54	-	4.2×10^{-2}	-	2.315	2.336	2.633	2.696	12.08	13.35
-39H2		3.93	-	6.5×10^{-3}	-	-	2.372	-	2.695	-	11.97
-40V	5767' 10½"	0.07	-	1.2×10^{-4}	-	2.521	2.542	2.657	2.706	5.14	6.07
-40H		0.06	-	1.0×10^{-4}	-	2.518	2.542	2.659	2.709	5.29	6.17
-41V	5773' 0½"	0.02	-	3.3×10^{-5}	-	2.552	2.581	2.653	2.700	3.79	4.41
-41H1		0.02	-	3.8×10^{-5}	-	2.543	2.575	2.652	2.699	4.12	4.60
-41H2		0.02	-	2.8×10^{-5}	-	-	2.554	-	2.705	-	5.58
-42V	5778' 1½"	0.09	-	1.4×10^{-4}	-	2.513	2.545	2.643	2.691	4.94	5.45
-42H		0.04	-	6.5×10^{-5}	-	2.500	2.531	2.640	2.689	5.30	5.85

SHERWOOD SANDSTONE GROUP ("BUNTER" SANDSTONE)

Plug No	Depth (ft)	kg	kL	Kg	KL	ρBn	ρBL	ρGn	ρGL	An	AL
1225-43V	5783' 0"	0.39	-	$6.5x10^{-4}$	-	2.397	2.459	2.678	2.738	10.50	10.20
-43H1		6.09	-	$1.0x10^{-2}$	-	2.350	2.444	2.668	2.726	11.94	10.35
-43H2		16.6	-	$2.7x10^{-2}$	-	-	2.456	-	2.700	-	11.34
-44V	5788' 2"	1.40	-	$2.3x10^{-3}$	-	2.249	2.276	2.616	2.687	14.03	15.30
-44H1		4.20	-	$6.9x10^{-3}$	-	2.266	2.289	2.623	2.694	13.61	15.02
-44H2		12.1	-	$2.0x10^{-2}$	-	-	2.238	-	2.693	-	16.91
-45V	5793' 8"	0.17	-	$2.8x10^{-4}$	-	2.480	2.515	2.646	2.697	6.26	6.74
-45H		0.56	-	$9.2x10^{-4}$	-	2.370	2.393	2.633	2.692	9.98	11.11
SHERWOOD SANDSTONE GROUP ("BUNTER" PEBBLE BEDS)											
1225-46V	5798' 1"	0.04	-	$6.2x10^{-5}$	-	2.501	2.527	2.641	2.692	5.31	6.10
-46H1		0.08	-	$1.3x10^{-4}$	-	2.479	2.512	2.637	2.688	6.01	6.54
-46H2		0.01	-	$2.2x10^{-5}$	-	-	2.487	-	2.693	-	7.63
-47V	5803' 10½"	0.20	-	$3.2x10^{-4}$	-	2.544	2.576	2.638	2.682	3.59	3.96
-47H		12.6*	-	$2.1x10^{-2}$*	-	2.547	2.586	2.641	2.675	3.58	3.33

5. LIST OF ENCLOSURES

82/3/1	Composite Log	1:500	
82/3/2	Mud Log	1:500	
Schlumberger Logs			
82/3/3	ISF/BHCS/GR	1:200	Run 1
82/3/4	ISF/BHCS/MSFL/GR/CAL	1:200	Run 2
82/3/5	FDC/CNL/GR/CAL (3010' - 5626')	1:200	Run 2
82/3/6	FDC/CNL/GR/CAL (5625' - T.D.)	1:200	Run 2
82/3/7	HDT - resistivity curves	1:200	
82/3/8	HDT - clustered data	1:200	
82/3/9	Temperature	1:200	
82/3/10	Caliper Log	1:200	
82/3/11	ISF/BHCS/GR	1:500	Run 1
82/3/12	ISF/BHCS/MSFL/GR/CAL	1:500	Run 2
82/3/13	FDC/CNL/GR/CAL (3010' - 5626')	1:500	Run 2
82/3/14	FDC/CNL/GR/CAL (5625' -T.D.)	1:500	Run 2
82/3/15	HDT - clustered data	1:500	
82/3/15	Temperature	1:500	
Tesel Logs			
82/3/16	CDT/GR/CAL	1:200	
82/3/17	AST	1:200	
82/3/18	IRT	1:200	
82/3/19	CDT/GR/CAL	1:500	
82/3/20	AST	1:500	
82/3/21	IRT	1:500	
Exploration Computing			
82/3/23	Continuous eccentricity plot	1:500	
82/3/24	Dip Log 2 ft x 2 ft (3009' - 5967') 1:500	1:200	
82/3/25	Dip Log 3" x 1" (3900' - 4150')	1:20	
82/3/26	Dip Log 3" x 1" (5650' - 5800')	1:20	
Seismograph Services Ltd			
82/3/27	Velocity Survey, Calibrated Log Data		
82/3/28	DWS field report		
82/3/29	Velocity Survey	1:500	
82/3/30	Velocity Survey	1:1000	
82/3/31	TWT	15 - 10 cms	
82/3/32	TWT listing		