THE ARAB REPUBLIC OF EGYPT

NORTH SINAI GROUNDWATER RESOURCES STUDY IN THE ARAB REPUBLIC OF EGYPT

FINAL REPORT

TECHNICAL REPORT

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JAPAN INTERNATIONAL COOPERATION AGENCY
(JICA)

TECHNICAL REPORT

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1. INTRODUCTION

1 INTRODUCTION

The groundwater use in North Sinai has a long history especially in the area along the eastern part of the Mediterranean coast. There are also many shallow wells scattered over the area between Bir El-Abd and Romana in the western part of the coastal plain. In addition, some exploratory wells for petroleum and other purposes have been drilled at many places in the study area.

All data collected were compiled into data sheets for processing, reviewing and reanalysis.

In order to obtain hydrogeological informations in the area where no data was available, some test wells were drilled during the study. RIWR also had a plan to drill test wells in the study area. Therefore, consideration was given to determine these test well locations to attain an integral data collection between the above two groups of test wells.

In the following part of this report, all available data were reviewed and analyzed in order to evaluate the groundwater resources in the study area.

Since the aquifers develop in different kinds of geologic units, they are primarily classified into two groups: the Quaternary and the Pre-Quaternary aquifers.

2. AVAILABLE DATA

2 AVAILABLE DATA

2-1 Aquifer in Quaternary

2-1-1 Introduction

Although details are not available at present, it is evident that groundwater in El-Arish area was used as a precious water source even during Roman times. Since that time, groundwater has remained an essential water source in this area.

The number of wells has rapidly increased in the 1980s in the area between El-Arish and Rafah along the north coast of the peninsula. At present, the number of wells exceeds 500; they are utilized for domestic use and the irrigation of local farms.

Shallow wells are also scattered over the area from Bir El Abd to Romana in the western part of the north coast in the study area. There are 400 of these wells. They are the only available source for irrigation of vegetables and fruits at local farms.

Although the number of existing wells is large, available hydrogeological data are somehow limited since most of them are drilled by local farmers for irrigation use.
These wells distribute in three areas with hydrogeological characteristics of each locality:

1) El-Arish area,
2) Sheikh Zuwayid - Rafah area and
3) Bir El-Abd - Romana area.

Data of the existing wells extracting groundwater from the Quaternary aquifers in the above areas are compiled in a comprehensive well data inventory, including a systematic well code, in the appendix of the Groundwater Management Study El-Arish-Rafah Plain Area (GMS) published by RIWR, 1988. This publication is the major data source of this study concerning the wells tapping water from the Quaternary aquifers in the above area. Therefore, a major part of the description of existing wells in the Quaternary aquifer is the status of the existing wells in 1988. To

avoid the intricacies of a numbering system for the existing wells of the Quaternary aquifers, the numbering of wells in this study follows the GMS code system.

In addition to the data on the existing wells, some additional well data were obtained by the test wells drilled by RIWR and the study team in the Quaternary aquifers as described below.

2-1-2 Existing Wells at El-Arish

There are 176 wells in the El-Arish area. The oldest one on record is the well No. 1-10 drilled in 1926 which locates three kilometers west of El-Arish town. It still produces 35 m^3/hr. About 10 wells were in operation by the end of the 1940s. They are distributed on the west and the east sides of El-Arish town except for well No. 1-95 which is located north of the airport.

Since then, 13 additional wells were drilled by the end of the 1960s. They are distributed in the eastern side of El-Arish town. At present there has been a remarkable increase in the number of water wells in the area.

All of these wells are consist of the following groups as summarized in Table 2-1-1.

It appears that there are abundant well data; however, the extent of the available data for interpretation of hydrogeological aspects is limited, since most of these wells were drilled by local farmers for irrigation.

There are 27 wells with lithological profiles and 5 wells with lithological descriptions accompanied by well logging data drilled by the GDDO in the early 1960s. Lithological profiles are also available for three wells drilled by RIWR. The locations of these wells are shown in Fig. 2-1-1.

Table 2-1-1 Existing Wells at El-Arish

Well Group	Number of Wells
1 Production Wells	145
(1) Domestic water source	33
(2) irrigation	112
2 Non production wells	31
(1) Production wells but not in use	15
(2) Abandoned	7
(3) Test wells	3
(4) Piezometer	3
(5) Observation wells	3
Total	176

These available data are interpreted for the analysis of the Quaternary aquifers from a hydrogeological point of view (2-2-4 Interpretation of Well Data).

2-1-3 Existing Wells at Sheikh Zuwayid and Rafah Area

A large number of wells distribute in this area. They are concentrated on the coastal sand dunes along the eastern part of the Mediterranean coast and on the terrace behind the dunes along the El-Arish - Rafah road. There are approximately 300 of these wells.

The oldest well (No. 16-14) recorded is located in Rafah town. It was drilled in 1920, is still in operation, and yiels about 40 m^3/hr. During the 1950s one more well (No. 1-112) was constructed. Fifteen wells were drilled in the 1960s. These wells are distributed on the eastern part of the coastal sand dunes and in the vicinity of Rafah town. The remaining large number of wells were constructed during the 1970s and the 1980s. There was a remarkable increase in the number of wells during this period.

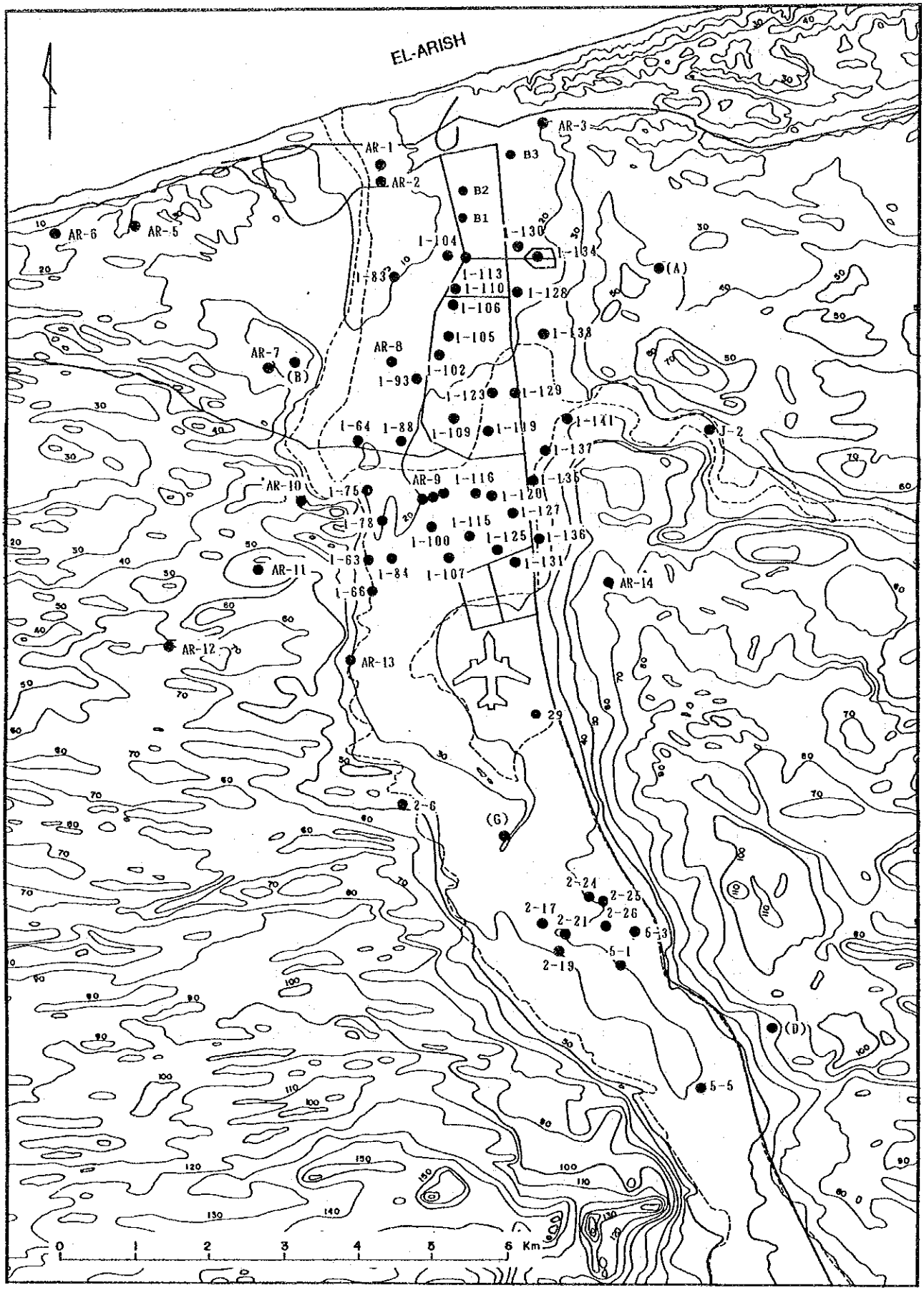


FIG. 2-1-1 LOCATION OF QUATERNARY WELLS AT EL - ARISH AREA

These wells consist of the following groups:

Table 2-1-2 Existing Wells at Sheikh Zuwayid and Rafah Area

Group of Wells	Number of Wells
1. Production Wells	280
(1) Domestic water source	52
(2) Irrigation	228
2. Non production wells	39
(1) Production wells not in use	32
(2) Abandoned	3
(3) Test wells	1
(4) Piezometer	2
(5) Observation wells	1
Total	319

Of these wells, lithological descriptions are available at 27 sites including two oil exploratory wells: El-Khabra and Misiri-1, and RIWR Darb El-Sultan test well.

Locations of these wells are shown in Fig. 2-1-2. These were interpreted for the analysis of hydrogeological aspects in Section 2-2-4

2-1-4 Existing Wells at Bir El-Abd and Romana Area

There are approximately 400 shallow wells scattered over 400 km^2 in the western part of the Mediterranean coast between Bir El Abd and Romana. These wells are intensively used for small-scale irrigation by local farmers.

The depth of these wells varies within ten meters from the ground surface. Many different types of structures were observed: simple dug wells, bored piped wells and wells with concrete rings. Many wells are equipped with a small motor pump. Water is tapped from the sand bed in the sand dune.
Location of these wells is shown in Fig. 3-2-3 of Section 3-2.

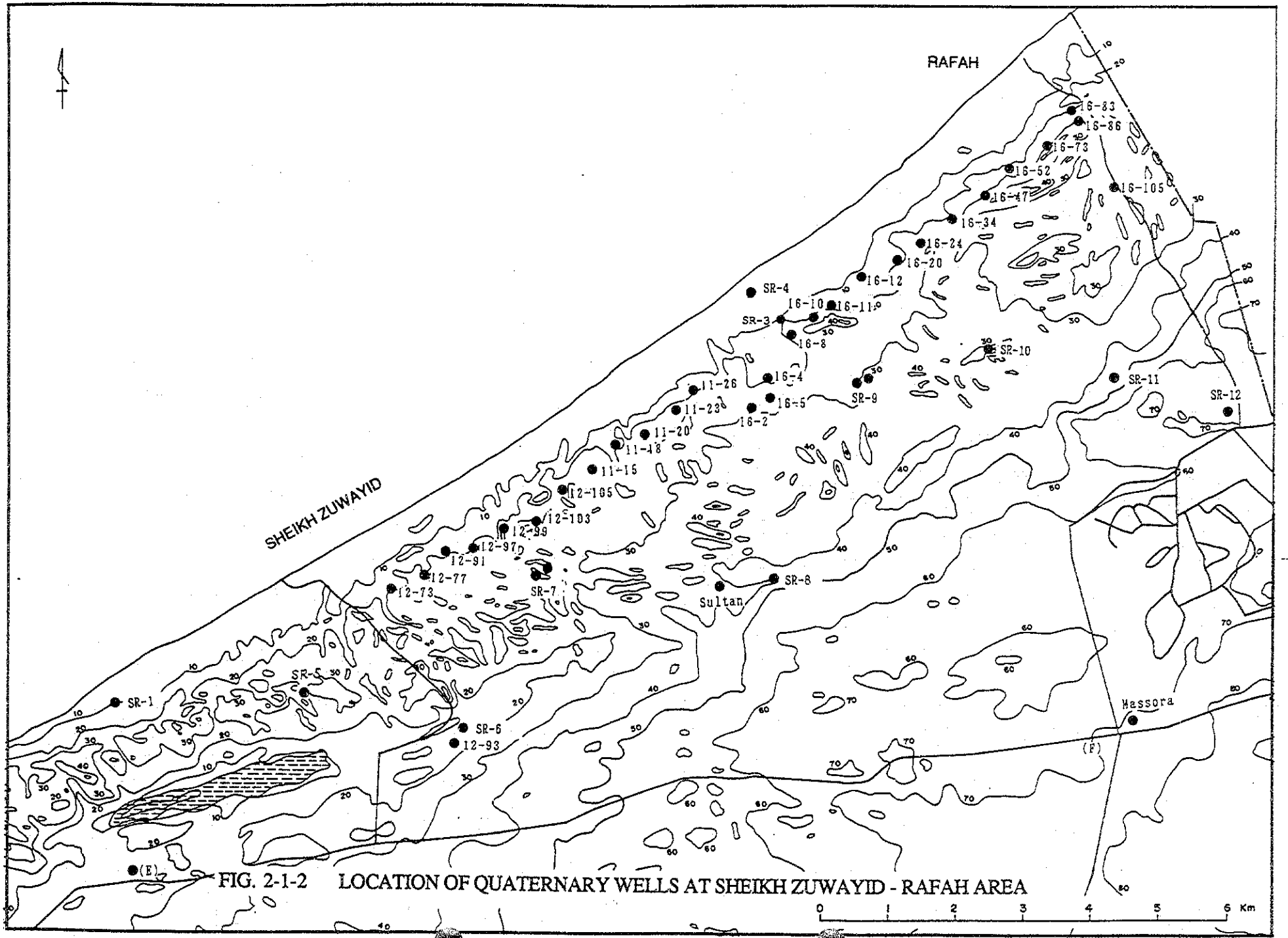


FIG. 2-1-2 LOCATION OF QUATERNARY WELLS AT SHEIKH ZUWAYID - RAFAH AREA

In spite of intensive water use, only a limited amount of data had been collected. Therefore, well survey was undertaken for the 246 wells selected during the study to locate the exact longitudinal and latitudinal positions down to the first decimal place of the second and to determine the ground height and the water level (in meters) above the sea level.

Approximately 80 water samples collected from local representative wells were analyzed at the chemical laboratory of the Suez Canal University. Results of these analysis were fed into the Data Base as presented in the Data Book of the Interim Report 2, July, 1990.

2-1-5 Test Wells

2-1-5-1 General

Although there are many wells extracting water from the aquifers of the Quaternary, most of them are either for domestic or irrigation purpose so that their distribution is uneven and records of their hydrogeological descriptions are scarce. For this reason some test wells were drilled into the Quaternary by RIWR and the study team.

2-1-5-2 Test Wells Drilled by Study Team

The objective of these test wells was to confirm the extension of the aquifer and identify unexploited aquifers in the Quaternary. For this purpose twelve test wells were drilled:

J No.1	: To examine subsurface conditions of the coastal sand dune in the West of El-Arish
J No.2 and 3	: To examine the extension of the gravel beds.
J No.4	: To examine the location of the gravel beds
J No.5,6,7,8 and 9	: To examine the extension of the coastal sandstones(kurkar).
J No. 10, 11 and 18	: To examine location of the gravel beds

Each test well location was determined by interpreting the existing geological data. The final location was confirmed by the results of the geophysical soundings as shown in Fig. 2-1-3. The depth of each test well was determined by referring to available geological information:

Table 2-1-3 Test Wells Drilled by Study Team

Well Number	Target Aquifer	Location	Drilling Depth
J No.1	Sand dune	20 km West of El-Arish	50 m
J No.2	Gravel bed	El-Mazaar	100 m
J No.3	Gravel bed	10 km East of El-Arish	100 m
J No.4	Gravel bed	a5 GMRDP resistivity survey point	70 m
J No.5	Sandstone	3 km South of Kabr Omir	100 m
J No.7	Sandstone	4 km South East of Sheikh Zuwayid	120 m
J No.8	Sandstone	Masora	100 m
J No.9	Sandstone	4 km South of Masora	80 m
J No.10	Gravel bed	4 km North West of El Berth	40 m
J No.11	Gravel bed	4 km South West of El Berth	40 m
J No.18	Gravel bed	Lehfen	60 m
	Total		940 m

Results of these test wells are discussed in the Section 2-2-3-4. Since the aquifer of test well No. 9 is developed in the Tertiary, it is classified as the Tertiary test well (Section 2-2-3-2).

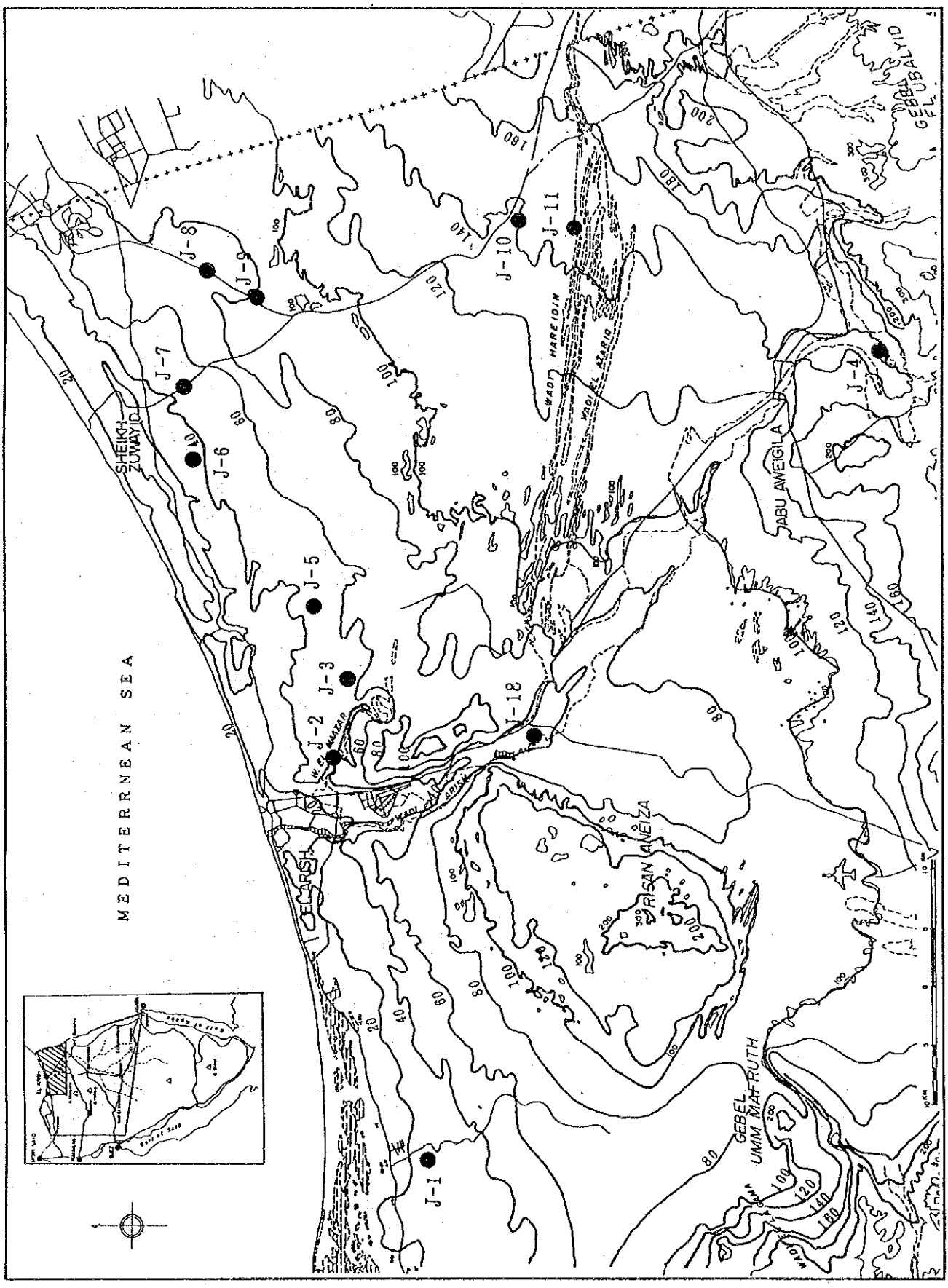


FIG. 2-1-3 LOCATION OF JICA QUATERNARY TEST WELLS

2-1-5-3 Test Wells Drilled by RIWR

To carry out integrated data collection from the test wells, IRWR planned on drilling test wells in different locations for their specific objectives other than these test wells drilled by the study team (Fig. 2-1-4 and 5).

Fourteen piezometers and five test wells were tried in the El-Arish area. Of these, twelve piezometer (P) and three test wells (T) were completed.

In the coastal plain from Sheikh Zuwayid to Rafah, six piezometers and ten test wells were planned, and completed three piezometers and seven test wells are summarized below:

Table 2-1-4 Test Wells Drilled by RIWR (El-Arish Area)

Piezometer		Test Holes		Objective
Well Number	Depth	Well Number	Depth	
P1	46 m			Sea water intrusion
P2	66 m			Sea water intrusion
P3	96 m			Alluvial aquifer
P4	canceled			Sea water intrusion
P5	70 m			Sea water intrusion
P6	78 m			Alluvial aquifer
P7	88 m			Kurkar
P8	100 m			Alluvial aquifer
P9/1	100 m	T9	68 m	Kurkar
P9/2	50 m			Alluvial aquifer
P10/1	86 m	T10	canceled	
P11/1	84 m	T11	94 m	Alluvial and Kurkar
P12	93 m			Alluvial aquifer
P13	70 m	T14	144 m	Alluvial aquifer
Total	1,027 m		306 m	

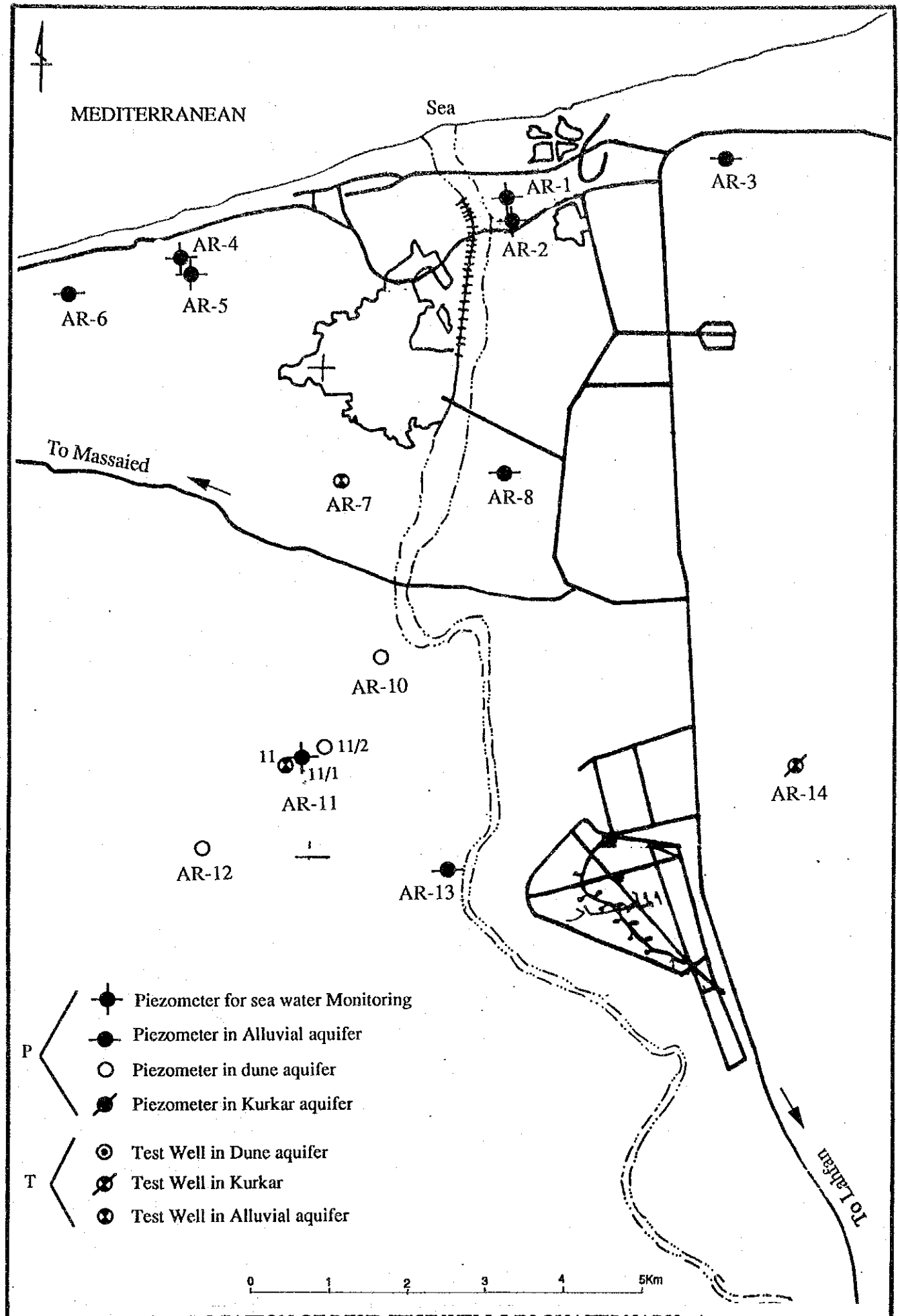


FIG. 2-1-4 LOCATION OF RIWR TEST WELLS IN QUATERNARY - 1

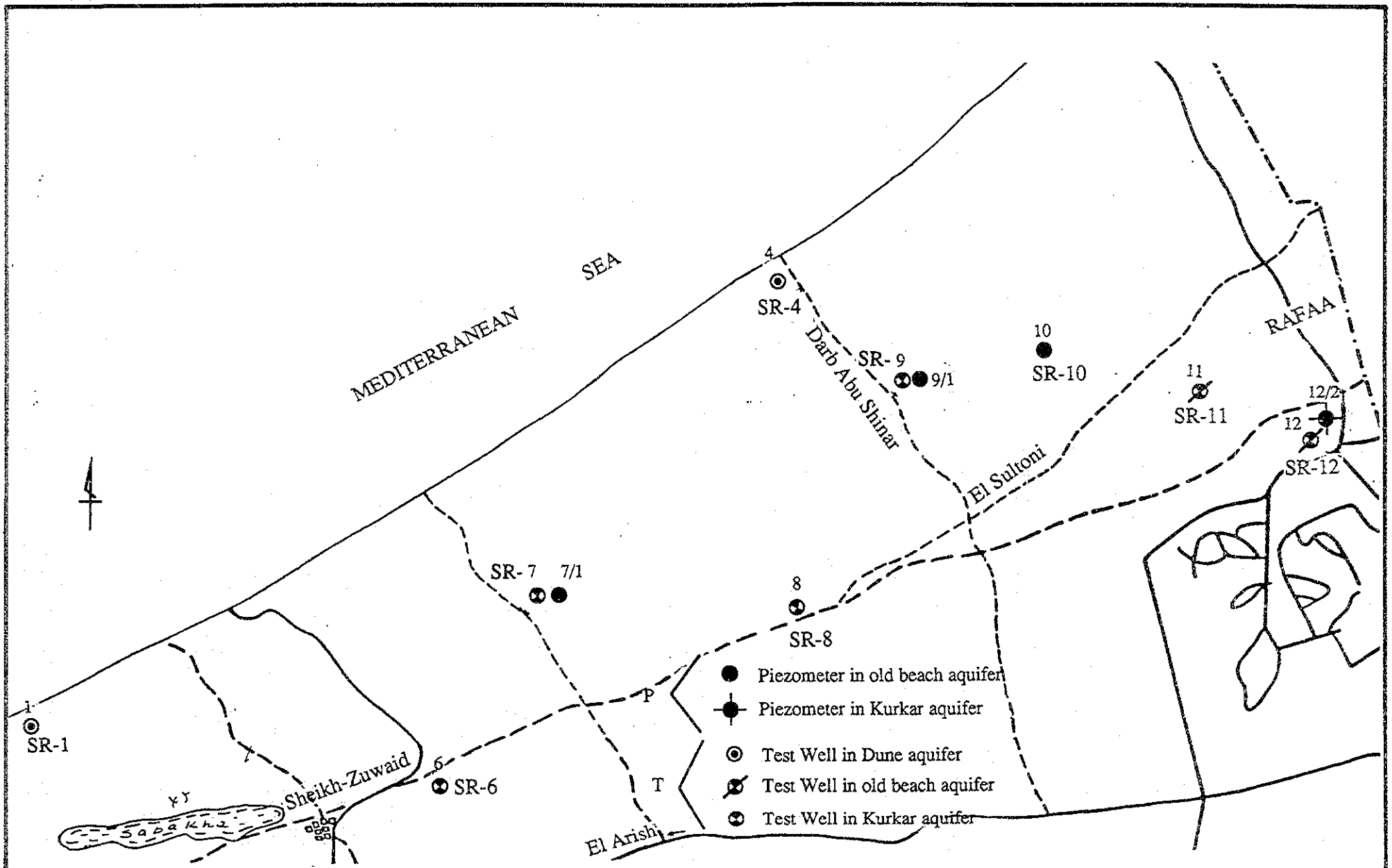


FIG. 2-1-5 LOCATION OF RIWR TEST WELLS IN QUATERNARY - 2

Table 2-1-5 Test Wells Drilled by RIWR (Sheik Zuwayid - Rafah Area)

Piezometer		Test Holes		Objective
Well Number	Depth	Well Number	Depth	
		T1	24 m	Dune aquifer
		T2	canceled	
P3	canceled	T4	30 m	Dune aquifer
P5/1	canceled	T5	51 m	Old beach sand
		T6	64 m	Old beach sand
P7/1	canceled	T7	92 m	Old beach sand
		T8	66 m	Old beach sand
P9/1	104 m	T9	102 m	Old beach sand
P10	102 m	T11	107 m	Kurkar
P12/1	102 m	T12	90 m	Kurkar
Total	308 m		485 m	

The test well results are summarized in the following Section and are also described in Section 2-1-4. Description of the aquifer test is shown in Chapter 5.

2-1-5-4 Result of Test Wells

The results of the test wells are summarized according to the test well number as shown below:

1) Test Wells-Drilled by JICA Study Team

J No.1

Location : 33°34'55.4"N, 31°03'18.7E
Ground level : 30 m asl
Total depth : 52 m
Static water level : dry

This well was drilled to confirm the subsurface conditions in the coastal sand dune area west of El-Arish. Although the drilling site had been proposed farther inland, there was no access to the proposed point due to heavy sand.
Eventually the present position was chosen.

As indicated in the resistivity profile, the thickness of sand, underlain by clay, is rather thin. The aquifer is sand bed. The water level is assumed to be 10 m above sea level (Fig. 2-1-6).

J No. 2

Location	:	33°53'54.2"N,31°04'41.5"E
Ground level	:	30 m asl
Total depth	:	100
Static water level	:	dry

This well was drilled to confirm the thickness of gravel and its hydrogeological conditions. There is a thin gravel bed (2 to 7 m) below the alternation of sand and clay underlain by yellow marl which is assumed to be the Pliocene. This well is dry (Fig. 2-1-7).

J No.3

Location	:	33°58'18.6"N, 31°06'50.2"E
Ground level	:	50 m asl
Total depth	:	80 m
Static water level	:	3.0 m asl

This well was drilled to confirm the extension of the gravel bed to the west from El-Arish and the sandstone (kurkar) to the south from the coast line. This site is covered by sand (35 m thick, overlying 10 m thick clayey sand). Below the clayey sand, gravel, sand and clay beds are underlain by 10 m thick sandstone. This gravel is assumed to be a conglomerate of the Pliocene.

FIG. 2-1-6 WELL DATA AND LITHOSTRAITGRAPHIC COLUMN

Sheet No. 1

Well Location
Well No. : 1
Location : El Medan
Elevation : 30m asl

Latitude : 31° 03' 18.7"
Longitude : 33° 34' 55.4"
Drilling Date : Feb. '90

Drilling Data
Drilling Depth : 52m
Bit Size : 14-3/4"
Logging Depth : 50m
Casing : -
Screen : -

Pumping Test
Static Water Level : -
Specific Yield : -
Water Quality : -

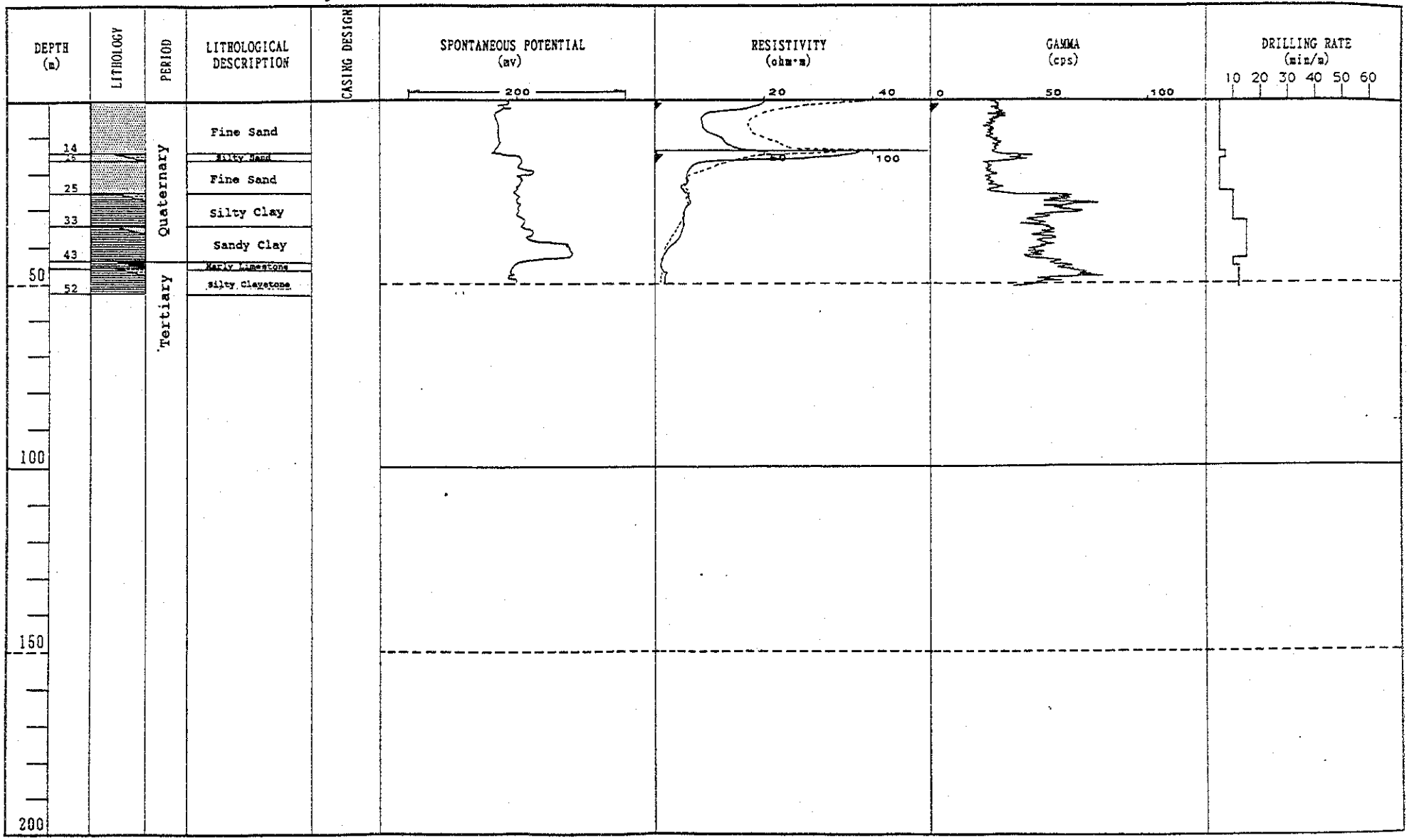


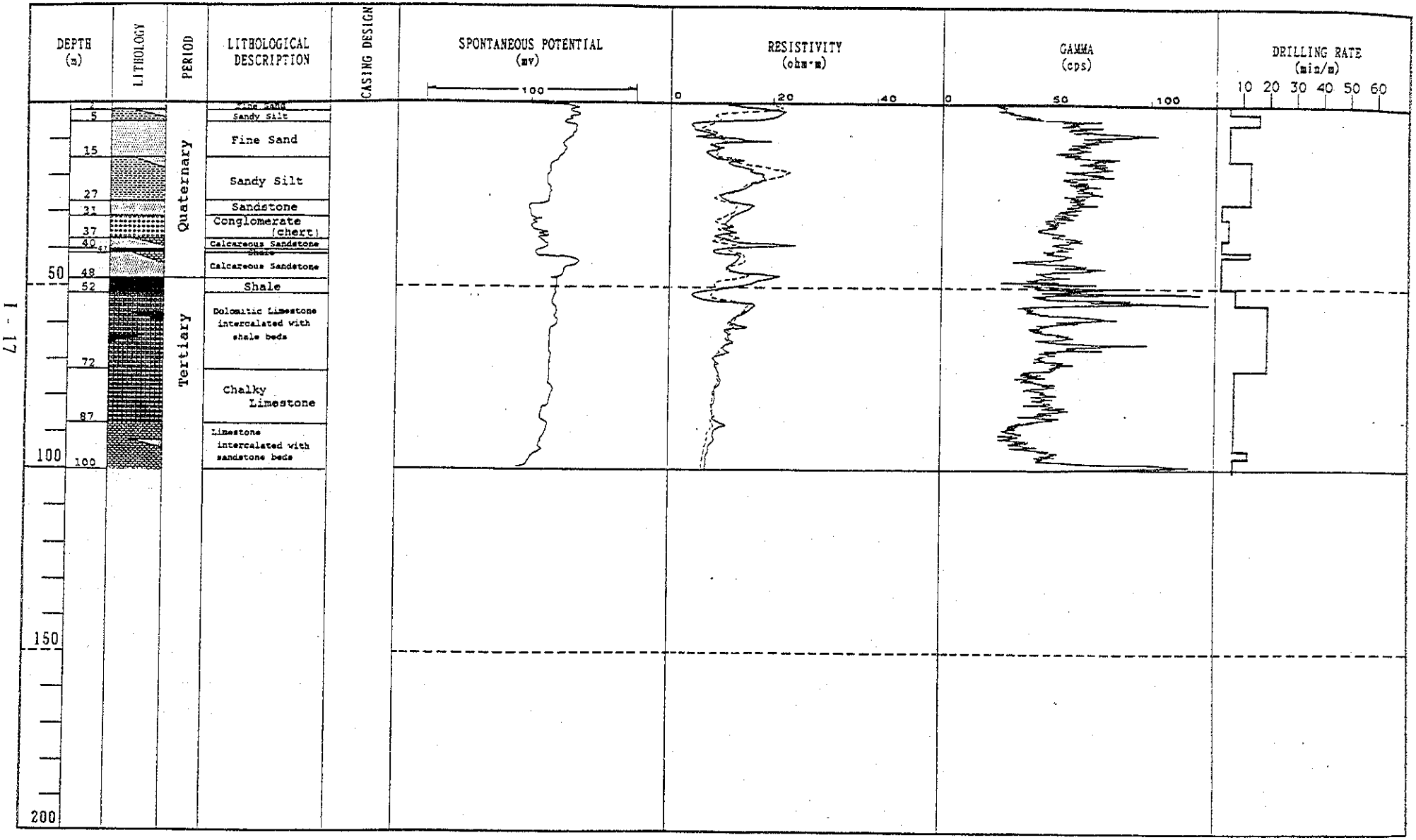
FIG. 2-1-7 WELL DATA AND LITHOSTRAITGRAPHIC COLUMN

Sheet No. 1

Well Location
Well No. : 2
Location : El Tawil
Elevation : 30m asl
Latitude : 31° 04′ 41.3″
Longitude : 33° 53′ 54.2″
Drilling Date : Feb. '90

Drilling Data
Drilling Depth : 100m
Bit Size : 14-1/4″
Logging Depth : 98m
Casing : -
Screen : -

Pumping Test
Static Water Level : -
Specific Yield : -
Water Quality : -



The aquifer is kurkar and it is proven that kurkar extends 8 km inland from the coast. The transmissivity is estimated to be 1,496 m^2/day (Fig. 2-1-8).

J No. 4

Location	:	34°07'12.5'N, 30°46'28.4"E
Ground level	:	139 m asl
Total depth	:	100 m
Static water level	:	dry

This well was drilled to confirm the existence of a gravel bed at the outlet of the Dinqa Gorge and to determine its hydrogeological conditions.

According to the lithological profile of the well, there are 30 m thick, gravel beds, intercalated by clayey sand and clay underlain by very thick clay. However, no water is found at this depth (Fig. 2-1-9).

J No.5

Location	:	34°00'39.7"N, 31°08'19.1"E
Ground level	:	48 m asl
Total depth	:	73 m
Static water level	:	8.1 m asl

This well was drilled to confirm the extension of sandstone to the south of the coast. The base of the Quaternary occurs at -5 m asl which is 15 m higher than that of J No. 3. The sandstone appears between 3 m to 5 m asl underlain by clay. From the level of 3 m

FIG. 2-1-8 WELL DATA AND LITHOSTRAITGRAPHIC COLUMN

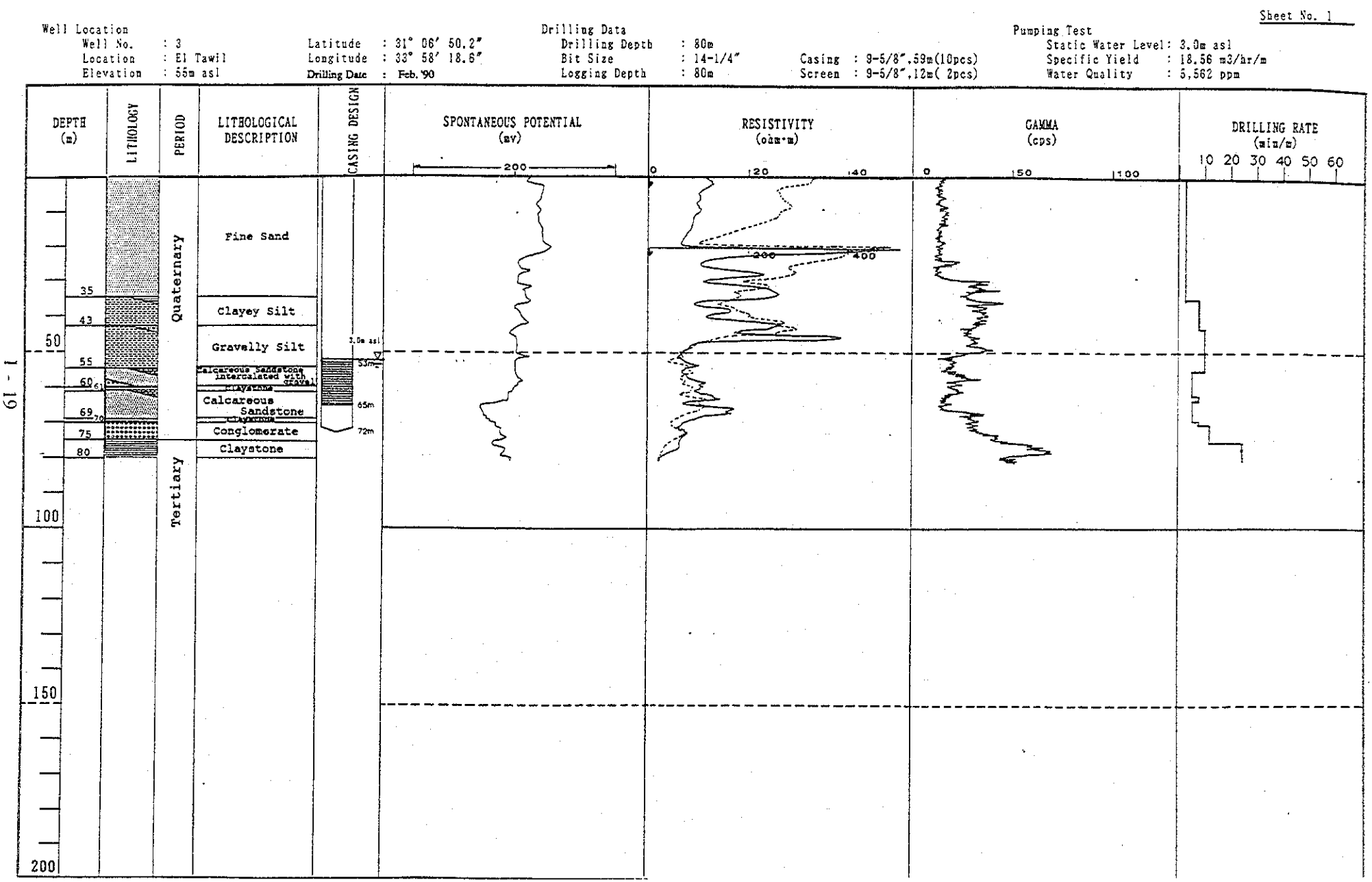


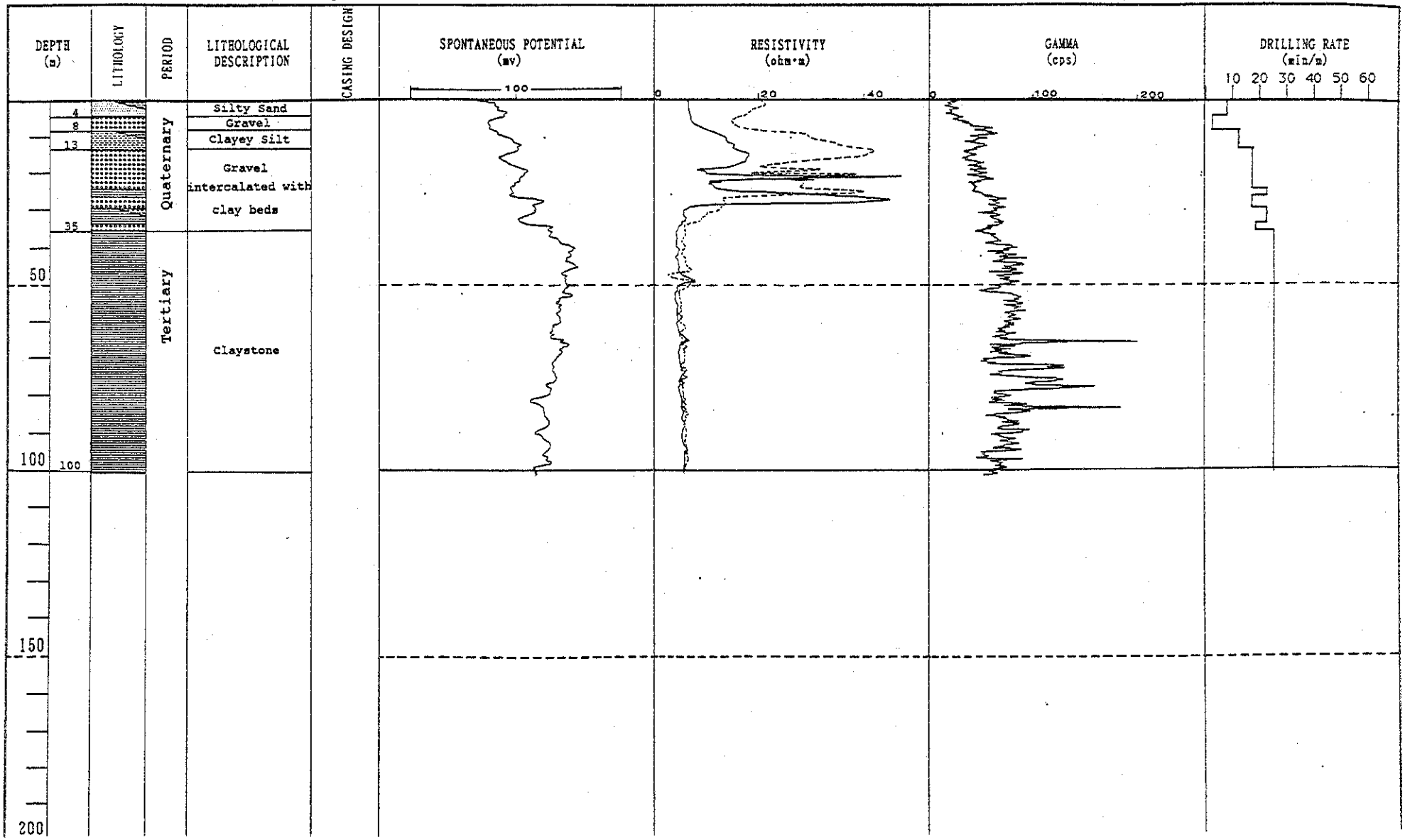
FIG. 2-1-9 WELL DATA AND LITHOSTRAITGRAPHIC COLUMN

Sheet No. 1

Well Location
Well No. : 4
Location : Rawafa dam
Elevation : 139m asl
Latitude : 30° 46′ 28.4″
Longitude : 34° 07′ 12.5″
Drilling Date : Feb. '90

Drilling Data
Drilling Depth : 100m
Bit Size : 14-3/4″
Logging Depth : 100m
Casing : -
Screen : -

Pumping Test
Static Water Level: -
Specific Yield : -
Water Quality : -



to 17 m asl, there is a gravel bed underlain by sandstone.

The static water level is observed at 8.1 m asl and the transmissivity is estimated to be 1,114 m^2/day (Fig. 2-1-10).

J No.6

Location	:	34°02'42.4"N, 31°10'45.2"E
Ground level	:	42 m asl
Total depth	:	98 m
Static water level	:	4.9 m asl

This well is drilled to confirm the extension of sandstone to the south of the coast. The sandstone occurs at -24 m to -54 m asl underlain by clay. Sand and clay overlie the sandstone; however, this portion appears to be clayey rather than sandy.

The aquifer is kurkar. The static water level is observed at 4.9 m asl, although the transmissivity is low (494 m^2/day) (Fig. 2-1-11).

J No.7

Location	:	34°08'21.7"N, 31°10'15.1"E
Ground level	:	50 m asl
Total depth	:	120 m
Static water level	:	4.5 m asl

This well is located at the site 10 km south of the coast. It was drilled to confirm the extension of the sandstone to the south. Sand, clay and sandy clay alternate to the level of 7 m from the ground surface (60 m asl). These beds are underlain by a thin sandstone bed (6 m thick). Below this, clay and sand are intercalated with the sandstone from -16 m to -25 m asl and is underlain by clay (11 m thick). Below the clay there appears a thin bed of gravel. Groundwater occurs in the second bed of the sandstone. Due to a thick cover of clayey

FIG. 2-1-10 WELL DATA AND LITHOSTRAITGRAPHIC COLUMN

Sheet No. 1

Well Location
Well No. : 5
Location : El Kharoba
Elevation : 48m asl
Latitude : 31° 08′ 19.1″
Longitude : 34° 00′ 39.7″
Drilling Date : Feb. '90

Drilling Data
Drilling Depth : 73m
Bit Size : 14-1/4″
Logging Depth : 72.2m
Casing : 9-5/8″,47m(8pcs)
Screen : 9-5/8″,12m(2pcs)

Pumping Test
Static Water Level: 8.1m asl
Specific Yield : 15 m3/hr/m
Water Quality : 4,290 ppm

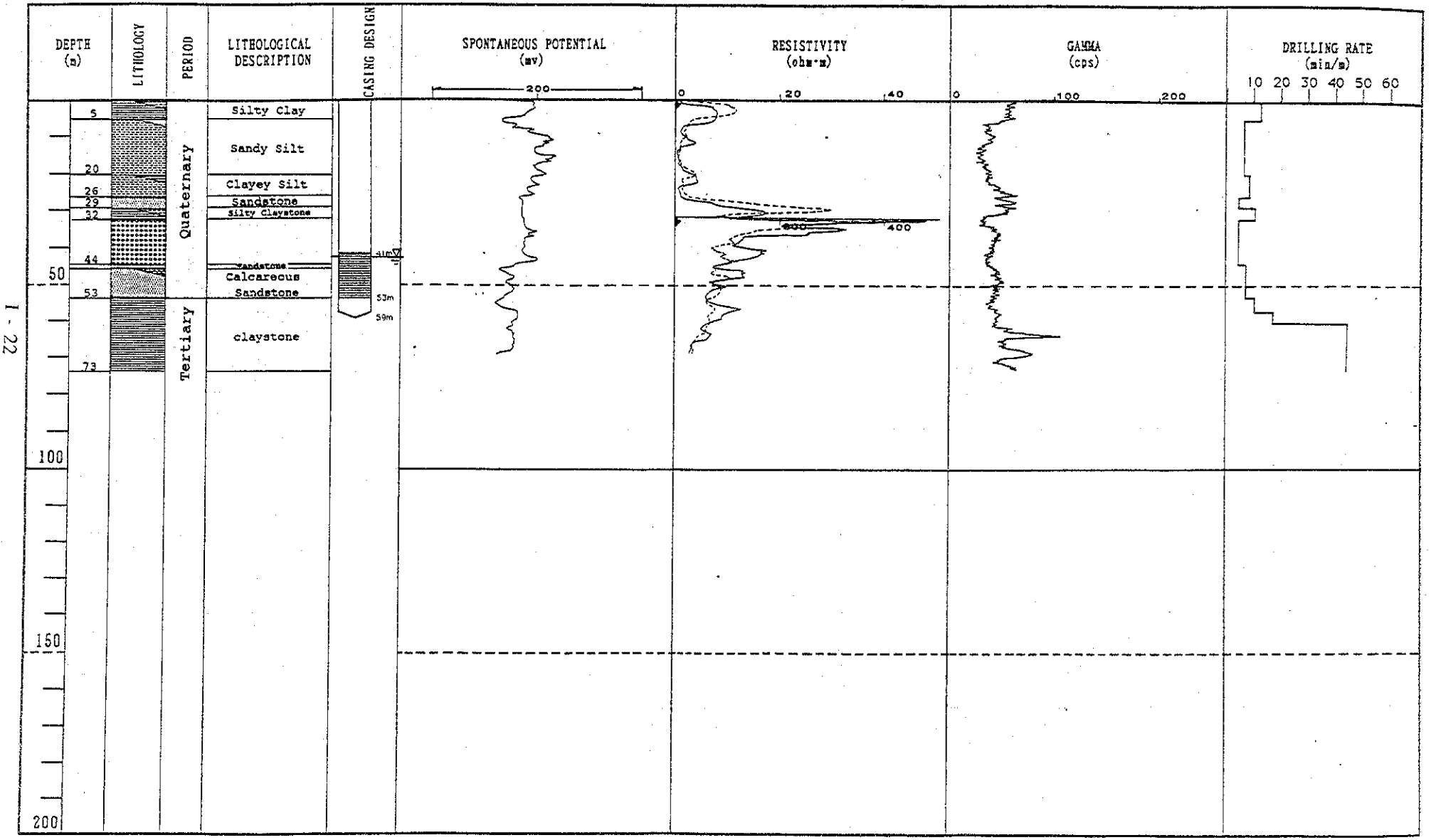


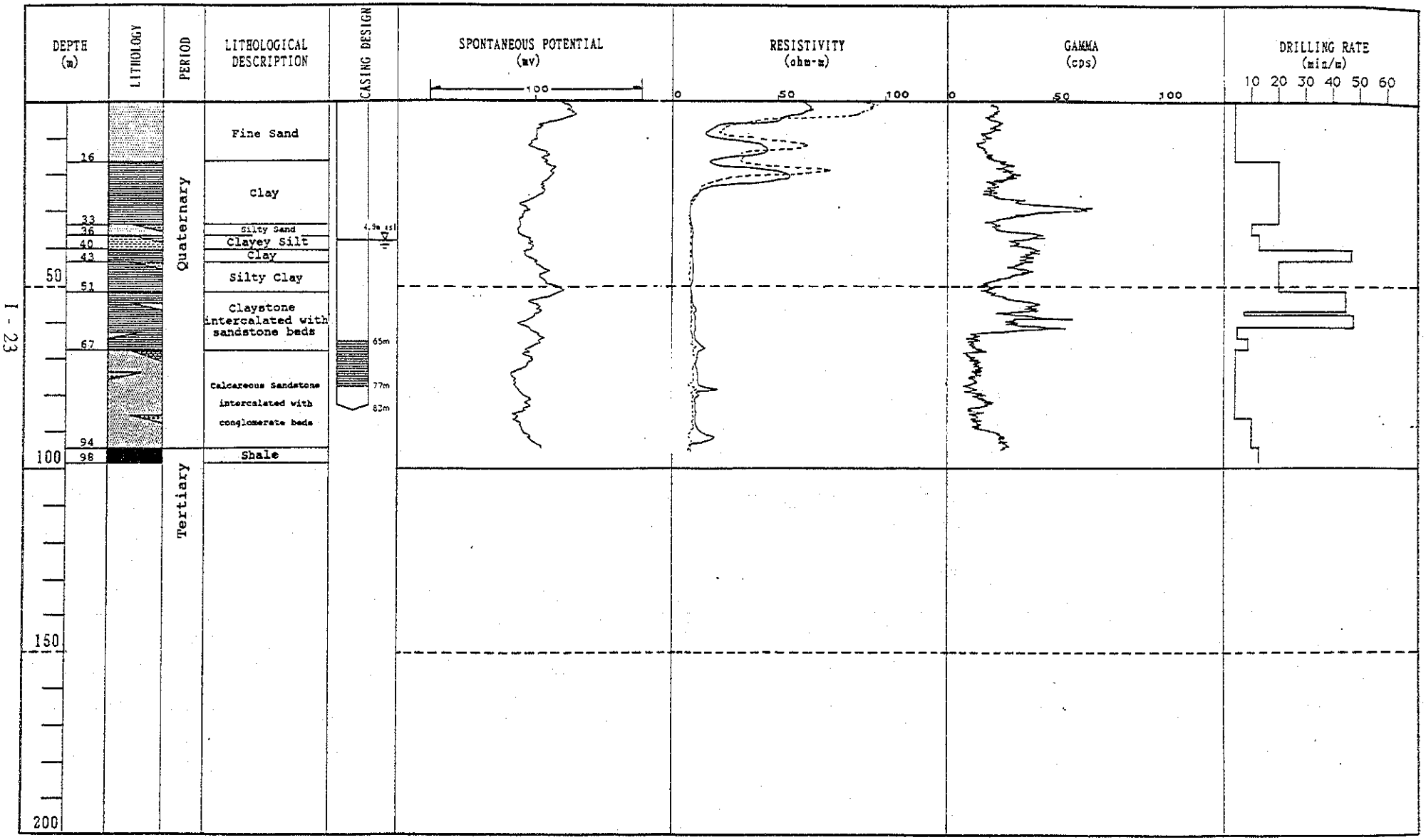
FIG. 2-1-11 WELL DATA AND LITHOSTRAITGRAPHIC COLUMN

Sheet No. 1

Well Location
Well No. : 6
Location : El Shikh Zuwayed
Elevation : 43m asl
Latitude : 31° 10′ 45.2″
Longitude : 34° 02′ 42.4″
Drilling Date : Jan. '90

Drilling Data
Drilling Depth : 98m
Bit Size : 14-3/4″
Logging Depth : 98m
Casing : 9-5/8″,71m(12pcs)
Screen : 9-5/8″,12m(2pcs)

Pumping Test
Static Water Level: 4.9m asl
Specific Yield : 6.98 m3/hr/m
Water Quality : 4,830 ppm



materials, this groundwater is assumed to be semi-confined with a static water level at 4.5 m asl.

The transmissivity is estimated to be 813 m^2/day (Fig. 2-1-12).

J No.8

Location	:	34°13'20.2"N, 31°12'37"E
Ground level	:	75 m asl
Total depth	:	110 m
Static water level	:	5.2 m asl

This well was drilled to identify hydrogeological conditions at a site 3 km west of Masora. The static water level is at 5.2 m asl; however, the yield is so small that an attempted pump test failed.

This test well is confirmed to be dry in spite of the existence of a sandstone bed more than 20 m thick (Fig. 2-1-13).

J No.9

Location	:	34°11'31.9"N, 31°09'35.0"E
Ground level	:	78 m asl
Total depth	:	91 m
Static water level	:	0.7 m asl

Since the aquifer of this test well was identified as the Miocene of the Tertiary, it was determined to classify it as being a Pre-Quaternary aquifer (See Section 2-2-3).

J No.10

Location	:	34°17'57.9"N, 30°58'14.2"E
Ground level	:	157 m asl
Total depth	:	63 m
Static water level	:	104 m asl

Together with test well No. 11 at Wadi Hardin, this well was drilled to confirm the existence of gravel beds.

FIG. 2-1-12 WELL DATA AND LITHOSTRAITGRAPHIC COLUMN

Sheet No. 1

Well Location
Well No. : 7
Location : El Sheikh Zuwayed
Elevation : 50m asl
Latitude : 31° 10′ 15.1″
Longitude : 34° 08′ 21.7″
Drilling Date : Jan. '90

Drilling Data
Drilling Depth : 120m
Bit Size : 14-1/4″
Logging Depth : 120m
Casing : 9-5/8″,81m(14pcs)
Screen : 9-5/8″,12m(2pcs)

Pumping Test
Static Water Level : 4.5m asl
Specific Yield : 17.72 m3/hr/m
Water Quality : 5,560 ppm

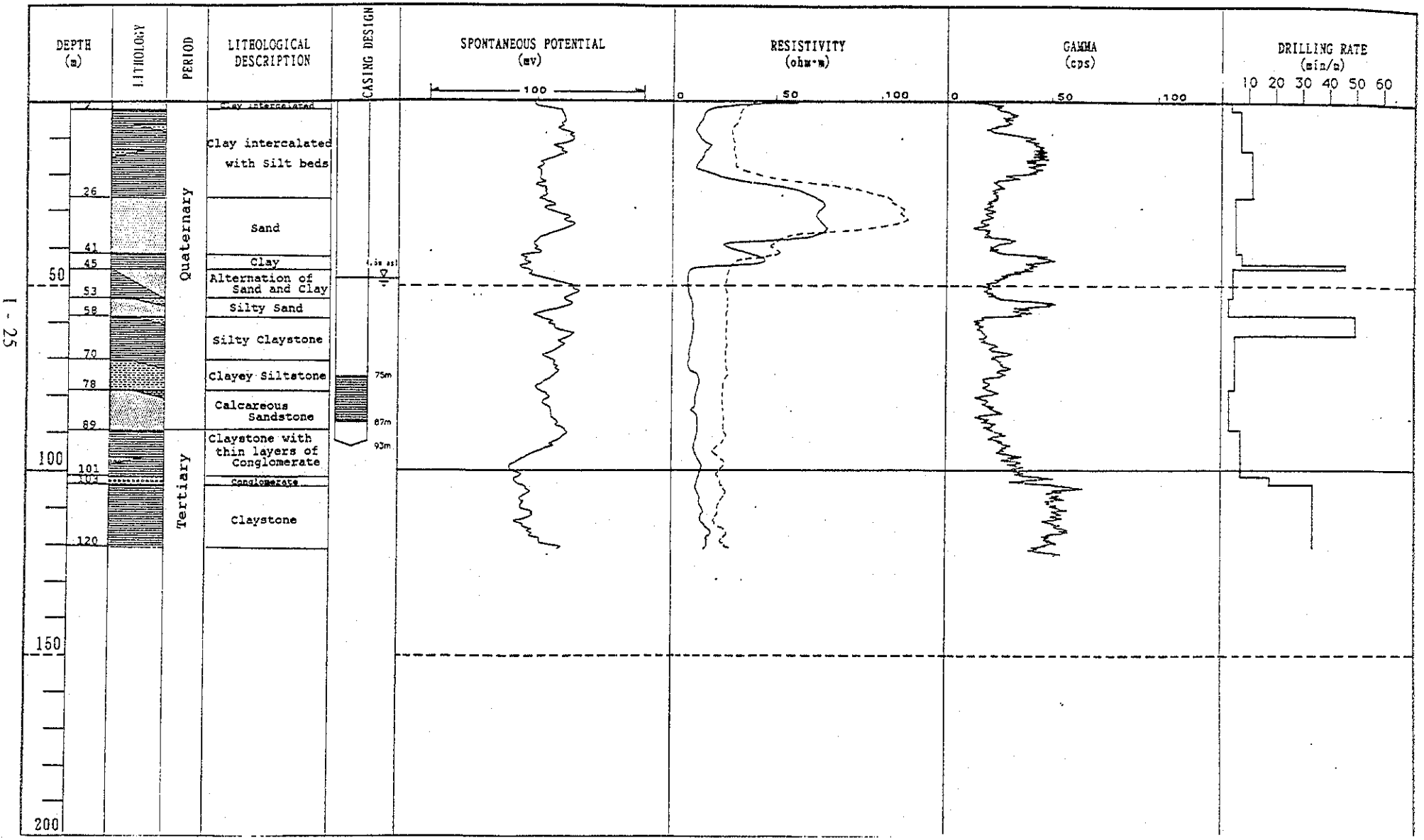


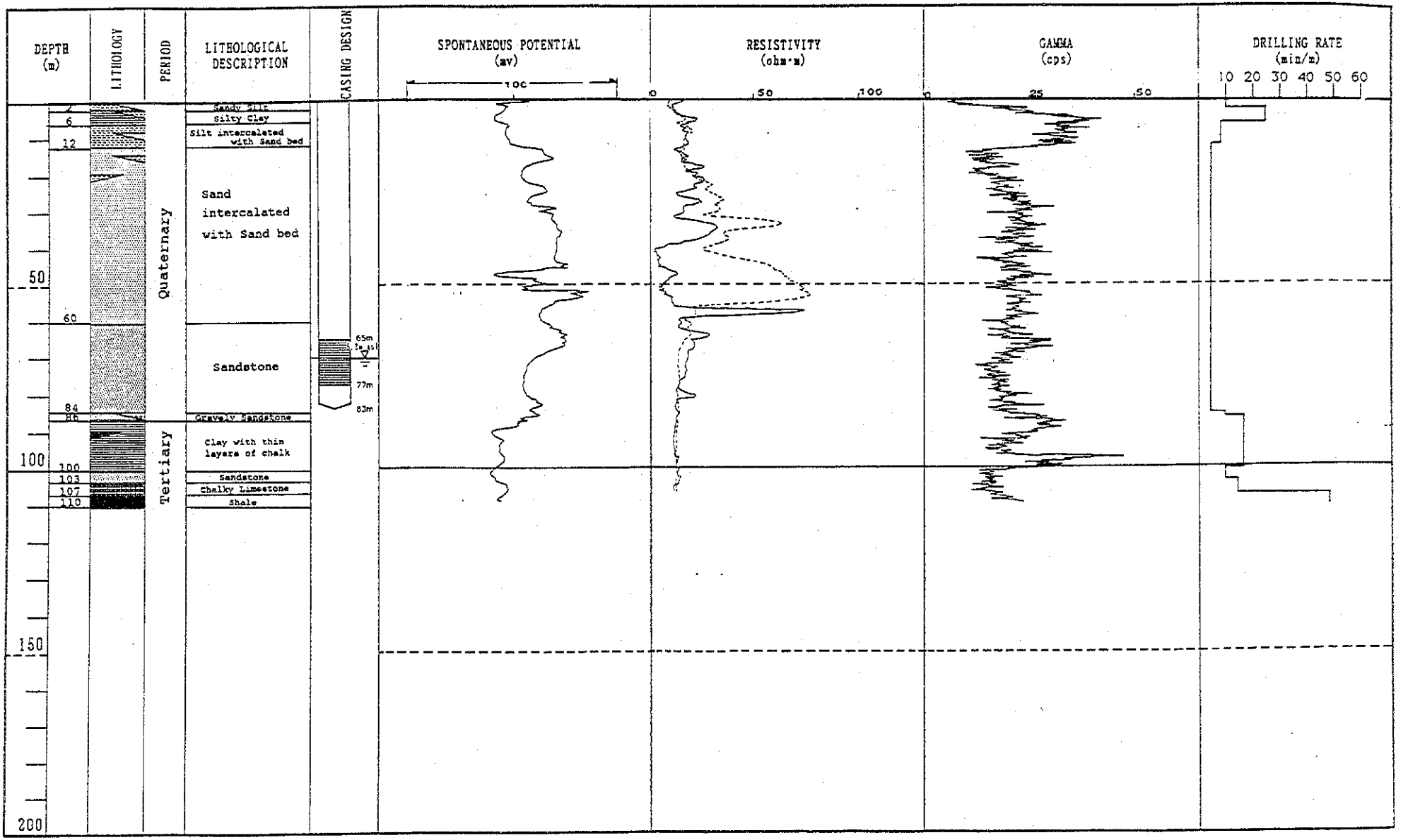
FIG. 2-1-13 WELL DATA AND LITHOSTRAITGRAPHIC COLUMN

Sheet No. 1

Well Location
Well No. : 8
Location : El Massora
Elevation : 75m asl
Latitude : 31° 12′ 37.6″
Longitude : 34° 13′ 20.2″
Drilling Date : Jan. '90

Drilling Data
Drilling Depth : 110m
Bit Size : 14-3/4″
Logging Depth : 108m
Casing : 9-5/8″71m(12pcs)
Screen : 9-5/8″12m(2pcs)

Pumping Test
Static Water Level: 5.2m asl
Specific Yield :-
Water Quality : 2,192 ppm



A sandstone bed occurs from 114 m to 101 m asl. This bed is overlain by sand, sandy clay, clay and alternations of thin gravel and clay. However, the water level is at 104 m asl, only 4 m above the top of clay which underlies the sandstone. The yield is so small that an attempted pump test failed (Fig. 2-1-14).

J No.11

Location	:	34°18'31.9"N, 30°56'43.8"E
Ground level	:	157 m asl
Total depth	:	45 m
Static water level	:	dry

This well is located at 3 km to the south of test well No. 10. Two thin gravel beds overlie a thin sandstone bed. There was no sign of groundwater (Fig. 2-1-15).

J No.18

Location	:	33°52'57.5"N, 30°59'25.3"E
Ground level	:	57 m asl
Total depth	:	65 m
Static water level	:	dry

This well is drilled to confirm the existence of the gravel bed at the Lhafen area. It reveals that there are gravel beds from 15 m to 40 m asl underlain by thick clay. There was no sign of groundwater (Fig. 2-1-16).

FIG. 2-1-14 WELL DATA AND LITHOSTRAITGRAPHIC COLUMN

Sheet No. 1

Well Location
Well No. : 10
Location : Barth
Elevation : 153m asl
Latitude : 30° 58′ 14.2″
Longitude : 34° 17′ 57.9″
Drilling Date : Jan. '90

Drilling Data
Drilling Depth : 63m
Bit Size : 14-3/4″
Logging Depth : 63m
Casing : 9-5/8″,50m(9pcs)
Screen : 9-5/8″,12m(2pcs)

Pumping Test
Static Water Level: 104m asl
Specific Yield : 1.14 m3/hr/m
Water Quality : 3,622 ppm

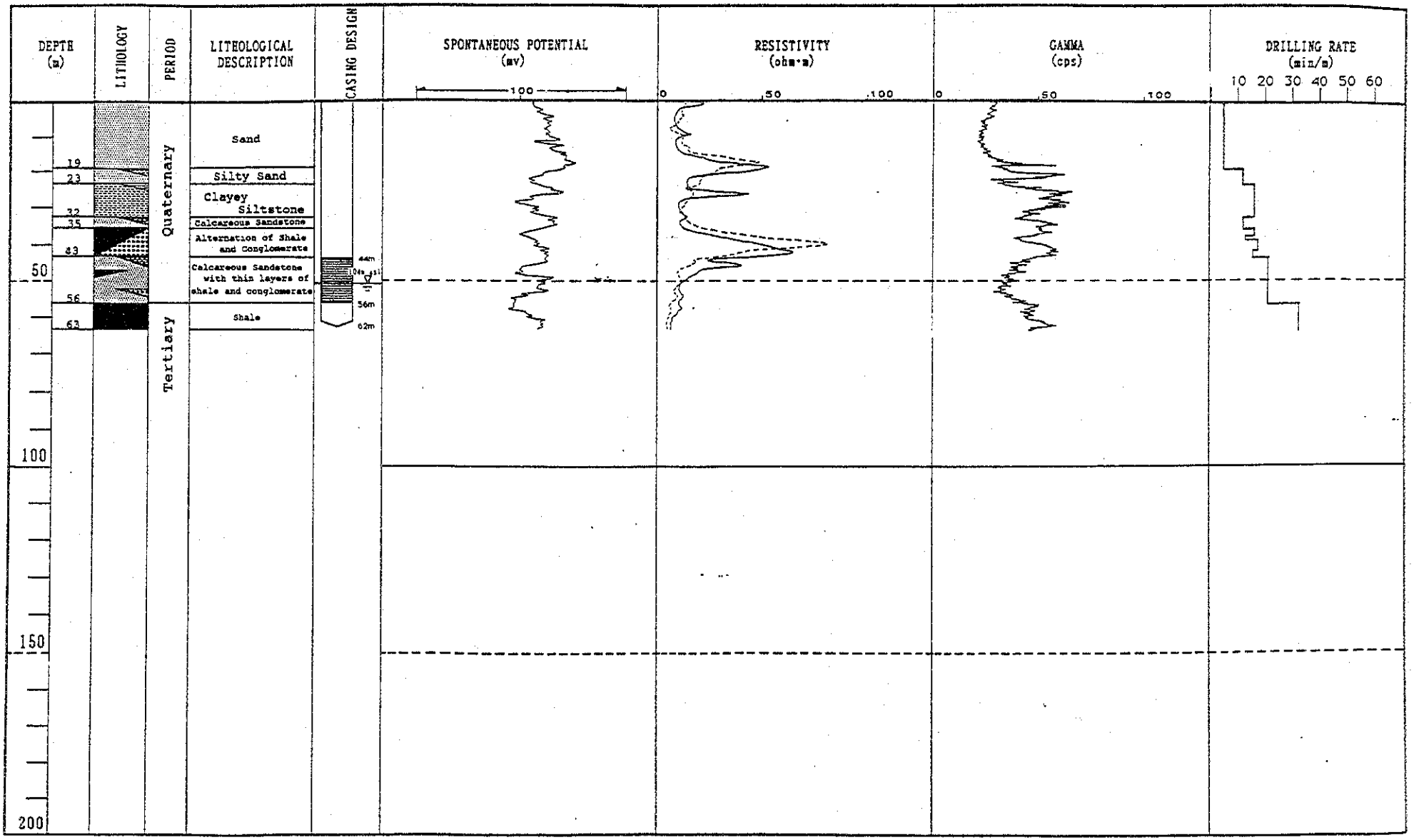


FIG. 2-1-15 WELL DATA AND LITHOSTRAITGRAPHIC COLUMN

Well Location
Well No. : 11
Location : Barth
Elevation : 157m asl
Latitude : 30° 56′ 43.8″
Longitude : 34° 18′ 31.9″
Drilling Date : Jan. '90

Drilling Data
Drilling Depth : 45m
Bit Size : 14-3/4″
Logging Depth : 45m
Casing : -
Screen : -

Pumping Test
Static Water Level : -
Specific Yield : -
Water Quality : -

Sheet No. 1

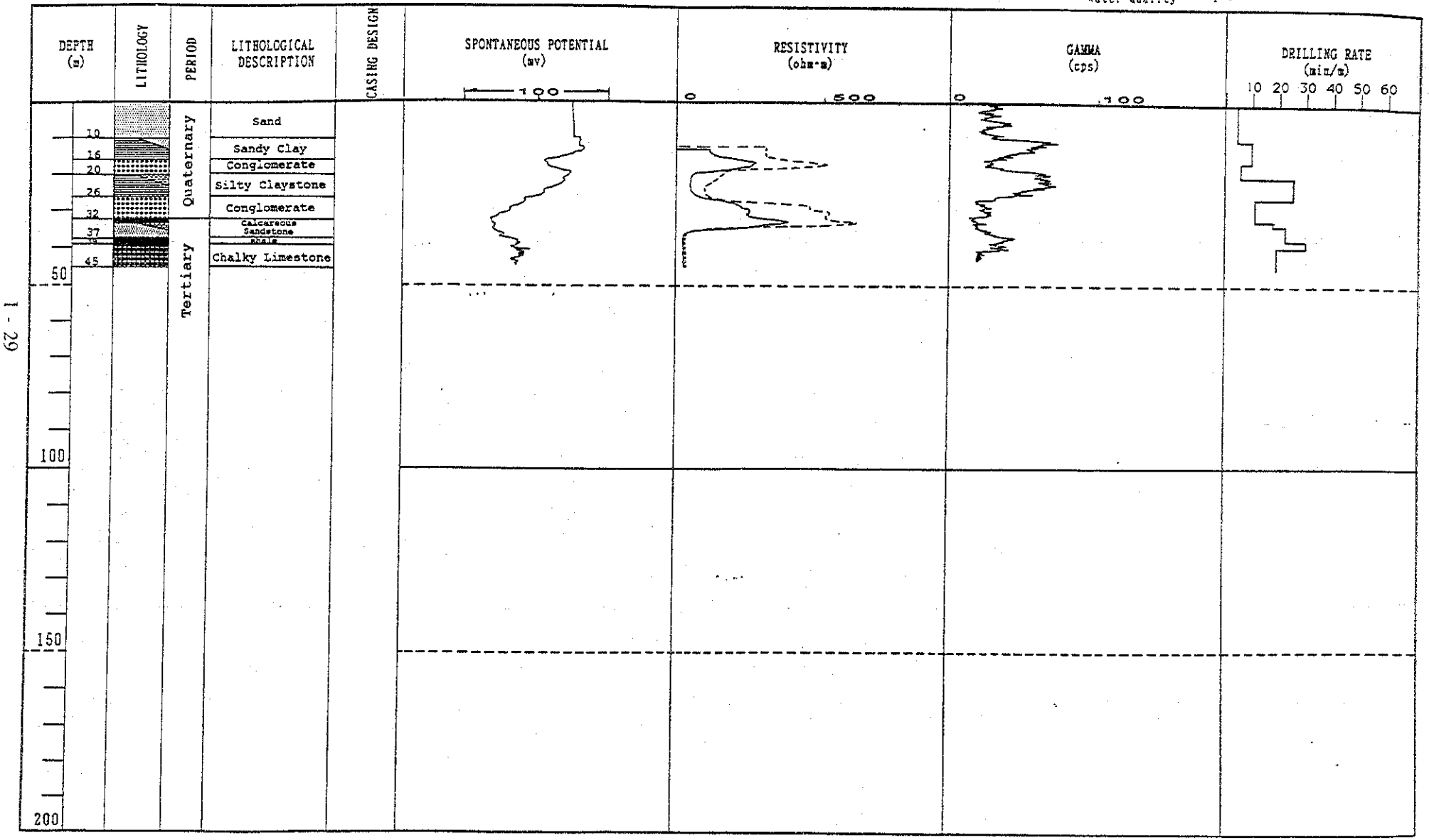


FIG. 2-1-16 WELL DATA AND LITHOSTRAITGRAPHIC COLUMN

Sheet No. 1

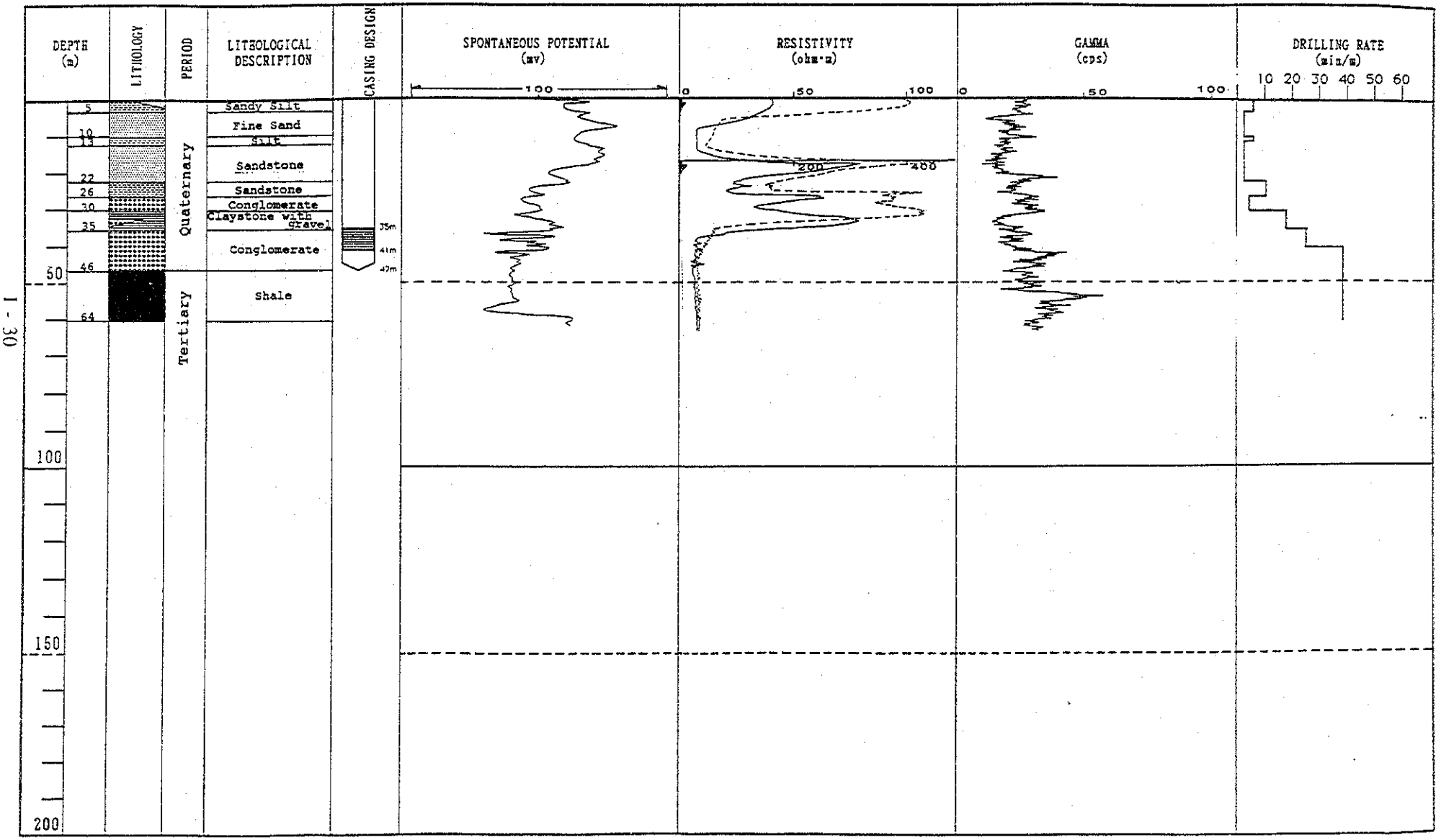
Well Location
Well No. : 18
Location : Lehfen
Elevation : 45m asl

Latitude : 30° 59′ 25.3″
Longitude : 33° 52′ 57.5″
Drilling Date : Feb. '90

Drilling Data
Drilling Depth : 64m
Bit Size : 14-1/4″
Logging Depth : 64m

Casing : 9-5/8″, 41m(7pcs)
Screen : 9-5/8″, 6m(1pcs)

Pumping Test
Static Water Level : -
Specific Yield : -
Water Quality : -



2) Test Well Drilled by RIWR

Results of the test wells drilled by the RIWR is summarized in sequence of the identification number below. To avoid confusion, AR and SR are affixed to the well number for indication of either Arish well or Sheikh-Zuwayid - Rafah well. The well number refers to the number listed in 2-1-5-3.

AR P1

Location	:	1226.920N, 186.840E
Ground level	:	5.14 m asl
Total depth	:	47 m
Static water level	:	1.14 m asl

This is a piezometer located on the right bank of the Wadi El-Arish close to the river mouth to the Mediterranean. The objective of this well is to find the Quaternary subsurface lithology in the area and to monitor sea water intrusion. A clayey material predominates throughout the profile; however, there are thin (approximately 5 m thick) gravelly intercalations. Calcareous sandstone occupies the zone that extends 40 m below the grand surface.

AR P2

Location	:	1226.645N, 186.861E
Ground level	:	5.18 m asl
Total depth	:	65 m
Static water level	:	1.2 m asl

This piezometer is located about 100 m south of AR P1. It's objective is the same as AR P1. The lithological profile is similar to that of AR P1 and a six meter thick Pleistocene calcareous sandstone encounters at 41 m from the ground surface underlain by a stratum composed of clay, gravel, sand and chert. The Miocene surface is found at 60 m from the ground surface.

AR P3

Location	:	3 km to the east from the river mouth of the Wad El-Arish
Ground level	:	15.2 m asl
Total depth	:	99.6 m
Static water level	:	1.2 m asl

The objective of this piezometer is to establish the subsurface lithology of the Quaternary formation for confirmation of the extension of aquifers to the east from the Wadi El-Arish river mouth. Prospecting alluvial aquifers indicate sand, gravel clay with predominating sand from the ground surface to the depth at 39 m. A calcareous sandstone stratum encounters between 44 m and 61 m from the ground surface. The base of the Quaternary is found at 61 m from the ground surface.

AR P5

Location	:	122.5950N, 183.436E
Ground level	:	21.3 m asl
Total depth	:	70 m
Static water level	:	1.5 m asl

This is a piezometer located on the Mediterranean coast a few kilometers to the west from El-Arish. This well was drilled for establishment of the subsurface lithology of the Quaternary and also for monitoring the sea water intrusion.

A sand dune deposit extends down to 23 m from the ground surface underlain by alluvial deposits of 30 m thick. The lower part of the profiles are predominated by calcareous sandstone to the bottom.

AR P6

Location	:	122.5633N, 181.715E
Ground level	:	10.7 m asl
Total depth	:	76 m
Static water level	:	0.63 m asl

The location of this piezometer is a few kilometers to the west of AR P5. The objective of this piezometer is the same as that of AR P5, but also is for confirming the extension of the Quaternary to the West along the coast.

Deposits of sand dune extends to 32 m from the ground surface underlain by alluvial deposits consisted of clay, sand and gravel of 32 m thick. Calcareous sandstone occupies from 47 m to 64 m in the alluvial deposits and also a thin one from 67 to 70 m from the ground surface. The bottom of the Quaternary is at 64 m from the ground surface.

AR T7

Location	:	1 km to the south from El-Arish
Ground level	:	19.8 m asl
Total depth	:	88 m
Static water level	:	-2.3 m asl

This is a test well located outside of the south western corner of El-Arish. Objective of this test well is to establish the subsurface profile of the Quaternary since there is no reliable lithological information in spite of many production wells tapping water from the Quaternary aquifer.

The ground surface is covered by 12 m thick sand underlain by a thick alluvial deposits consisting of clay, sand and gravel. Below this stratum, there encounters calcareous sandstone down to the bottom of the Quaternary at 64 m from the ground surface.

The transmissivity is estimated at 518 m^2/day

AR P8

Location	:	33°49'N, 31°6' 50"
Ground level	:	17.0 m asl
Total depth	:	102 m
Static water level	:	-1.28 m asl

This is a piezometer located in the broad agricultural field southeast of El-Arish. The objective of this well is to establish the Quaternary lithology and to monitor the behavior of the groundwater level in this agricultural field.

The whole profile is an alternation of thin sand and clay together with their mixture associated with occasional gravel to the bottom. Thin calcareous sandstones (3 m thick) appear at the depths from 30 m to 33 m and 38 m to 42 m from the ground surface. The bottom of the Quaternary is at 93 m from the ground surface underlain by the Miocene.

AR T9

Location	:	33°49' 6"N, 31° 5' 50"E
Ground level	:	23.1 m asl
Total depth	:	102
Static water level	:	-1.13 m asl

This is a test well for establishing the subsurface lithology of the Quaternary in the middle part of the agricultural field between El-Arish and the airport. Two piezometers are associated with this well for monitoring two different aquifers (alluvial and kurkar). Screens of these two piezometers are installed at each kurkar and sandstone.

The predominating lithology is clay, sand and kurkar associated with occasional gravel to the bottom of the Quaternary at the depth of 64.5 m from the ground surface. A 11.5 m thick calcareous sandstone : kurkar, encounters from the depth at 50 m from the ground surface.

The transmissivity is estimated at 605 m^2/day.

AR P10

Location	:	33°47' 57'N, 31°5' 49"E
Ground level	:	51.2 m asl
Total depth	:	90 m
Static water level	:	Dry

This piezometer was drilled to establish the subsurface lithology of the Quaternary and also the dune sand. The predominating lithology in the profile is clay with occasional gravel. A calcareous sandstone with interbedded clay encounters from 67 m to 79 m deep from the ground surface.

The bottom of the Quaternary is at 79 m from ground surface.

AR T11

Location	:	121.982N, 183.500E
Ground level	:	55.88 m asl
Total depth	:	84 m
Static water level	:	-0.85 m asl

This test well is associated with two piezometers. The same principle used at test well AR T9 was adopted to monitor two different aquifers (sand and kurkar).

The predominating lithology in the profile is an alternation of sand and clay from the ground surface to the depth at 63 m. Kurkar encounters from 63 m to 72 m from the ground surface underlain by the Miocene.

The transmissivity is estimated at 302 m^2/day.

AR P12

Location	:	121.869N, 182.527E
Ground level	:	52.4 m asl
Total depth	:	106 m
Static water level	:	-0.44 m asl

This is a piezometer located at 5 kilometer west of the airport. The objective of this well is to establish the subsurface lithology at the western fringe of the alluvial plain of Wadi El-Arish and to monitor the water level.

A general feature of the profile is a sandy nature underlain by the Miocene at 70 m from the ground surface. A thin kurkar occurs from 64 m from the ground surface to the bottom of the Quaternary.

AR P13

Location	:	1219.976N, 186.394E
Ground level	:	28.3 m asl
Total depth	:	72 m
Static water level	:	-1.7 m asl

This is a piezometer drilled on the left bank of the Wadi El-Arish at the eastern side of the airport. The objective is to establish the subsurface lithology of the Quaternary in the central part of the alluvial plain of Wadi El-Arish and to monitor the water level.

The predominating lithology is an alternation of a rather thin strata of sand and clay with occasional gravel. A calcarcous sandstone interbedded by a few meter thick clay encounters from 48 m to 58.5 m from the ground surface. The Quaternary is underlain by the clay of the Miocene at 60 m from the ground surface.

AR T14

Location	:	1221.758N, 189.592E
Ground level	:	39.7 m asl
Total depth	:	144 m
Static water level	:	0.99 m asl

This is a test well drilled near the airport at the eastern fringe of the alluvial plain of Wadi El-Arish. It was intended to confirm the extension of the alluvial deposits and kurkar to the east and to monitor the water level and the quality.

The predominating lithology is gravel alternated by thin clay and sand underlain by the clay of the Miocene at the depth of 100 m from the ground surface. Kurkar encounters from 92 m to the bottom of the Quaternary.

The transmissivity is estimated at 4,320 m^2/day.

SR T1

Location	:	34° 4' 8"N, 31° 13; 36"E
Ground level	:	5.5 m asl
Total depth	:	24 m
Static water level	:	10.1 m asl

This is a test well drilled on the Mediterranean coast at Sheikh Zuwayid to establish the lithology of the Quaternary and monitor the water level and the quality.

The predominating lithology is sand with occasional sandstone and gravel.

The transmissivity is estimated at 173 m^2/day.

SR P3

Location	:	1241.886N, 220.502E
Ground level	:	12.8 m asl
Total depth	:	48 m
Static water level	:	-2.1 m asl

This is a piezometer drilled on the coastal sand dune at the northeastern corner of the study area. The well was drilled to establish the lithology of the old beach sand and associated strata and to monitor the water level.

A general feature of sandy profile is interbedded by calcareous sandstone from 30 m to 43 m from the ground surface underlain by sandy clay.

SR T4

Location	:	124.250N, 220.891E
Ground level	:	7.5 m asl
Total depth	:	30 m
Static water level	:	1.17 m asl

This is a test well drilled on the Mediterranean beach at the end of the Darb Abu Shinar road. A sand dune aquifer was explored.

The sand dune deposits extend to the depth of 17 m from the ground surface underlain by the old beach sand, the lower limit of which is undetermined.

The transmissivity is estimated at 346 m^2/day.

SR T5

Location	:	34° 6' 15"
Ground level	:	31.7 m asl
Total depth	:	51 m
Static water level	:	0.67 m asl

This is a test well drilled midway between Sheikh Zuwayid and the beach. The drilling was carried out to investigate the aquifers in the old beach sand and its physical properties. This is associated with one piezometer to monitor the water level of the old beach sand.

The sand dune deposits extend to the depth of 30 m from the ground surface underlain by the Pleistocene strata predominating sand and clay. The Calcareous sandstone encounters from 51 m to 66 m from the ground surface. The bottom of the Quaternary is presumed at 82 m from the ground surface.

The transmissivity is estimated at 389 m^2/day.

SR T6

Location	:	34° 7' 30'N
Ground level	:	15.6 m asl
Total depth	:	62 m
Static water level	:	3.36 m asl

This is a test well drilled two kilometers east of Sheikh Zuwayid along the El-Arish - Rafah road. The Quaternary lithology including the old beach sand was explored and physical properties of the aquifer was examined.

The old beach deposits extend to the level at 35 m from the ground surface underlain by the Pleistocene strata consisting of sandstone down to the bottom of the quaternary overlying the clay of the Miocene.

The transmissivity is estimated at 432 m^2/day.

SR T7

Location	:	123.875N, 217.423E
Ground level	:	20 m asl
Total depth	:	52 m
Static water level	:	1.28 m asl

This is a test well associated with one piezometer drilled 5 kilometers east of test well SR T5. The drilling intended to establish the subsurface lithology of the Quaternary including the old beach sand and to determine the physical properties of the aquifer including the water quality. The piezometer is planned to monitor the water level.

The ground surface is covered by the sand dune deposit to 14 m from ground surface underlain by the old beach sand consisting of clay sand and sandstone down to 50 m. The calcareous sandstone encounters from 58 m to 68 m. The bottom of the Quaternary is at 89 m from the ground surface underlain by the clay of the Miocene.

The transmissivity is estimated at 510 m^2/day.

SR T9

Location	:	124.15N, 222.010 E
Ground level	:	21.4 m asl
Total depth	:	52 m
Static water level	:	1.82 m asl

This is a test well associated with one piezometer drilled at the middle part of the Darb Ab Shinar road from the junction with the El-Arish - Rafah road. The objective of this well is to establish the subsurface lithology of the Quaternary including the old beach sand and to examine the physical properties of aquifers. The piezometer is to be used for monitoring the water levels.

The profile of this well is similar to that of SR T7 : 14 meter thick sand dune deposit on the top underlain by 35 meter thick old beach strata consisting of sand, clay and old beach calcareous sandstone. The calcareous sandstone is found at 51 m from the ground surface

down to 76 m. The bottom of the Quaternary is at 94 m underlain by the limy clay of the Miocene.

The transmissivity is estimated at 259 m^2/day.

SR P10

Location	:	124.339N, 224.811E
Ground level	:	29.7 m asl
Total depth	:	103 m
Static water level	:	1.6 m asl

This is a piezometer located midway between the SR T9 and SR T11. The well was drilled to establish the subsurface lithology of the Quaternary and to confirm the extension of the old beach sand; monitoring of the water level was also intended.

The sand dune deposits extend to 18 m from the ground surface underlain by 41 m thick old beach strata consisting of predominating clay and sand. The calcareous sandstone encounters from 62 m to 82 m interbedded with a thin silty clay. The bottom of the Quaternary stands at 82 m from the ground surface underlain by the chalky limestone of the Miocene.

SR T11

Location	:	124.161N, 225.900E
Ground level	:	45.8 m asl
Total depth	:	106 m
Static water level	:	1.2 m asl

This is a test well located about two kilometers to the north of Rafah. The well was drilled to establish the subsurface lithology of the Quaternary, including kurkar, and to determine the physical properties of the aquifers.

The ground surface is covered by sand dune deposits to 10 m from the ground surface underlain by 36 meter thick old beach strata consisting of sand and calcareous sandstone. From 46 m or 79 m encounters the clay dominating Quaternary stratum underlain by the calcareous sandstone (kurkar) of 10 m thick. The bottom the

Quaternary is at 89 m from ground surface underlain by the chert of the Miocene.

The transmissivity is estimated at 864 m^2/day.

SR T12

Location	:	34° 14' 48'N, 31° 16'E
Ground level	:	63.6 m asl
Total depth	:	90 m
Static water level	:	1.5 m asl

This is a test well associated with one piezometer drilled at the northern fringe of Rafah Town, drilled to identify the subsurface conditions especially the physical property of the kurkar.

The ground surface is covered by a thin (2 m) sand dune deposit underlain by the old beach sands with occasional gravel and silt. The thickness of the old beach sand is approximately 50 meters including calcareous sand and sandstone from 22 m to 52 m from the ground surface.

The Quaternary encounters further down to 71 m from the ground surface including a thin calcareous sandstone (5 m) overlying the silty sand of the Miocene.

The transmissivity is estimated at 43 m^2/day.

2-1-6 Interpretation

Existing well data number more than hundred and include production wells, test wells. Most of these wells distribute in the alluvial plain of the Wadi El-Arish and the coastal plain extending from Sheikh Zuwayid to Rafah. Some of old test wells are located in the inland plain.

The collected well data are plotted on the topographic maps in scale of one to fifty thousand. The ground levels of the wells are estimated by reading the contours of the map where the levels are missing.

Locations of existing wells are shown in Fig. 2-1-1 and locations of test wells are also shown in Figs. 2-1-2, 3, 4 and 5.

Lithological profiles were also reviewed and some descriptions were corrected whenever they were obviously incorrect, such as the limestone bed at well No. 12-97. In order to draw a general feature of the geologic profile of well data, lithological descriptions were standardized by discarding very thin intercalated beds, such as sand and clay, since these are of no importance from a hydrogeological point of view.

Special attention was drawn to the confirmation of kurkar. Whenever there was uncertainty about the geological profile, the original data recorded by the contractor were interpreted for confirmation of the lithology. Lithological description of well data in the vicinity of the questioned data were also referred to for interpretation of the stratigraphic sequences.

Although many lithological profiles compiled in the GMS do not indicate impermeable clay beds overlying the aquifer, it is thought that many cases of groundwater in the existing wells are confined or semiconfined types.

Effort has been made to identify the boundary between the Quaternary and the Pre-Quaternary in order to figure out the base of the Quaternary and the lithology of the top of the Pre-Quaternary. For this purpose the sequence of lithology and stratigraphy are interpreted and references were made to the microfossil analysis.

Results of the above interpretation of existing well data are summarized in Table 2-1-1.

2-2 Pre-Quaternary Data

2-2-1 Introduction

There are many petroleum exploratory wells drilled by oil companies and some wells drilled by UNICEF for domestic purposes in North Sinai. In addition, some test wells were also drilled by RIWR and the study team. More than 250 of these wells were drilled. However,

most of them have insufficient data for making the hydrogeological analysis. Of the well data, about eighty seven were selected for further analysis.

All well data selected in the study have been reviewed and reanalyzed through interpretation of the lithological descriptions and the logging data referring to the geologic columns in order to determine the composite columns.

In this study the wells were numbered using SDS's well code and RIWR's numbering system. However, all the names, usually taken from their locations, are also put together.

2-2-2 Existing Wells

There are approximately ninety wells reaching aquifers of the Pre-Quaternary. Their simplified stratigraphical description is shown in Table 2-2-1.

The geographical distribution of the wells in the study area is one in each 300 km^2. However, distribution of these wells is uneven. No data is available in a vast area of over 10,000 km^2 extending within the lines combining Quseima, Nakhl and Naqb.

Table 2-2-1 Existing Wells in the Aquifer of Pre-Quaternary

Aquifer Types	Tertiary				Upper Cretaceous	Lower Cretaceous	Jurassic	Total
	Miocene	Eocene	Paleocene	(Sub total)				
Oil well	6	0	0	6	3	9	1	19
Production well	2	2	0	4	14	12	36	66
Spring	0	2	0	2	0	0	0	2
Total	8	4	0	12	17	21	37	87

2-2-2-1 Tertiary Wells

Most of these Tertiary wells (tapping water from aquifers in the Tertiary) are located along Wadi El-Arish in North Sinai. A famous spring called "Ain Qudeirat" issues from Tertiary aquifer in Gebel El-Risha near Quseima.

The wells tapping water from aquifers in the Eocene are distributed in the area extending from Gifgafa through Hasana to Quseima and also in the vicinity of Rus Sudr (Fig. 2-2-1).

Some of the wells tapping water from aquifers in the Miocene distribute in the area around Ayun Musa.

Most of these wells of the Tertiary are tapping water from the aquifer of either the Miocene or the Eocene.

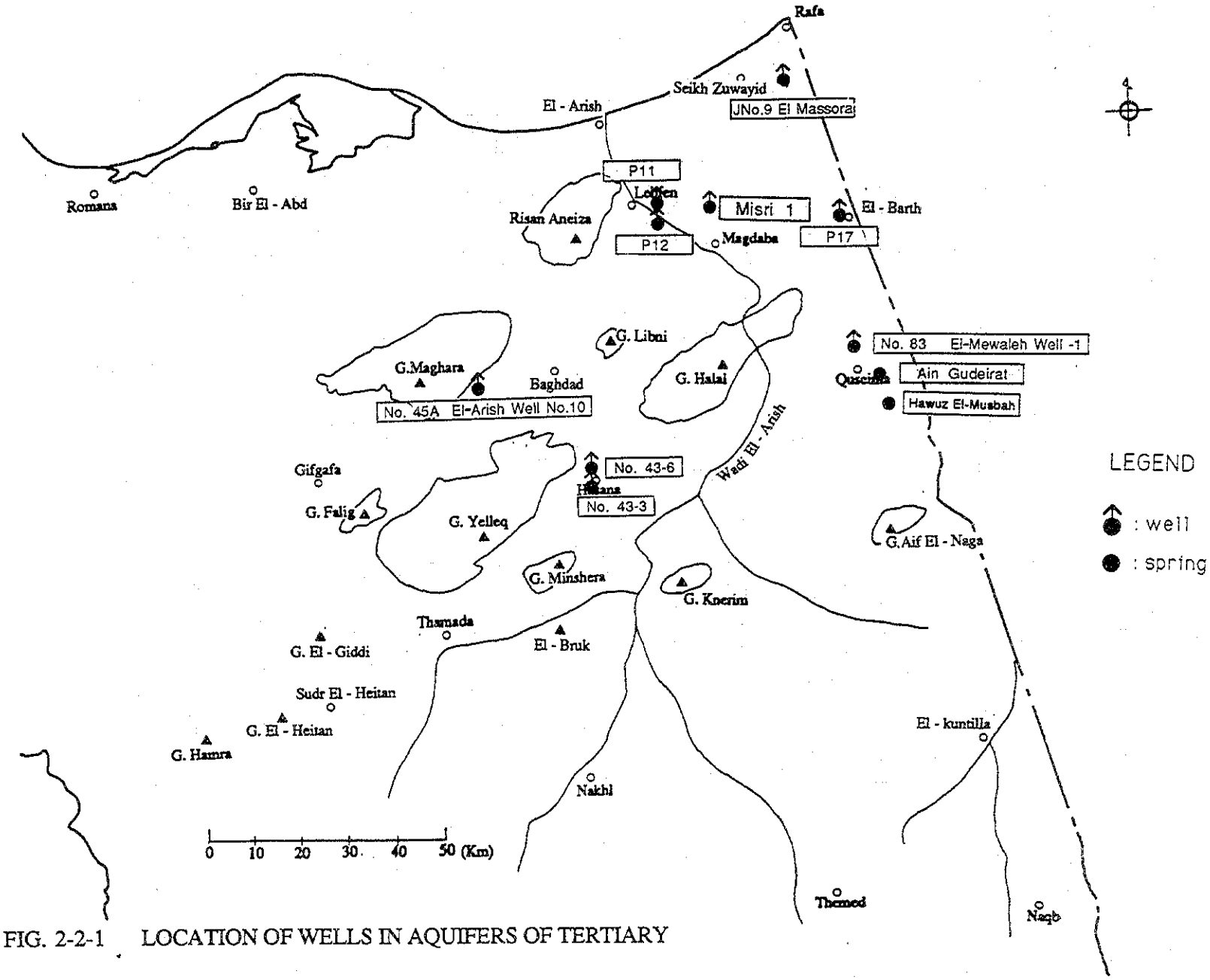


FIG. 2-2-1 LOCATION OF WELLS IN AQUIFERS OF TERTIARY

2-2-2-2 Upper Cretaceous

There are approximately fifty wells tapping water from the aquifer in the Upper Cretaceous in the vicinity of Hasana, Libni and Nakhl (Fig. 2-2-2).

Except oil exploratory wells in the Mediterranean coastal area, these wells are located mainly in the area surrounding Gebel Yellq and Libni.

There are some wells drilled by UNICEF tapping water from the aquifer in the Upper-Cretaceous. However, screens are installed wherever an aquifer is assumed to exist, so that these wells are tapping water from various types of aquifers. These wells are found at Gifgafa, Hasana Nakhl and El Amro. In this study, these wells are not classified as the wells tapping water from the aquifer of the Upper-Cretaceous since the groundwater origin is uncertain.

2-2-2-3 Lower Cretaceous

There are forty wells tapping water from the aquifer in the Lower Cretaceous. These wells are classified into three groups according to their depth: wells reaching 1,000 m, wells of depth between 100 m and 500 m and the remaining dug wells (Fig. 2-2-3).

The deep wells classified as the first group are the oil exploratory wells, test wells drilled by RIWR and the study team, and Army wells at Gifgafa. Oil exploratory wells are mainly located in the Mediterranean coastal area and along the Suez canal.

The wells of depth between 100 m and 500 m are test wells drilled by the study team (well J Nos. 12, 13, 14, and 15) and some production wells.

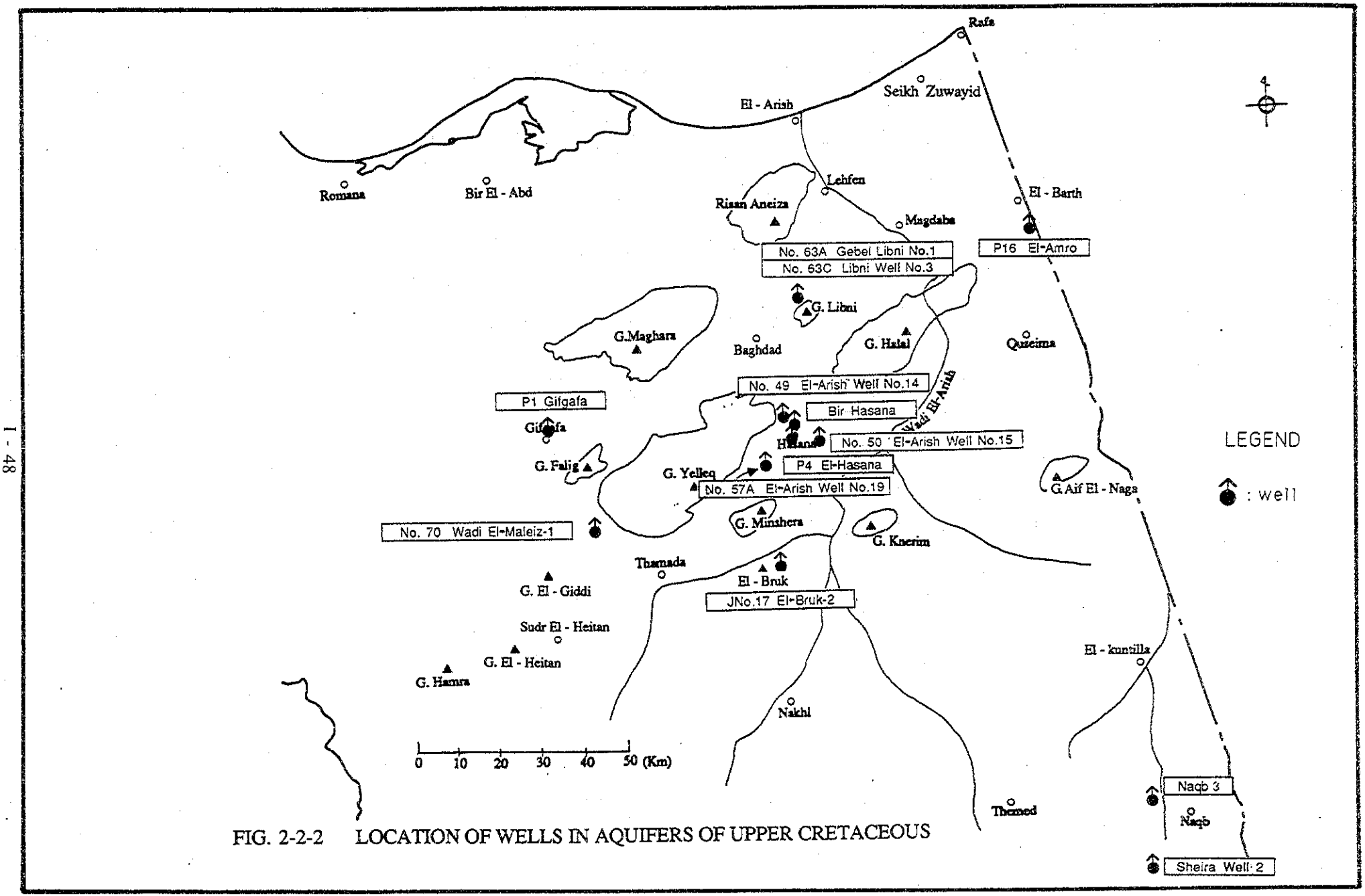


FIG. 2-2-2 LOCATION OF WELLS IN AQUIFERS OF UPPER CRETACEOUS

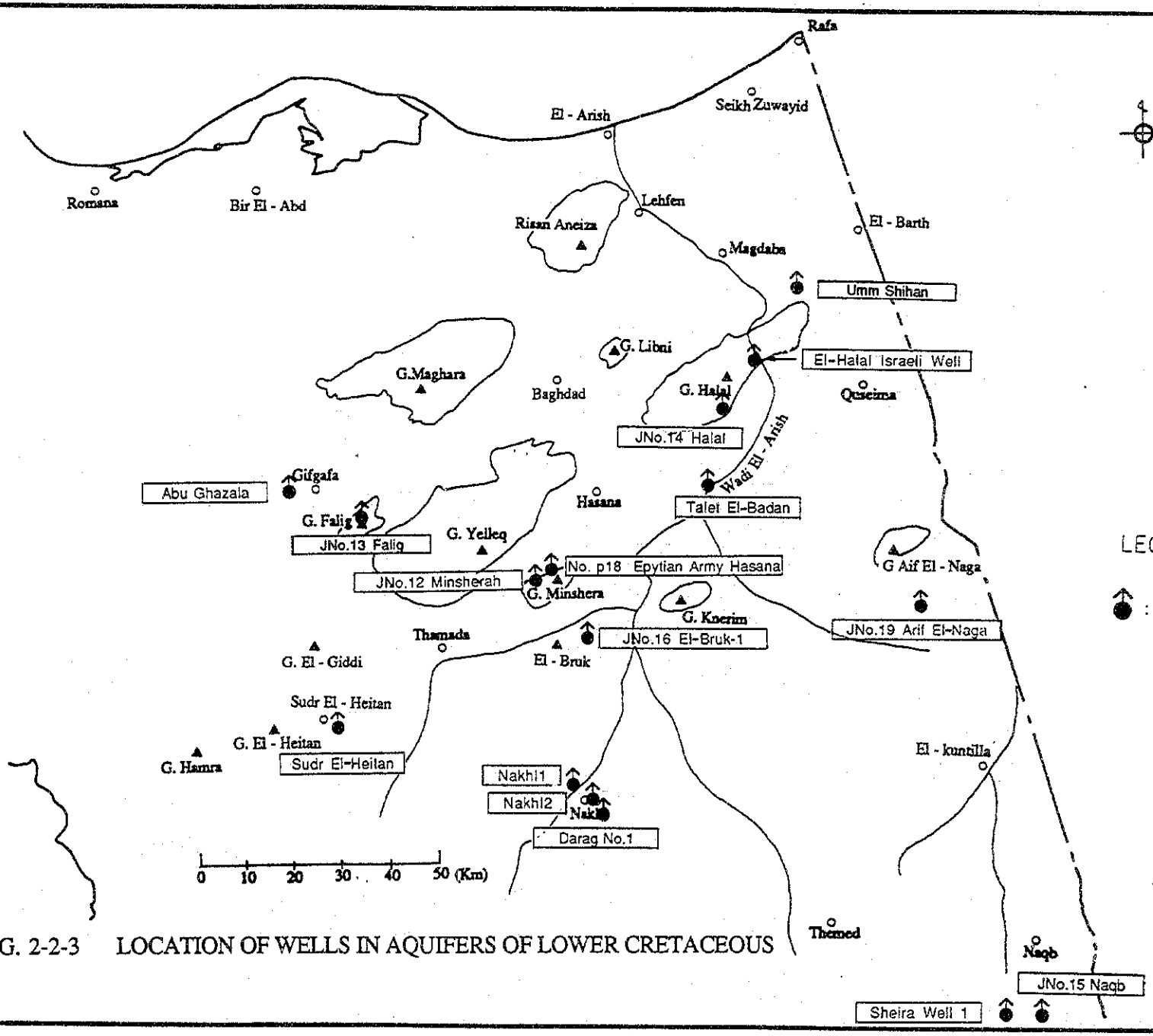


FIG. 2-2-3 LOCATION OF WELLS IN AQUIFERS OF LOWER CRETACEOUS

2-2-2-4 Jurassic

Aquifers yeilding water to the existing wells are found only in the Jurassic among the Pre-Cretaceous formations. These wells, tapping water from the aquifers developing in the Jurassic, are found in the Gebel Maghara area (wells in the coal mine, RIWR test wells and dug wells) (Fig. 2-2-4).

2-2-3 Test Wells

2-2-3-1 General

Considering the extent of the distribution of the formations and their lithological nature to develop an aquifer, the Lower Cretaceous was selected as a target formation among the Pre-Quaternary formations. Accordingly, test wells were drilled into the Lower Cretaceous. A total of seven test wells were drilled by the study team and other test wells were also drilled by RIWR.

2-2-3-2 Test Wells Drilled by Study Team

All of these test wells were drilled into the Lower Cretaceous. The objectives of these test wells are:

1. Confirmation of water level of aquifers of the Lower Cretaceous in the area of the dome structure (J No. 12, 13 and 14).

2. Confirmation of the influence of the geological structure on the ground water conditions.

3. Availability of the ground water for the future development of Naqb area.

4. Confirmation of the hydrogeological conditions of the Lower Cretaceous in the vast low lying area.

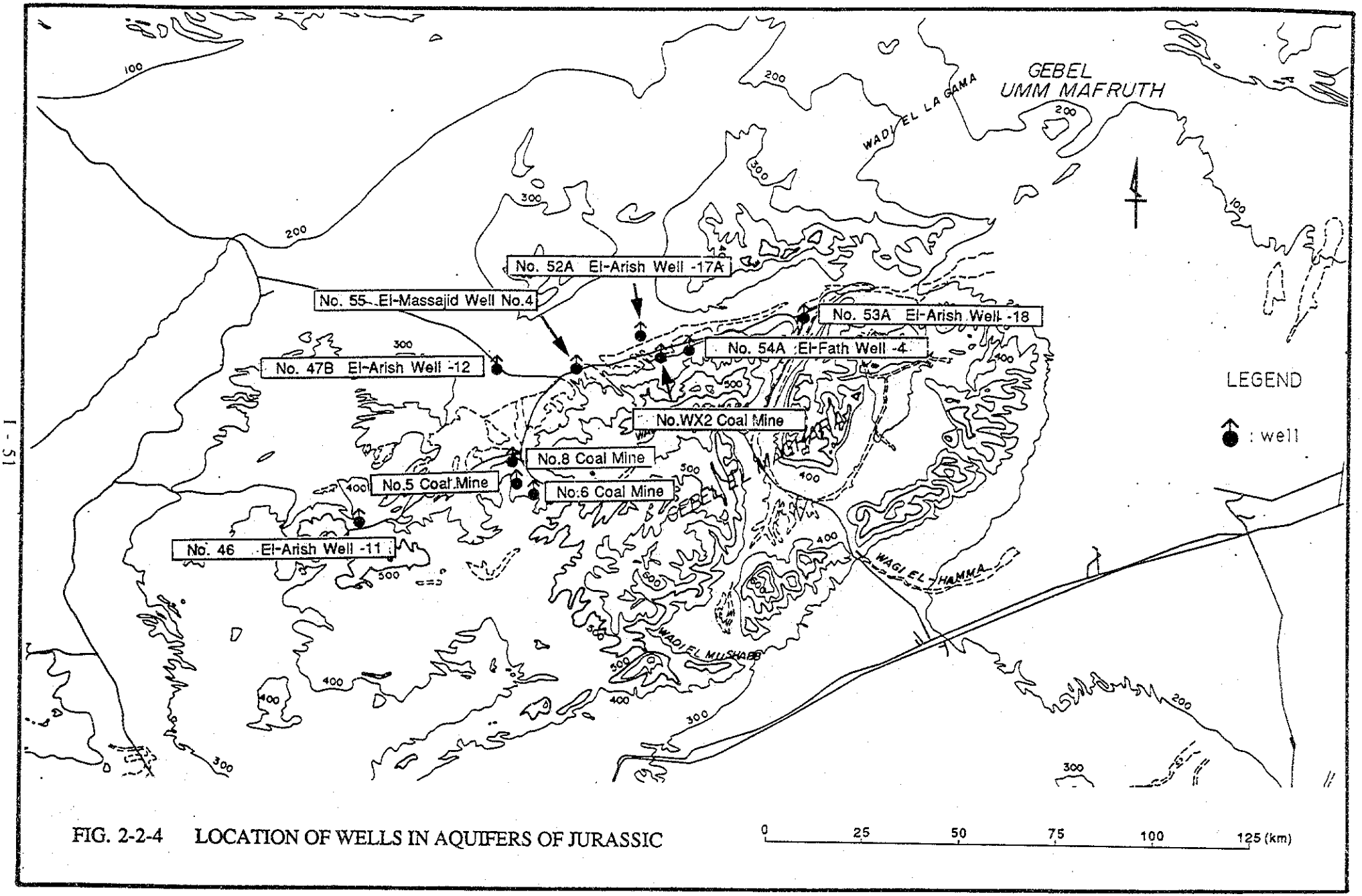


FIG. 2-2-4 LOCATION OF WELLS IN AQUIFERS OF JURASSIC

The locations and drilling depths are summarized below;

Table 2-2-2 Test Wells Drilled by Study Team

No.	Location	Depth	Targe Strata
J No. 9	Massora	91 m	Tertiary
J No. 12	Minshera	350 m	Lower Cretaceous
J No. 13	Yeliq	400 m	Lower Cretaceous
J No. 14	Hallal	300 m	Lower Cretaceous
J No. 15	Naqb	400 m	Lower Cretaceous
J No. 16	El-Bruk 1	799 m	Lower Cretaceous
J No. 17	El-Bruk 2	188 m	Upper Cretaceous
J No. 19	Arif El-Naga	900 m	Lower Cretaceous
Total		3,428 m	

2-2-3-3 Test Wells Drilled by RIWR

Test wells were also drilled by RIWR for investigation of the aquifers in the Lower Cretaceous as shown below:

Table 2-2-3 Test Wells Drilled by RIWR

Location	Depth	Targe Strata
El-Kuntilla	645 m (Abandoned)	Lower Cretaceous
Sudr El-Heitan	1,025 m	Lower Cretaceous
Sheira-1	804 m	Lower Cretaceous
Sheira-2	300 m	Upper Cretaceous
Total	2,774 m	

2-2-3-4 Results of the Test Wells

A total number of eight test wells were drilled into the aquifers in the Pre-Quaternary by the study team. The geologic age of the units was determined by referring to the results of lithofacies interpretation based on the condition of slimes, the stratigraphy and fossil analysis (Technical Report II).

The results of the test wells drilled by RIWR are also integrated in the composite columns (Technical Report IV) and a description of the result is given below;

JNo.9 : 4 km south of Rafah.

Location	:	34°11'31.9"N, 31°09'35.0"E
Ground level	:	78 m asl
Total depth	:	91 m
Static water level	:	0.7 m asl

This well was drilled at the site 4 km southwest of the test well No. 8 to confirm the extension of the kurkar aquifer observed at No.8. It appears that a thick clayey bed extends to the depth of 57 m below the ground surface. Beneath this massive clayey bed, there is a 11 m thick sand bed underlain by 8 m thick clay. Below the base of this clay, gravel encounters from the level of -7 m asl and may extend down to -18 m asl. Although it seems like a confined type,the static water level is observed at 0.7 m asl.

The transmissivity is rather low (191 m^2/day). The aquifer of this test well is determined as of the Miocene of the Tertiary (Fig. 2-2-5).

J No.12 : Minshera

Location	:	On the dome structure of Gebel Minshera
Ground level	:	380 m asl
Total depth	:	300 m
Static water level	:	198 m asl
TDS	:	2,973 ppm

The Cenomanian extends to the depth of 40 m from the ground surface underlain by the sandstone of the Lower Cretaceous. The thickness of the Lower Cretaceous is 290 m underlain by the limestone of the Jurassic. The facies of the Jurassic is dolomitic

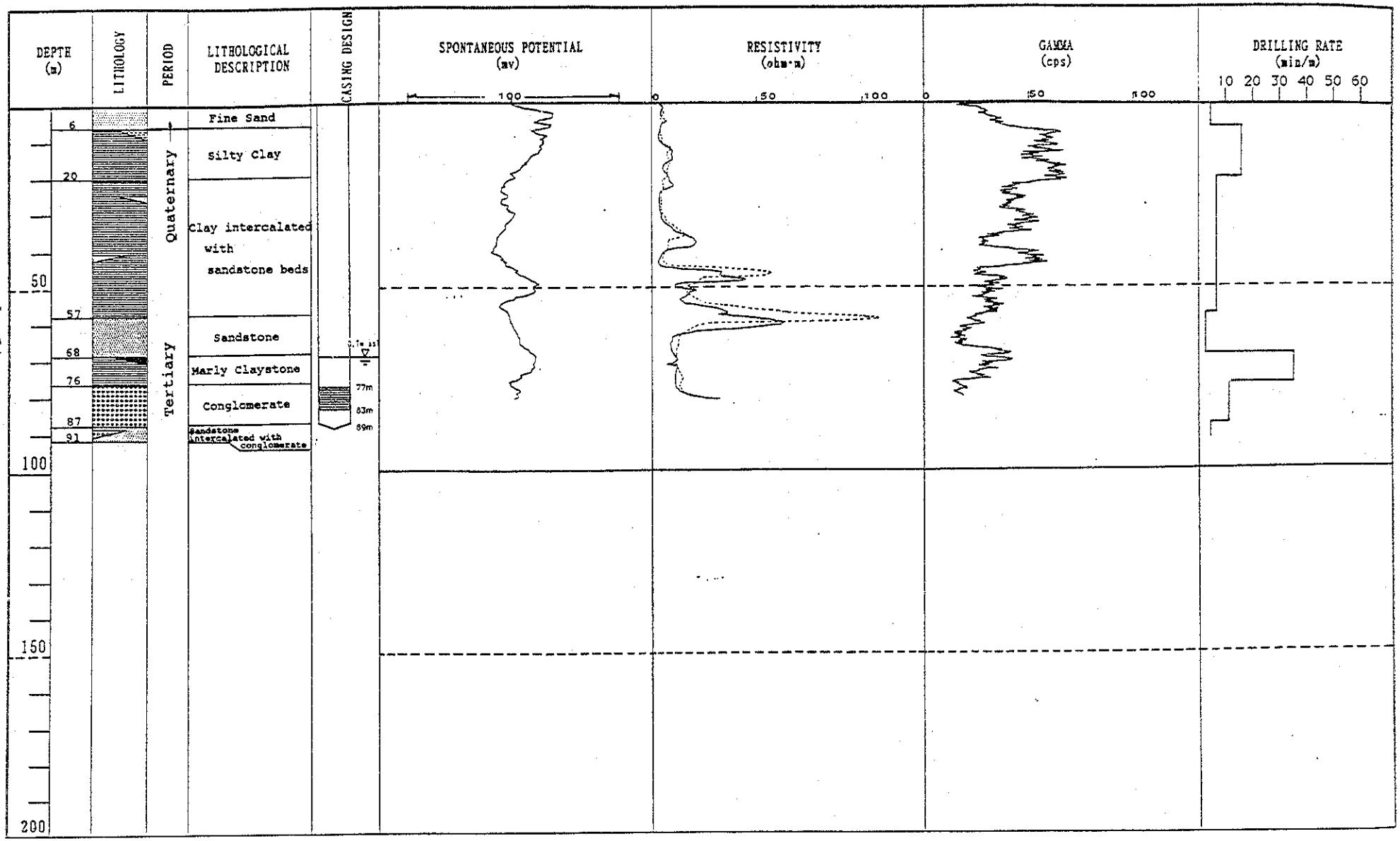
FIG. 2-2-5 WELL DATA AND LITHOSTRAITGRAPHIC COLUMN

Sheet No. 1

Well Location
Well No. : 9
Location : El Massora
Elevation : 69m asl
Latitude : 31° 09′ 35.0″
Longitude : 34° 11′ 34.4″
Drilling Date : Jan. '90

Drilling Data
Drilling Depth : 91m
Bit Size : 14-3/4″
Logging Depth : 80m
Casing : 9-5/8″,83m(14pcs)
Screen : 9-5/8″, 6m(1pc)

Pumping Test
Static Water Level: 0.7m asl
Specific Yield : 2.45 m3/hr/m
Water Quality : 3,470 ppm



limestone containing *Nautiloclina Circularis* so that the age is determined as the Masajid formation of the Upper Jurassic.

The transmissivity is estimated at 54.4 m^2/day (Fig. 2-2-6).

J No.13: Falig

Location	:	On the dome structure on the north western side of Gebel Yellq
Ground level	:	355 m asl
Total depth	:	400 m
Static water level	:	67 m asl
TDS	:	- -

The Lower Cretaceous extends down to 331 m from the ground surface underlain by the Jurassic. The lithofacies of the Lower Cretaceous consist of sandstone and thick shale. A thick shale stratum encounters at three levels;

50 m from the ground surface	30 m thick
95 m from the ground surface	10 m thick
230 m from the ground surface	35 m thick

The shale of the Jurassic consists of massive shale. According to the microfaunal assemblage of *foraminifera*, this shale is correlated with the Upper Jurassic;

Lenticulina subalata (Reuss)
Ammobaculites glaessneri (Said and Barakat)
Pseudocyclamina jaccardi (Schrodt)
Kurnubia jurassica (Henson)

Since the water level was beyond the capacity of the air-compressor for development, only the static water level was measured (Fig. 2-2-7).

FIG. 2-2-6 (1) WELL DATA AND LITHOSTRAITGRAPHIC COLUMN

Sheet No. 1/2

Well Location
Well No. : 12
Location : El Minsherah
Elevation : 380m asl
Latitude : 31° 17′ 28″
Longitude : 33° 40′ 4″
Drilling Date : Dec. '89 - Jan. '90

Drilling Data
Drilling Depth : 300m
Bit Size : 14-3/4″,8-1/2″
Logging Depth : 300m
Casing : 9-5/8″,141m(24pcs) / 5-1/2″, 90m(15pcs)
Screen : 5-1/2″, 78m(13pcs)

Pumping Test(by Air lifting)
Static Water Level: 198m asl
Specific Yield : 9.58 m3/hr/m
Water Quality : 2,973 ppm

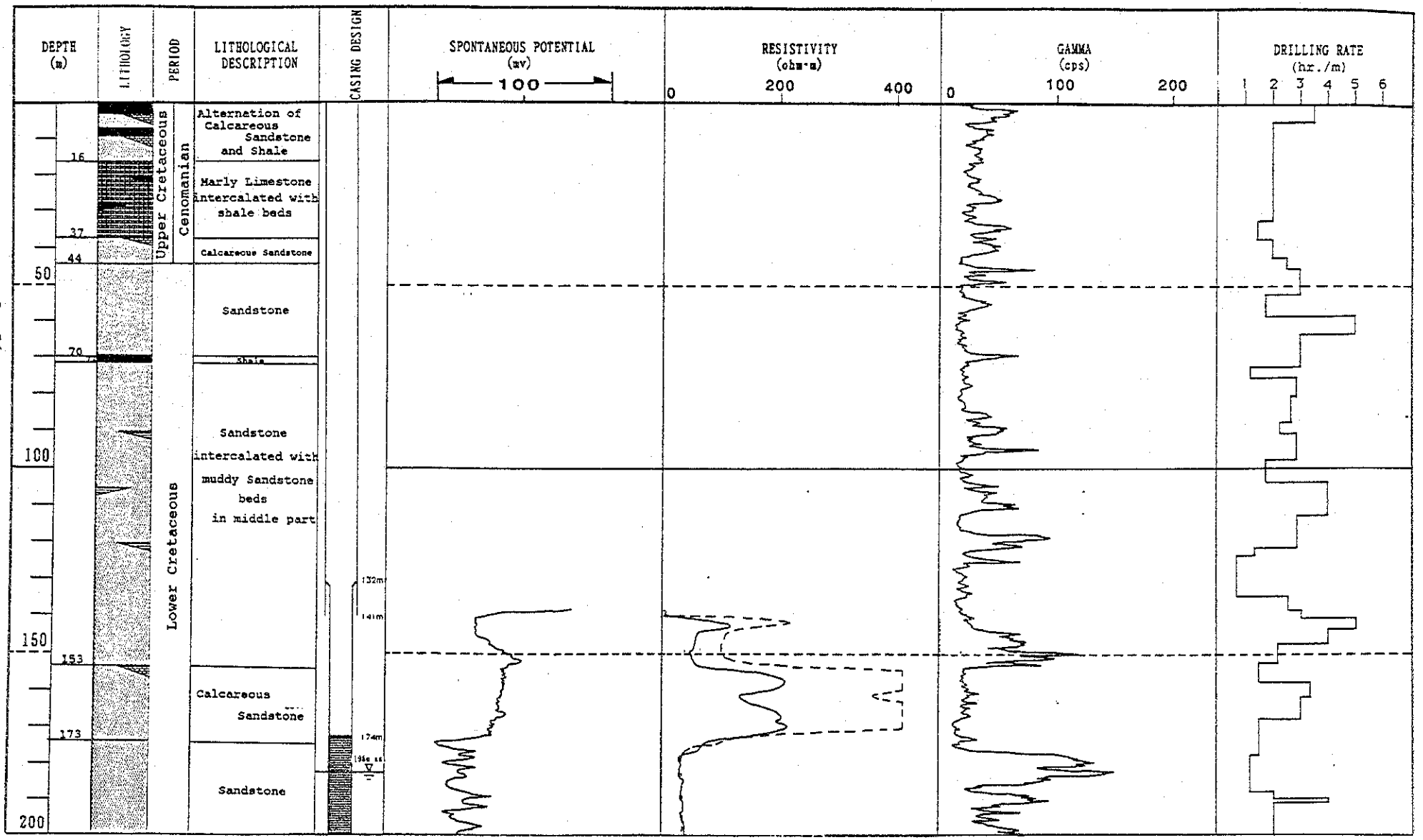


FIG. 2-2-6 (2) WELL DATA AND LITHOSTRAITGRAPHIC COLUMN

Sheet No. 2/2

Well No.12

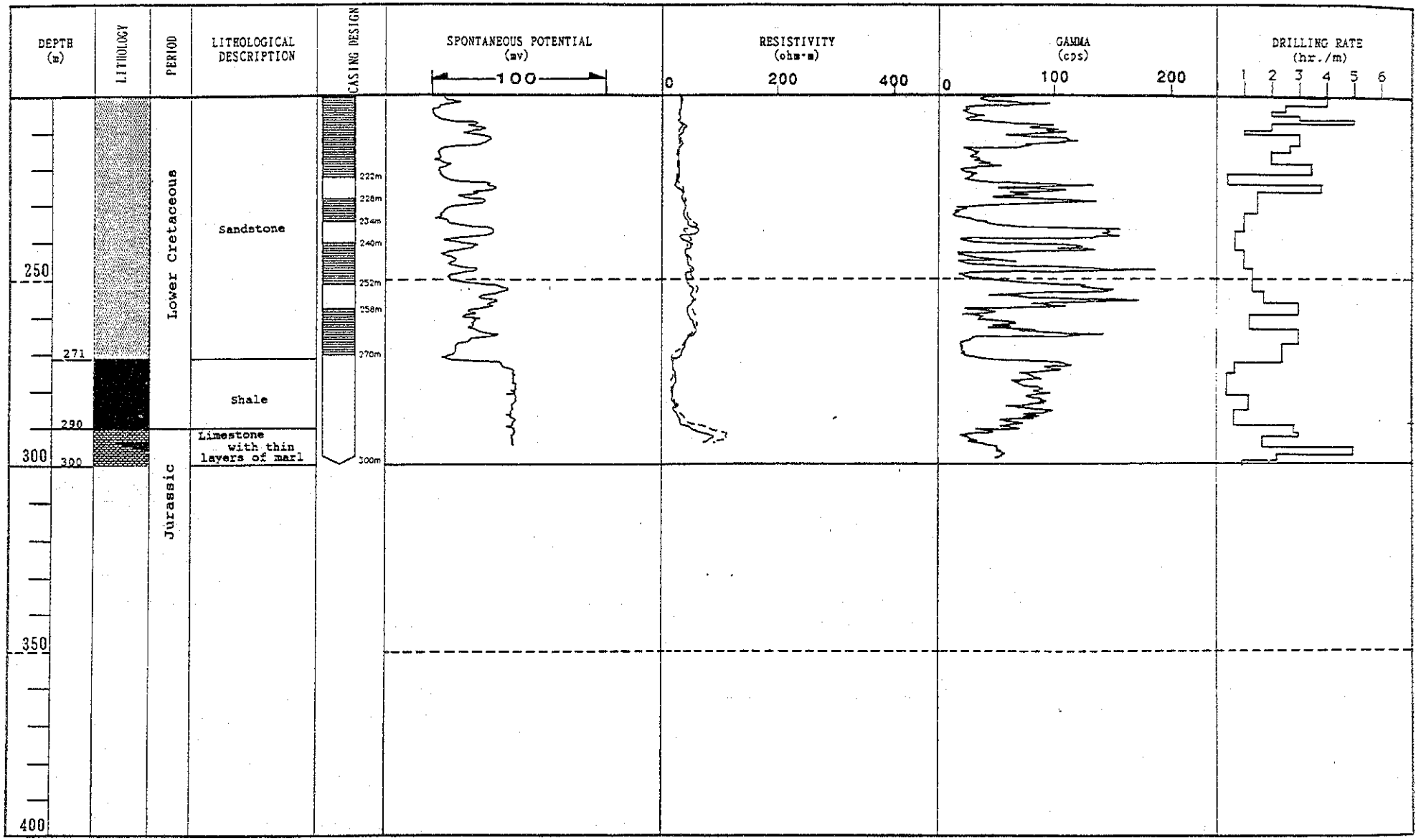


FIG. 2-2-7 (1) WELL DATA AND LITHOSTRAITGRAPHIC COLUMN

Sheet No. 1/2

Well Location
Well No. : 13
Location : Falig
Elevation : 355m asl
Latitude : 30° 23′ 34″
Longitude : 33° 16′ 20″
Drilling Date : Dec. '89 - Jan. '90

Drilling Data
Drilling Depth : 402m
Bit Size : 14-3/4″,12-1/4″
Logging Depth : 402m
Casing : 9-5/8″,252m(42pcs) / 5-1/2,30m(5pcs)
Screen : 9-5/8″,102m(17pcs) / 5-1/2″,30m(5pcs)

Pumping Test
Static Water Level: 67m asl
Specific Yield : -
Water Quality : -

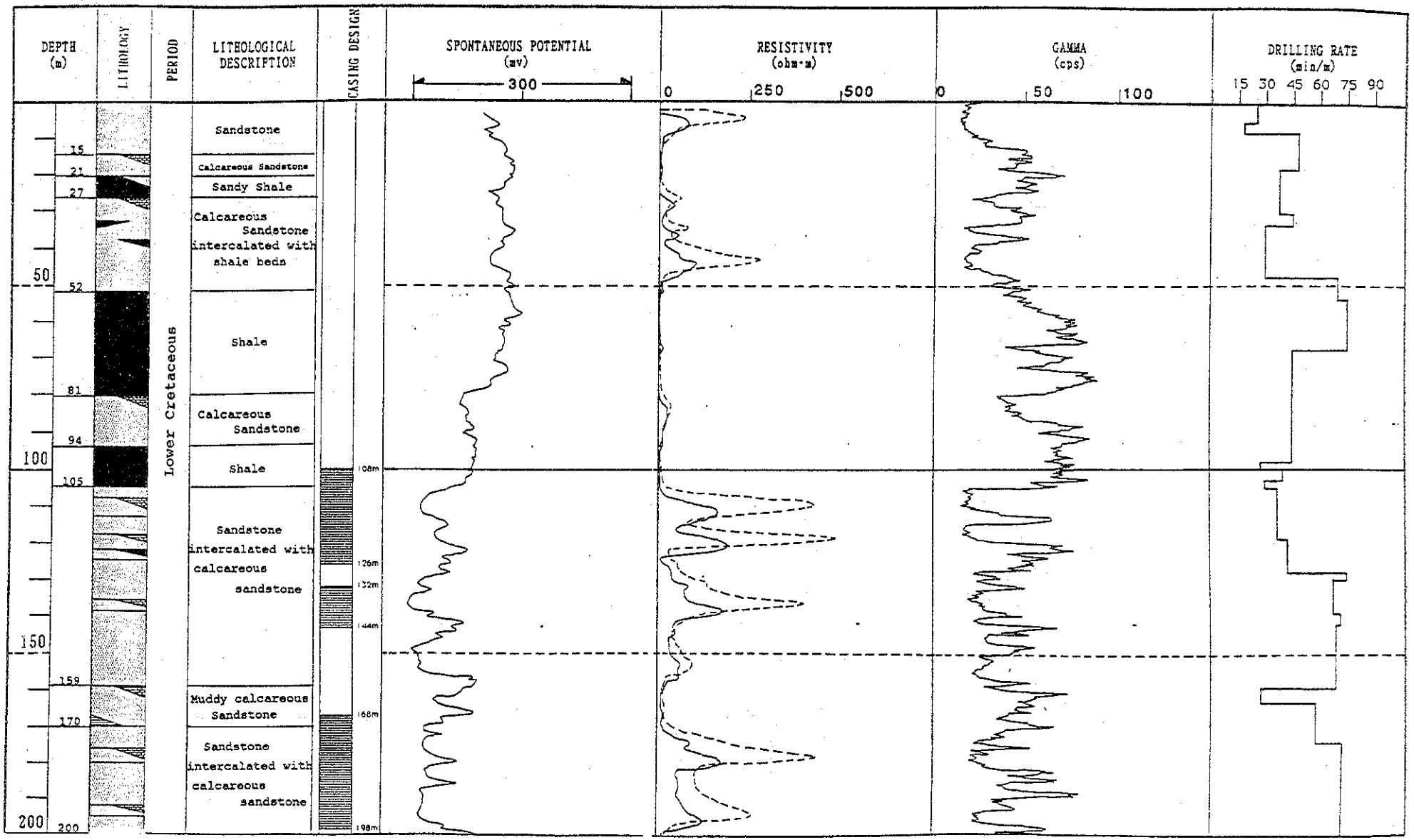
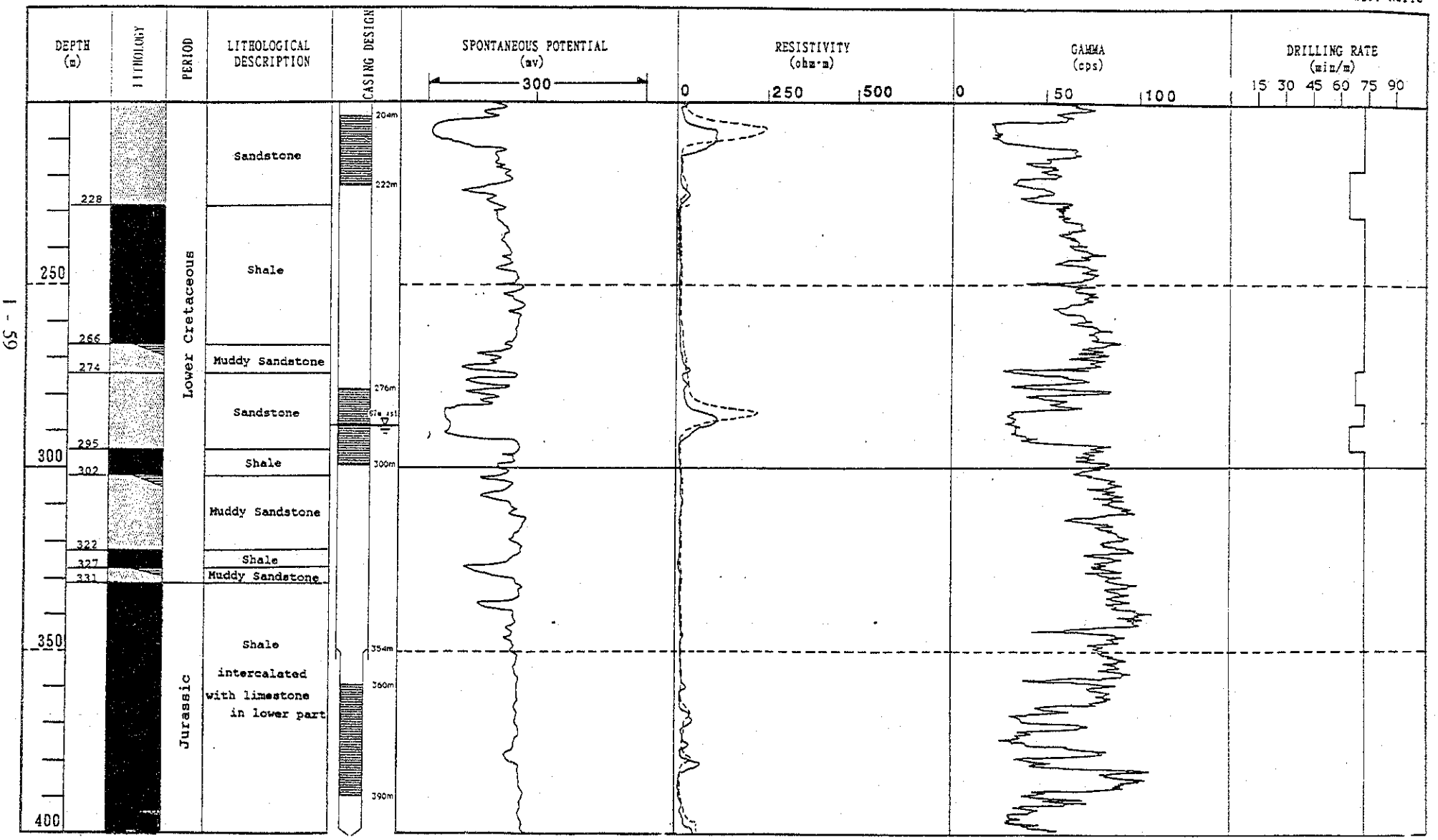


FIG. 2-2-7 (2) WELL DATA AND LITHOSTRAITGRAPHIC COLUMN

Well No.13



J No.14 : Halal

Location	:	Inside the core of Gebel Halal
Ground level	:	320 m asl
Total depth	:	300 m
Static water level	:	Dry
TDS	:	-

Below the top bed of the four meter thick Quaternary formation, the Lower Cretaceous extends to 165 m from the ground surface underlain by the Jurassic. The lithofacies of the Lower Cretaceous consists of sand and predominating shale, while those of the Jurassic consist of shale and claystone.

Cyclammina sp. and *Vivulinella* sp. were observed in the claystone below 165 m from the ground surface which is correlated with the Upper Jurassic. After well logging there was no sign of water. (Fig. 2-2-8)

J No. 15 : Naqb

Location	:	East to Wadi Watir:
Ground level	:	850 m asl
Total depth	:	400 m
Static water level	:	Dry
TDS	:	-

The Cenomanian of the Upper Cretaceous extends to 295 m from the ground surface underlain by the Lower Cretaceous.

The lithofacies of the Cenomanian consists of limestone and shale. Sandstone is predominates in the Lower Cretaceous with occasional shale.

The well does not reach the water level even at its bottom, i.e., 400 m from the ground surface. Sheira-1 (G.L. 760 m asl) about 10 km to

FIG. 2-2-8 (1) WELL DATA AND LITHOSTRAITGRAPHIC COLUMN

Well Location
Well No. : 14
Location : Halal
Elevation : 320m asl

Latitude : 30° 37′ 51″
Longitude : 34° 03′ 26″
Drilling Date : Dec. '89 - Feb. '90

Drilling Data
Drilling Depth : 300m
Bit Size : 14-3/4″
Logging Depth : 300m
Casing : -
Screen : -

Pumping Test
Static Water Level : -
Specific Yield : -
Water Quality : -

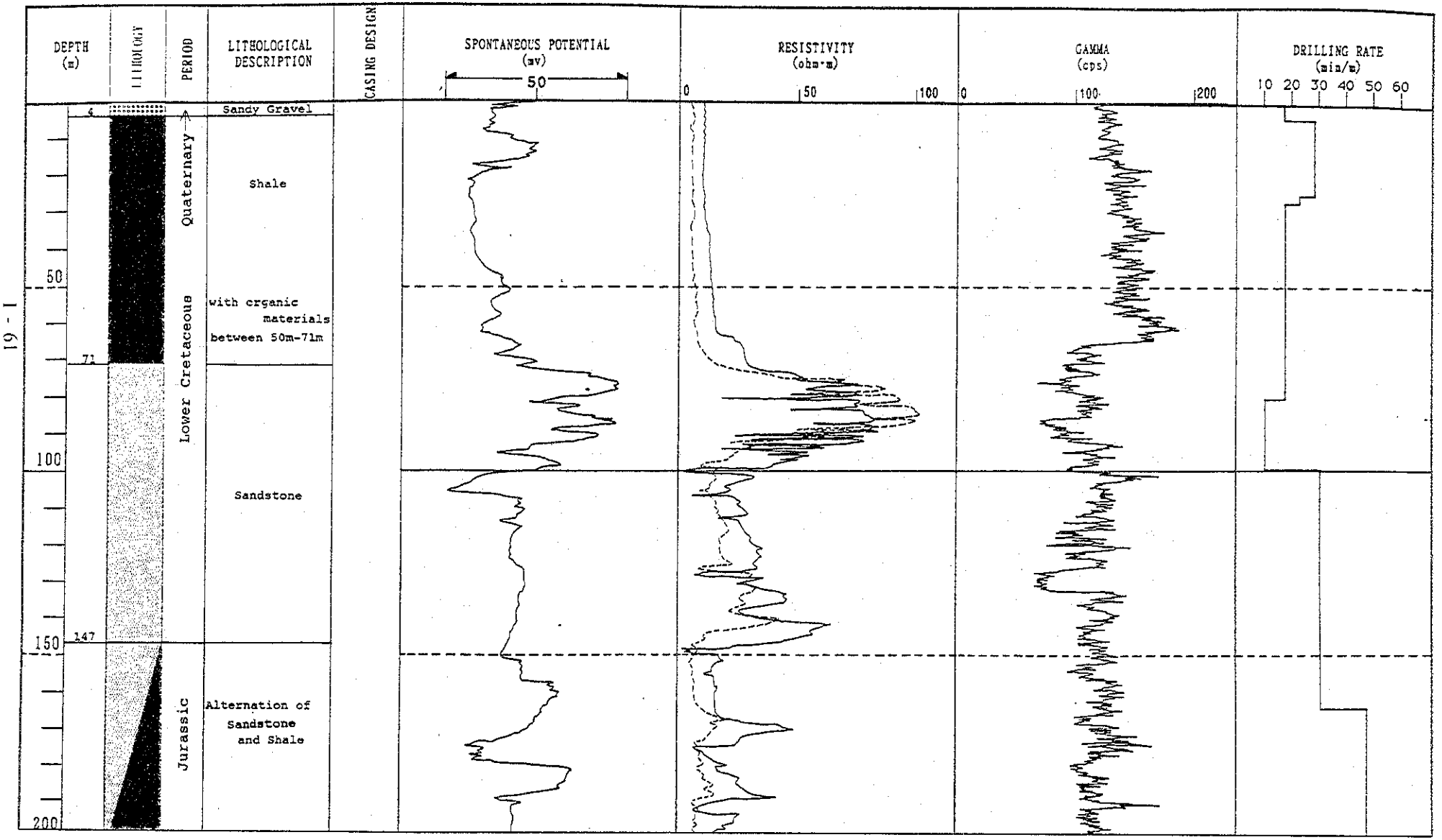
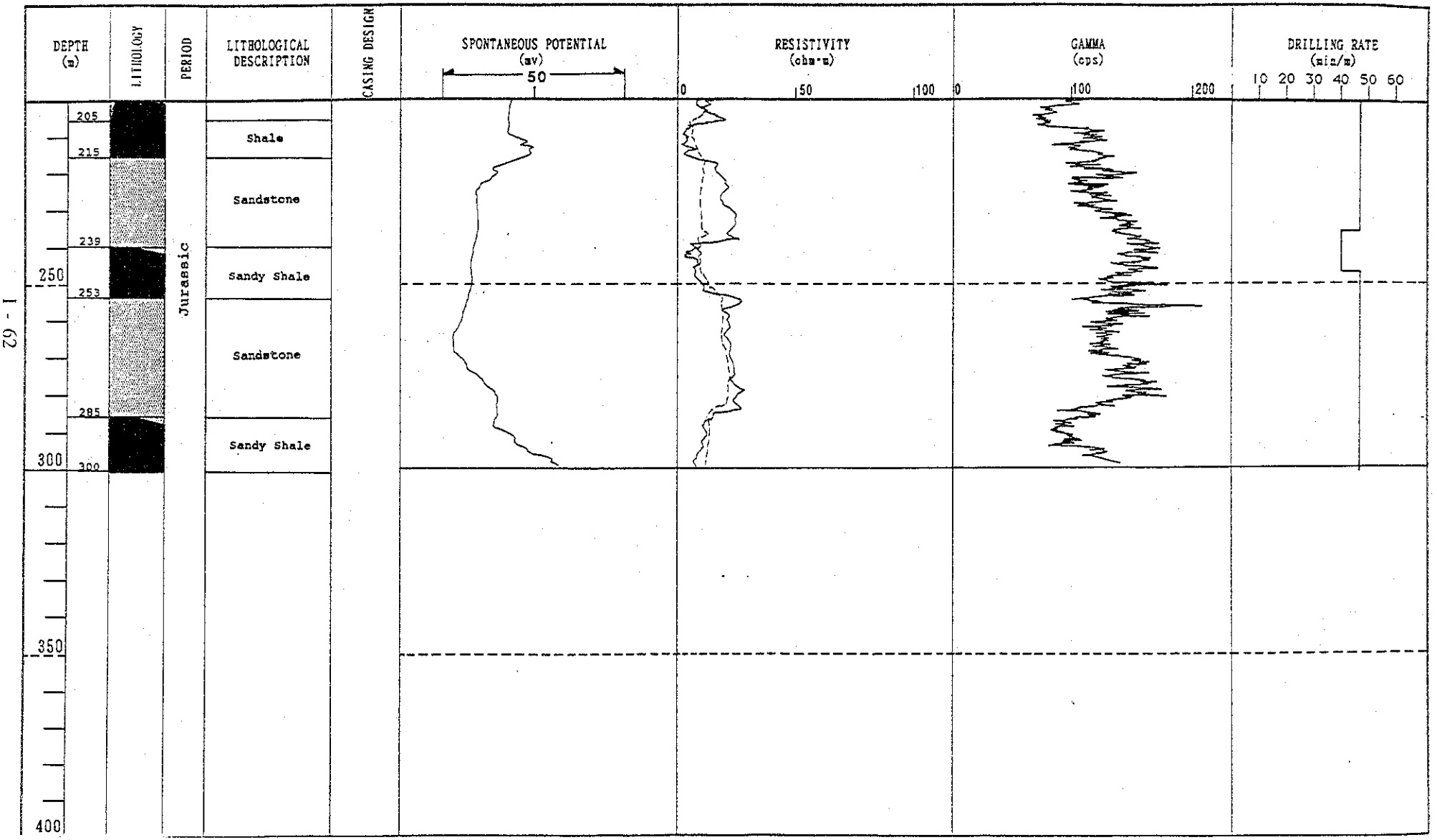


FIG. 2-2-8 (2) WELL DATA AND LITHOSTRAITGRAPHIC COLUMN

Well No.14



the west of this suggests that the water level of J No. 15 is about 430 m from the ground surface as its static water level stands at 420 m asl at a depth of 340 m from the ground surface (Fig. 2-2-9).

J No.16 : El Bruk-1 and J No.17 El Bruk-2

Location	:	In the dome structure at El-Bruk
Ground level	:	355 m asl
Total depth	:	799 m and 355 m
Static water level	:	203 m asl and 223 m asl
TDS	:	2,318 ppm and 5,628 ppm

The ground surface is covered by the 53 m thick Turonian underlain by the 500 m thick Cenomanian. The Lower Cretaceous overlain by the Cenomanian extends to the depth of 730 m from the ground surface underlain by the Jurassic.

The lithofacies of the Lower Cretaceous consists of sandstone and shalely sandstone, while that of the Jurassic consists of sandstone with occasional calcareous facies. Also, it occasionally encounters thin shale and coal. Although it is hardly possible to demarcate the boundary between the Lower Cretaceous and the Jurassic on the site due to the absence of index fossil in the slime, the stratum where the coal encounters is assumed to be the Jurassic. Due to the existence of coal, it is determined to be the Middle Jurassic.

The temperature of the groundwater is 38° C and has an odor which suggests the existence of sulfide in the water.

The transmissivity of the aquifer in the Lower Cretaceous is estimated at 11.9 m^2/day (Fig. 2-2-10).

When drilling this test well, large scale cracks were found at a depth of about 150 m from the ground surface and there was a sign of groundwater.

As a result, the location of test well J No. 17 was determined to confirm the aquifer in the Upper Cretaceous. The transmissivity is estimated at 658.9 m^2/day (Fig. 2-2-12).

FIG. 2-2-9 (1) WELL DATA AND LITHOSTRAITGRAPHIC COLUMN

Sheet No. 1/2

Well Location
Well No. : 15
Location : Naqb
Elevation : 850m asl
Latitude : 29° 27′ 56″
Longitude : 34° 41′ 11″
Drilling Date : Jan. '90 - Feb. '90

Drilling Data
Drilling Depth : 400m
Bit Size : 12-1/4″,8-1/2″
Logging Depth : 400m
Casing : 9-5/8″,309m(52pcs) / 5-1/2,48m(8pcs)
Screen : 5-1/2″,48m(8pcs)

Pumping Test
Static Water Level : -
Specific Yield : -
Water Quality : -

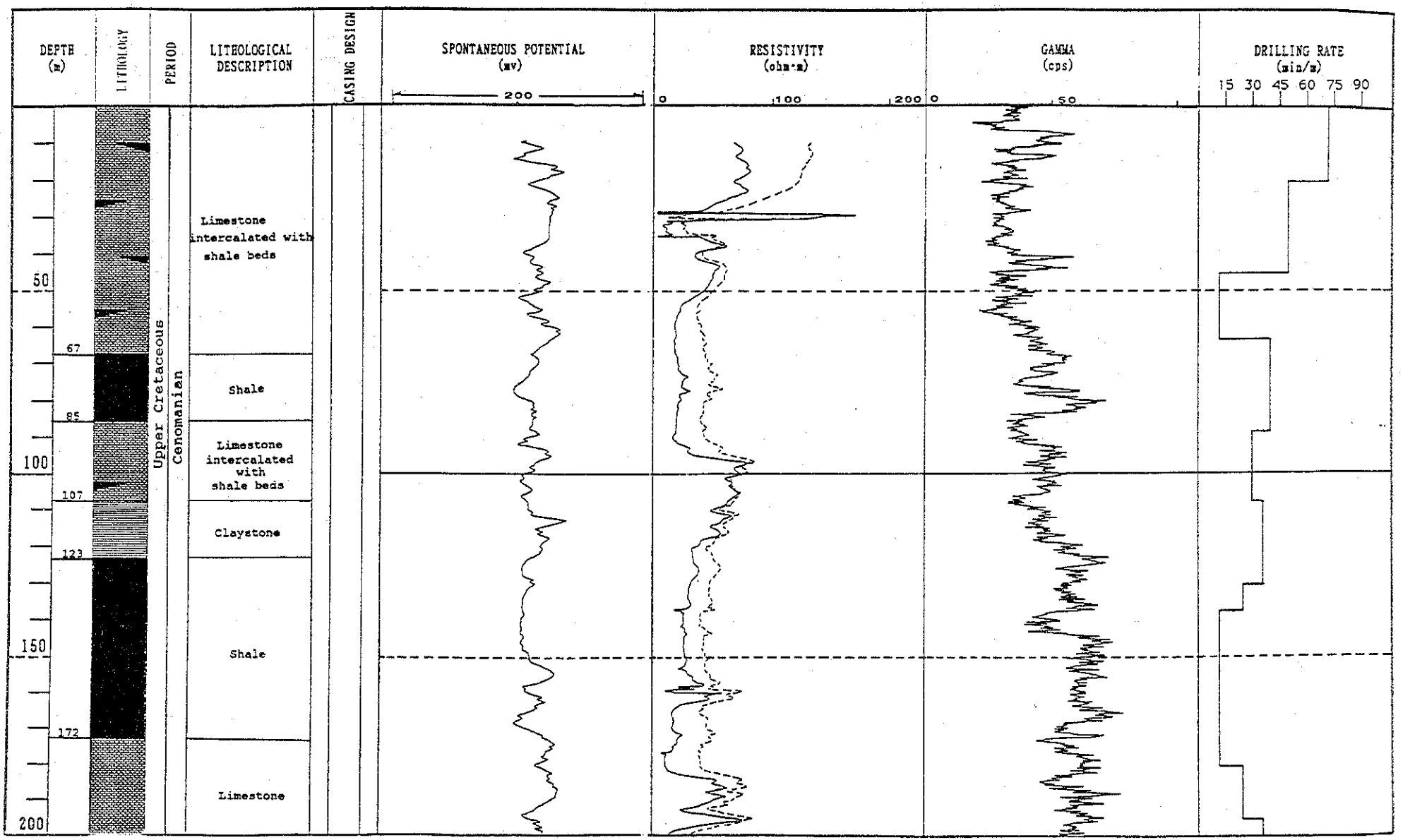


FIG. 2-2-9 (2) WELL DATA AND LITHOSTRAITGRAPHIC COLUMN

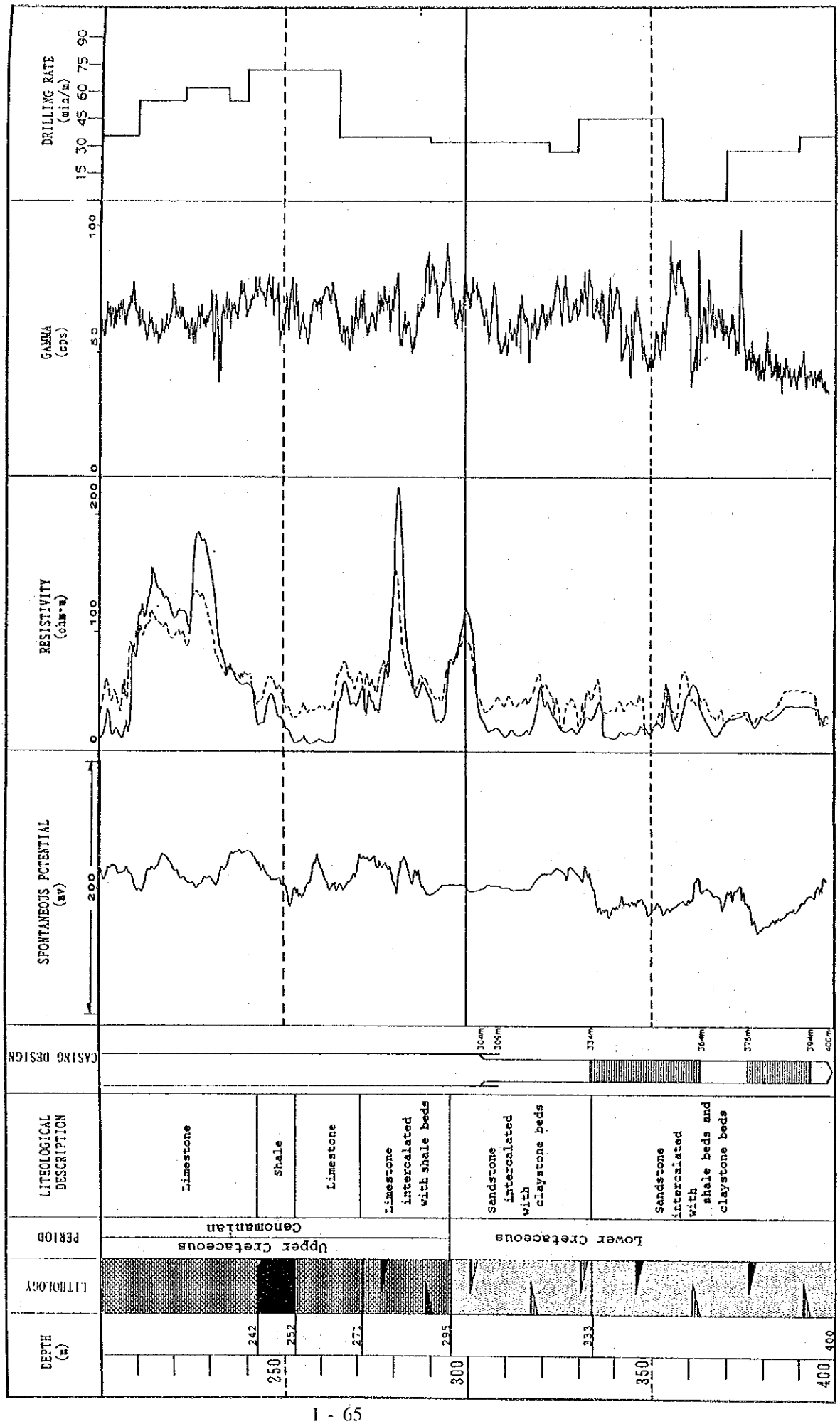


FIG. 2-2-10 (1) WELL DATA AND LITHOSTRAITGRAPHIC COLUMN

Well Location
Well No. : 16
Location : El Bruck-1
Elevation : 355m asl
Latitude : 30° 11' 20.0"
Longitude : 33° 42' 9.6"
Drilling Date : Nov. '90 - Mar. '91

Drilling Data
Drilling Depth : 798.5m
Bit Size : 12-1/4",8-1/2"
Logging Depth : 798.5m
Casing : 9-5/8",503m(84pcs) / 5-1/2",215m(36pcs)
Screen : 5-1/2",90m(15pcs)

Pumping Test
Static Water Level: 203m asl
Specific Yield : 0.47 m3/hr/m
Water Quality : 2,318 ppm

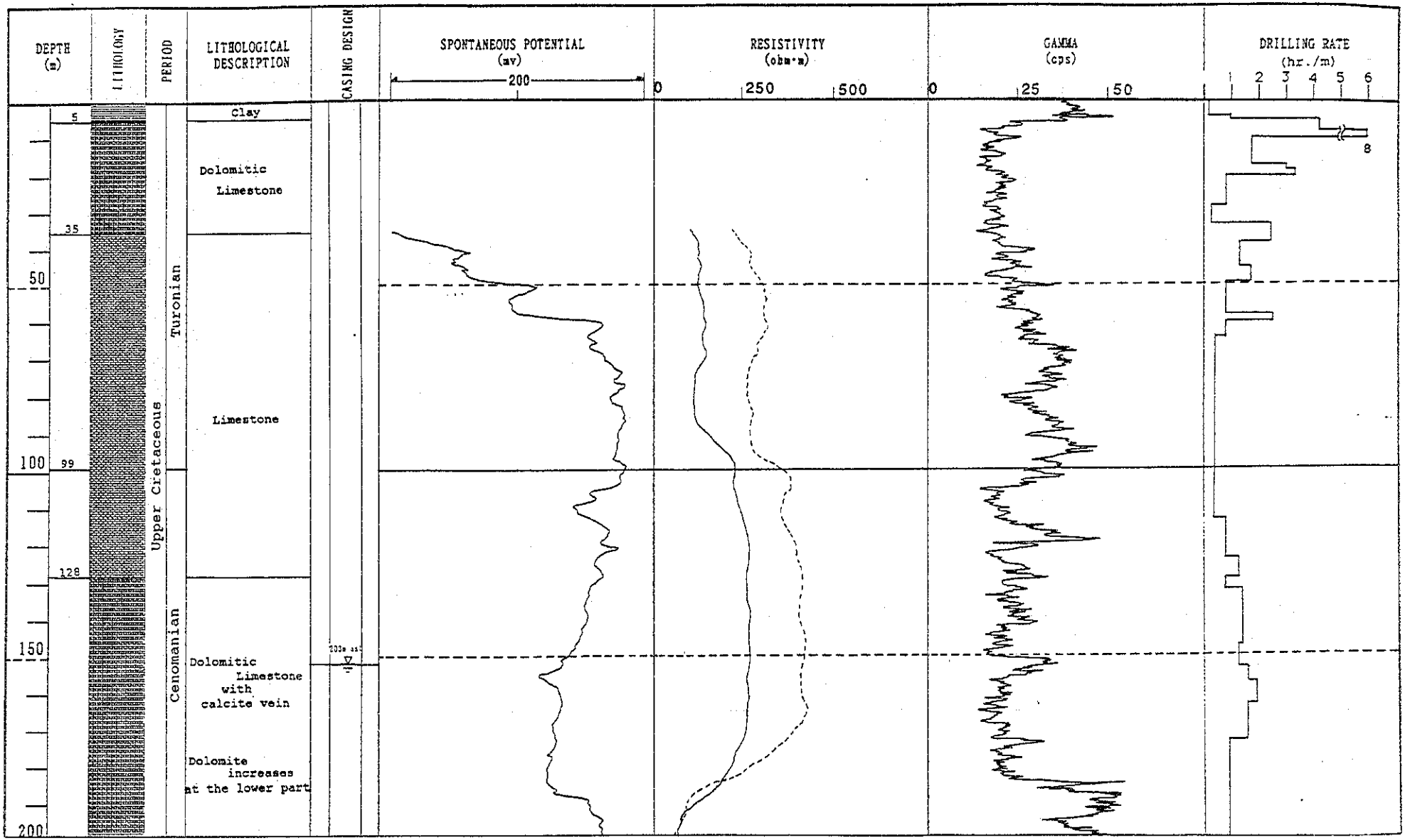


FIG. 2-2-10 (2) WELL DATA AND LITHOSTRAITGRAPHIC COLUMN

Well No.16

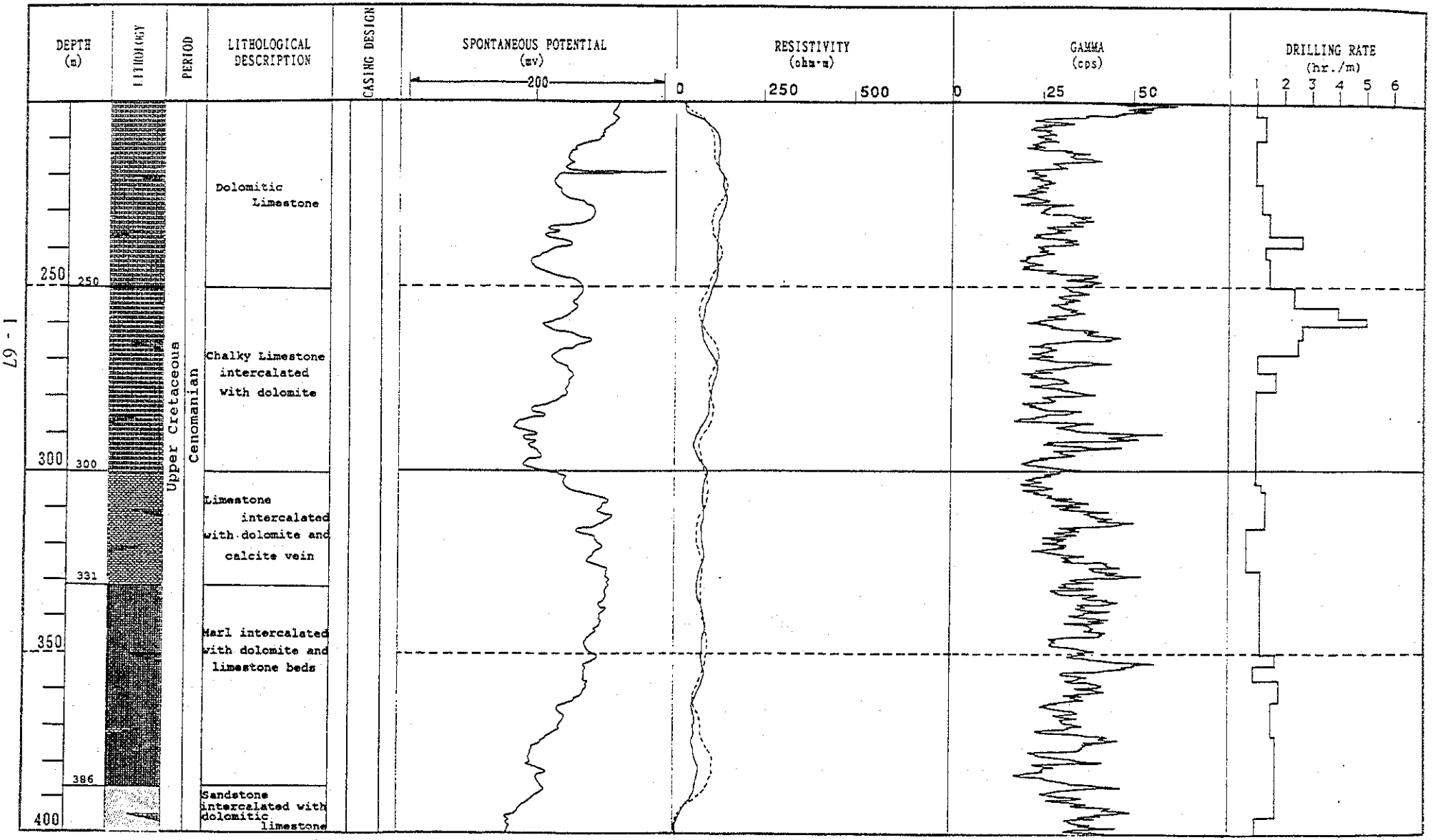
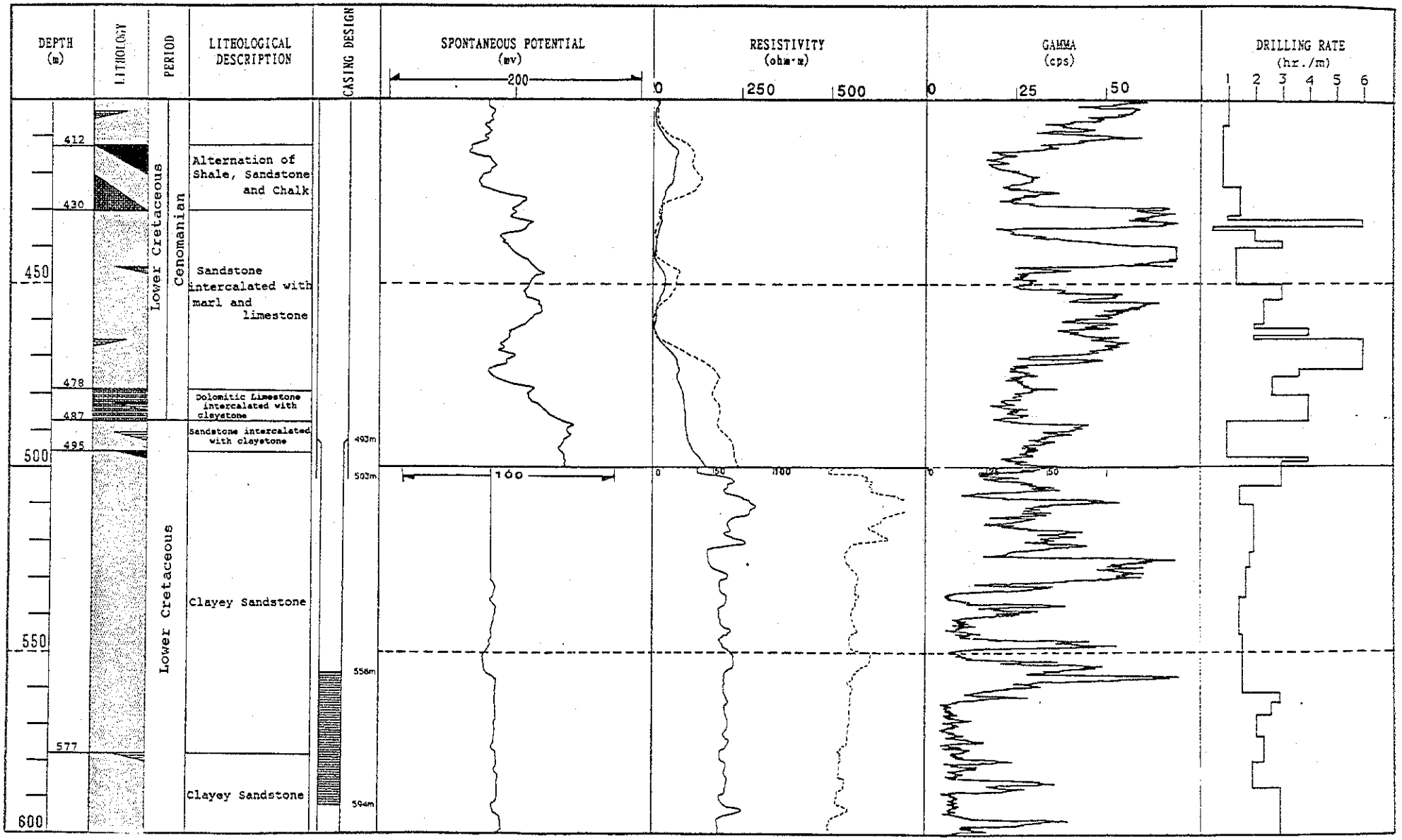


FIG. 2-2-10 (3) WELL DATA AND LITHOSTRAITGRAPHIC COLUMN

Well No.16



89 - 1

FIG. 2-2-10 (4) WELL DATA AND LITHOSTRAITGRAPHIC COLUMN

Well No.16

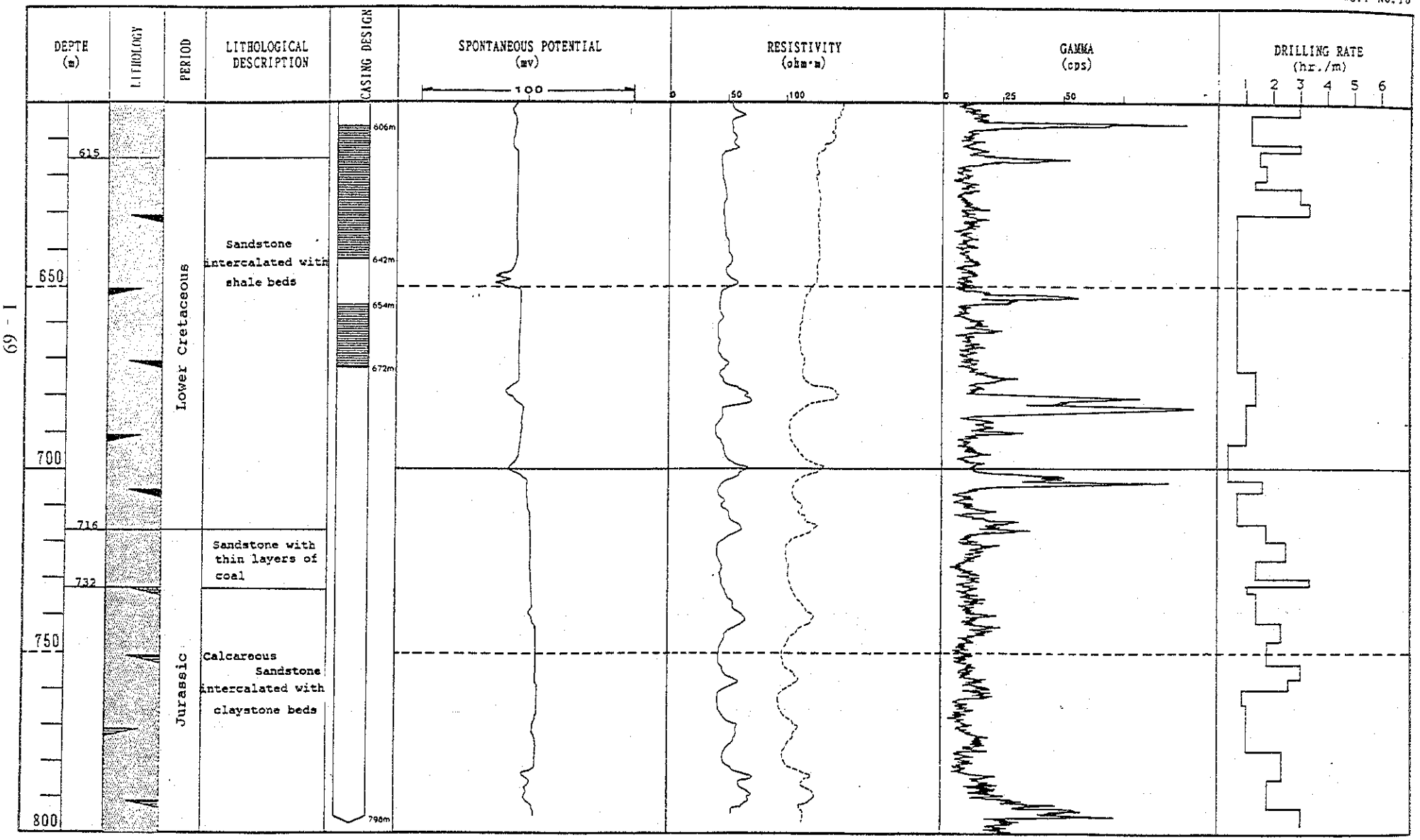


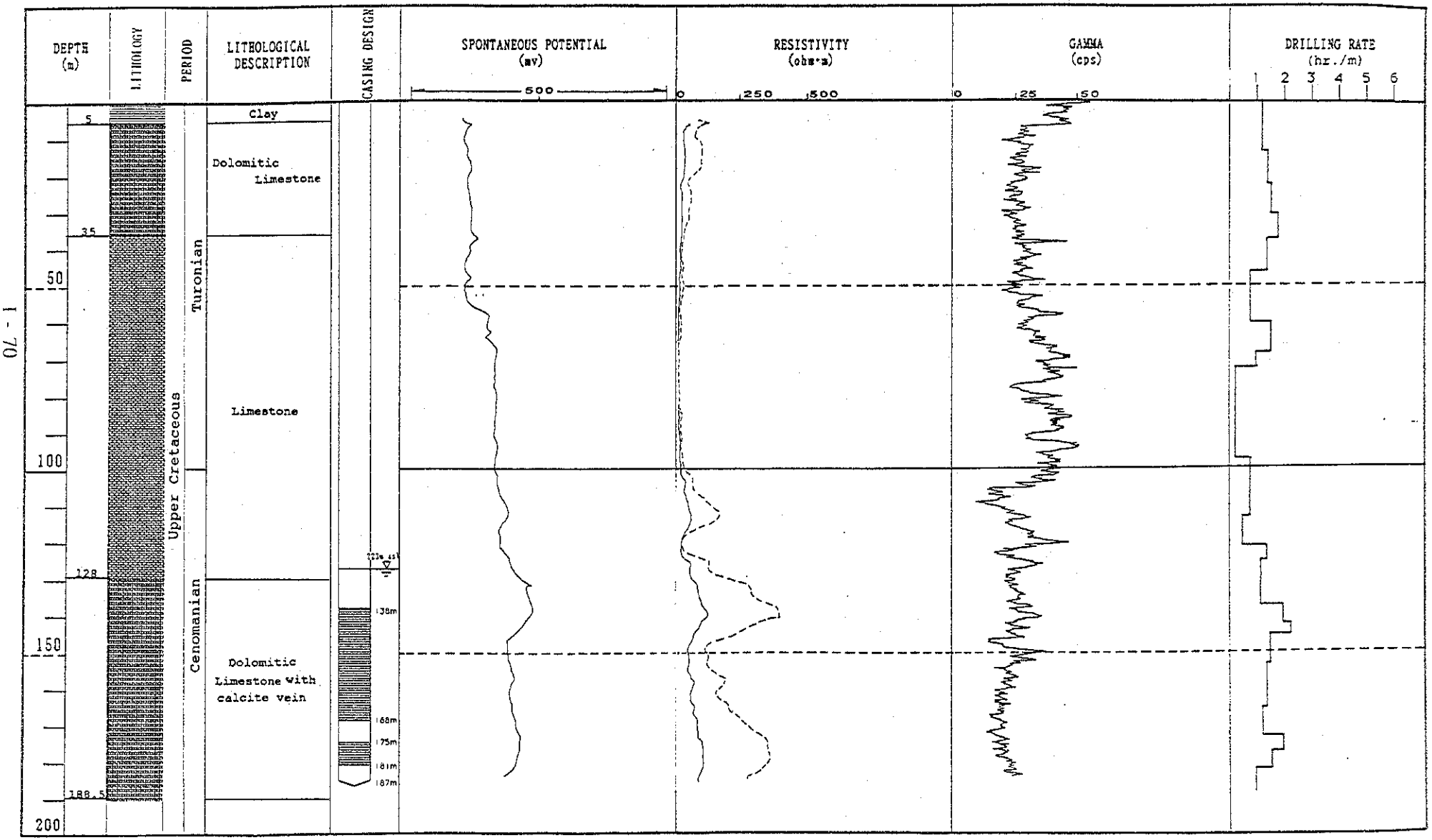
FIG. 2-2-11 WELL DATA AND LITHOSTRAITGRAPHIC COLUMN

Sheet No. 1

Well Location
Well No. : 17
Location : El Bruck -2
Elevation : 355m asl
Latitude : 30° 11' 24.7"
Longitude : 33° 42' 18.3"
Drilling Date : Apr. '91

Drilling Data
Drilling Depth : 188.5m
Bit Size : 14-3/4"
Logging Depth : 188.5m
Casing : 9-5/8", 150.6m(25pcs)
Screen : 9-5/8", 36.4m(6pcs)

Pumping Test
Static Water Level: 223m asl
Specific Yield : 4.52 m3/hr/m
Water Quality : 5,628 ppm



J No. 19: Arif El Naga

Location	:	10 km south of Gebel Arif El-Naga
Ground level	:	455 m asl
Total depth	:	900 m
Static water level	:	159 m asl
TDS	:	3,008 ppm

The chalk of the Senonian extends to 41 m deep from ground surface underlain by the Cenomanian of 515 m thick. The Lower Cretaceous, overlain by the Cenomanian, is underlain by the Jurassic at 720 m.

Lithofacies of the Lower Cretaceous is predominately sandstone with an occasional intercalation of shale. While that of the Jurassic is shale and sandstone encounters occasionally below the depth of 850 m from the ground surface.

The transmissivity is estimated to be 400 m^2/day (Fig. 2-2-12).

Shale, 120 m thick, was found at the top of the Jurassic which may play the role as a barrier between the aquifers of the Lower Cretaceous and the Jurassic. The TDS of the water sample from this well indicates a rather high value among other TDSs of the groundwater in the Lower Cretaceous (Section 4-3-5).

2-2-4 Interpretation

Although there are abundant data of water wells in the study area, most of the wells were drilled as production wells for immediate use purposes, such as domestic or the irrigation of local farms. Accordingly, the available hydrogeological data accompanying these wells are rarely complete except for the wells drilled as test wells and oil exploratory wells.

FIG. 2-2-12 (1) WELL DATA AND LITHOSTRAITGRAPHIC COLUMN

Sheet No. 1/5

Well Location
Well No. : 19
Location : Arif El Naga
Elevation : 455m asl
Latitude : 30° 18′ 21.1″
Longitude : 34° 27′ 34.7″
Drilling Date : Jun. '91 - Sep. '91

Drilling Data
Drilling Depth : 902m
Bit Size : 12-1/4″,8-1/2″
Logging Depth : 902m
Casing : 9-5/8″,552m(92pcs) / 5-1/2″,186m(31pcs)
Screen : 5-1/2″174m(29pcs)

Pumping Test
Static Water Level: 159m asl
Specific Yield : 8.13 m3/hr/m
Water Quality : 3,008 ppm

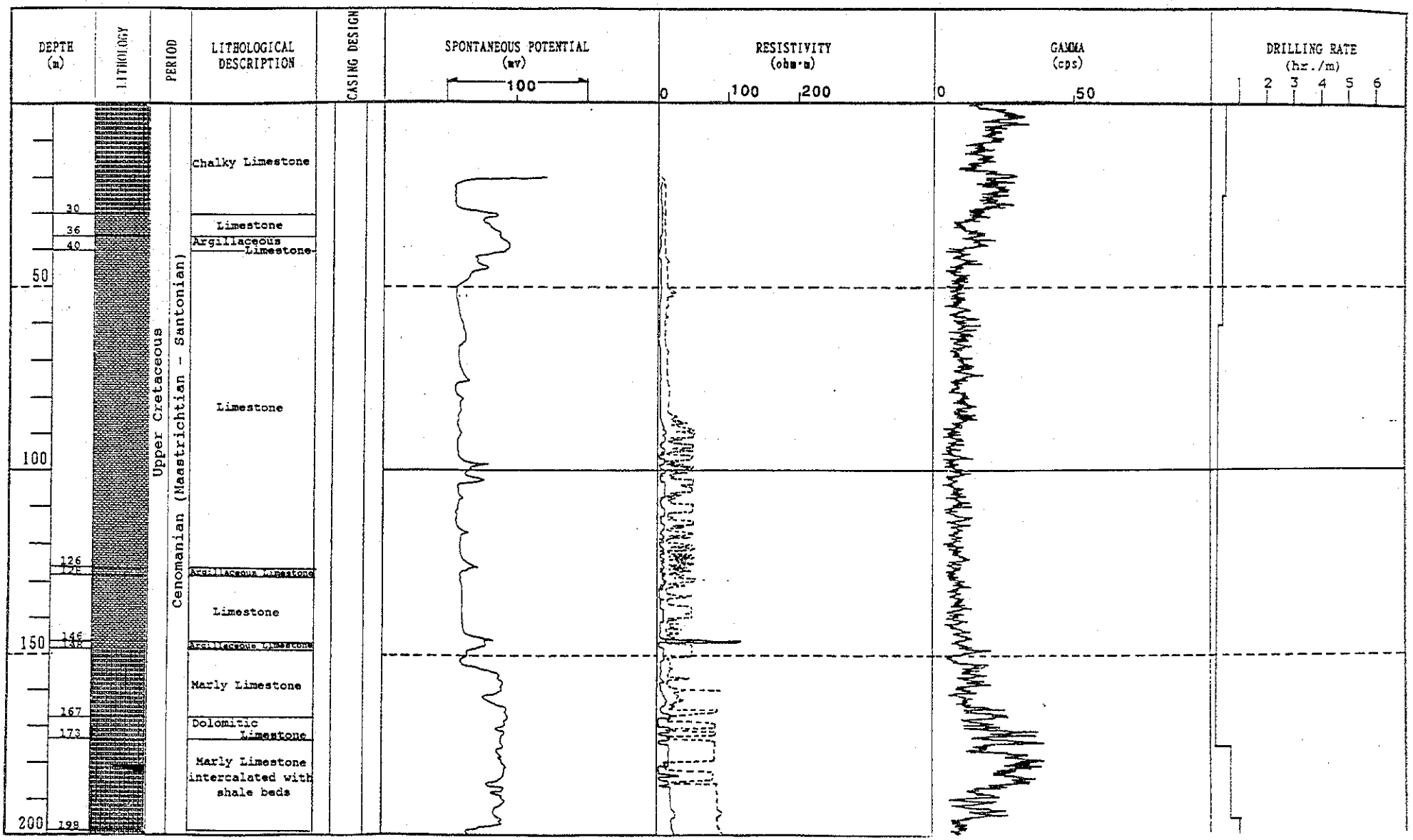


FIG. 2-2-12 (2) WELL DATA AND LITHOSTRAITGRAPHIC COLUMN

Well No.19

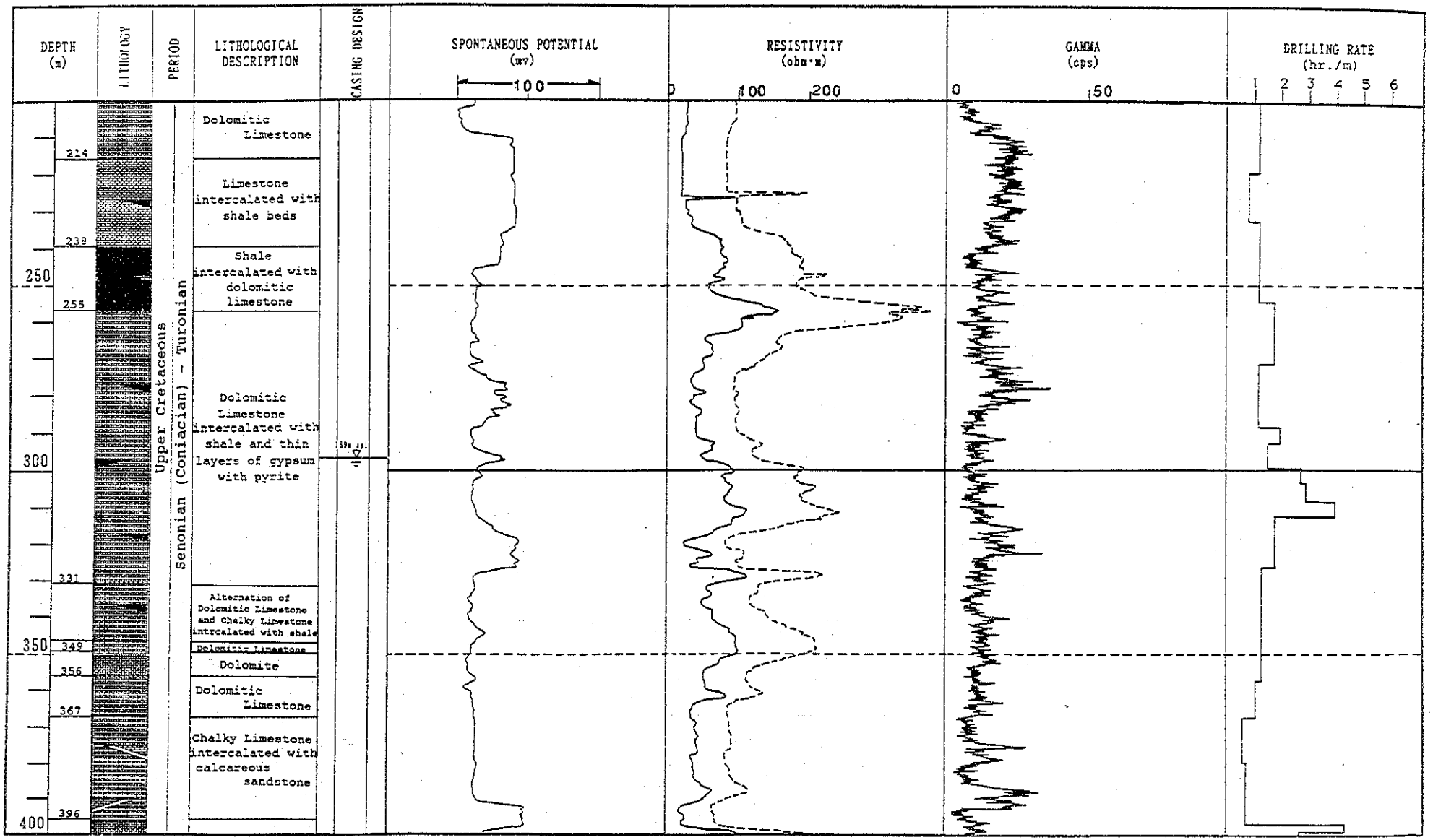


FIG. 2-2-12 (3) WELL DATA AND LITHOSTRAITGRAPHIC COLUMN

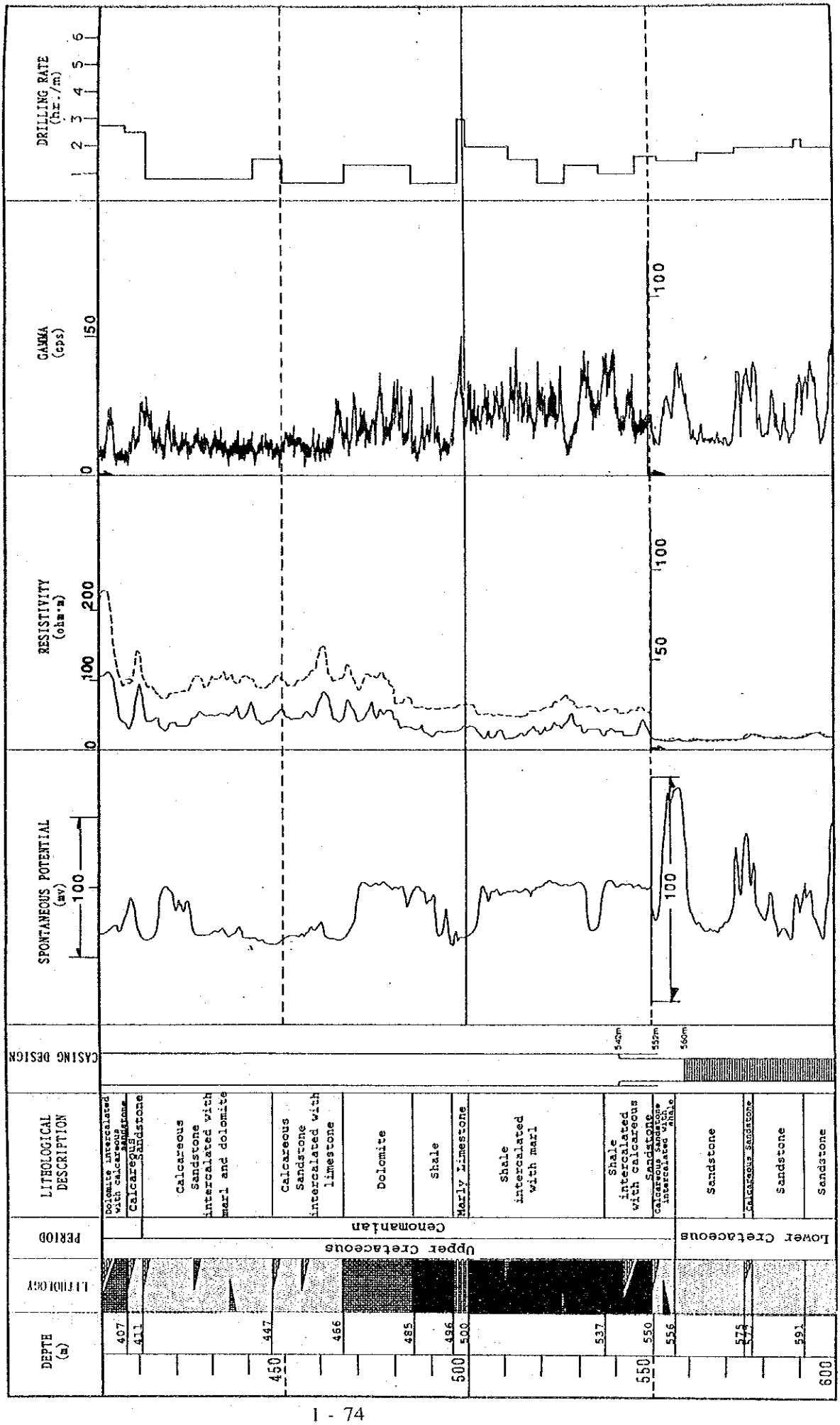


FIG. 2-2-12 (4) WELL DATA AND LITHOSTRAITGRAPHIC COLUMN

Sheet No. 4/5

Well No.19

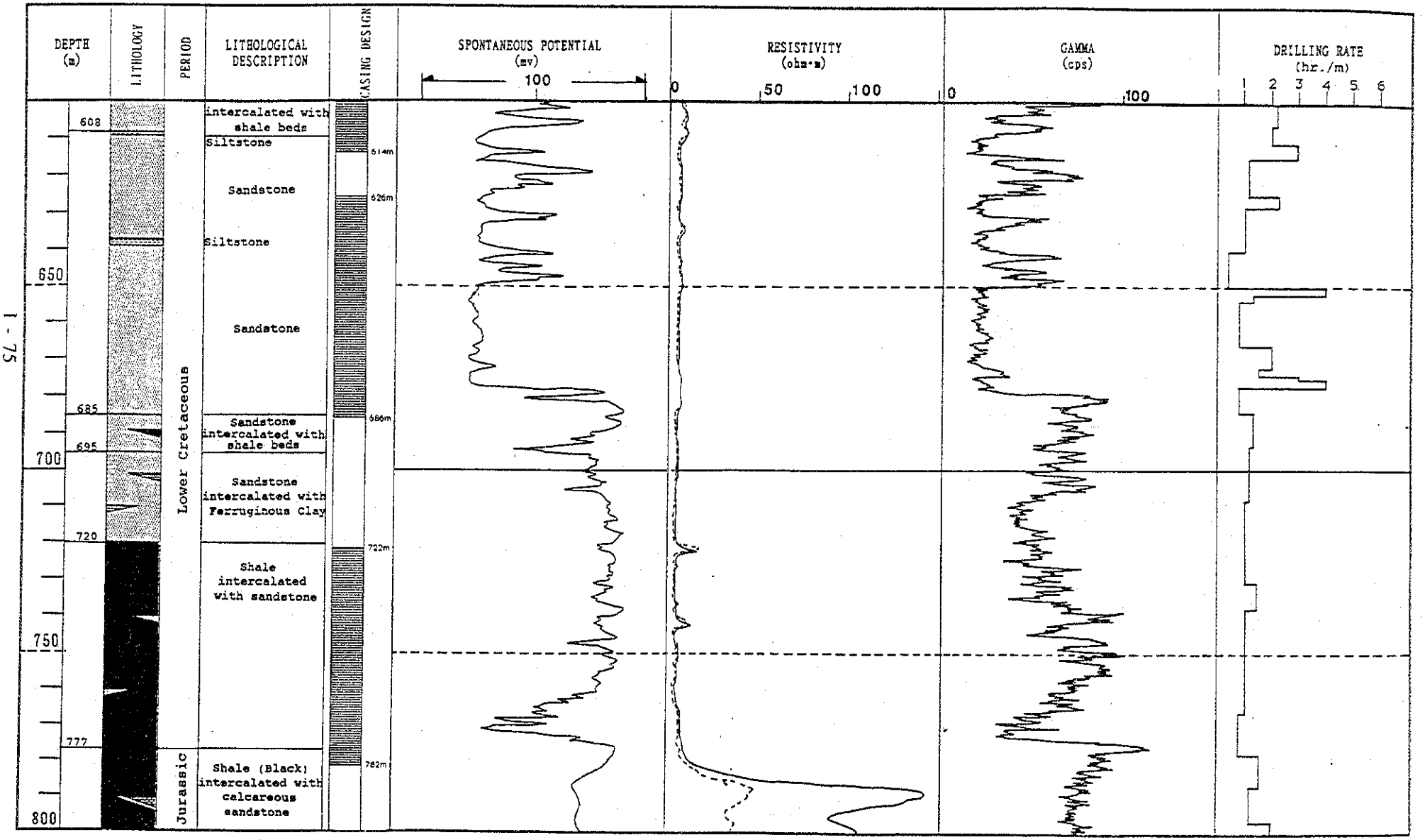
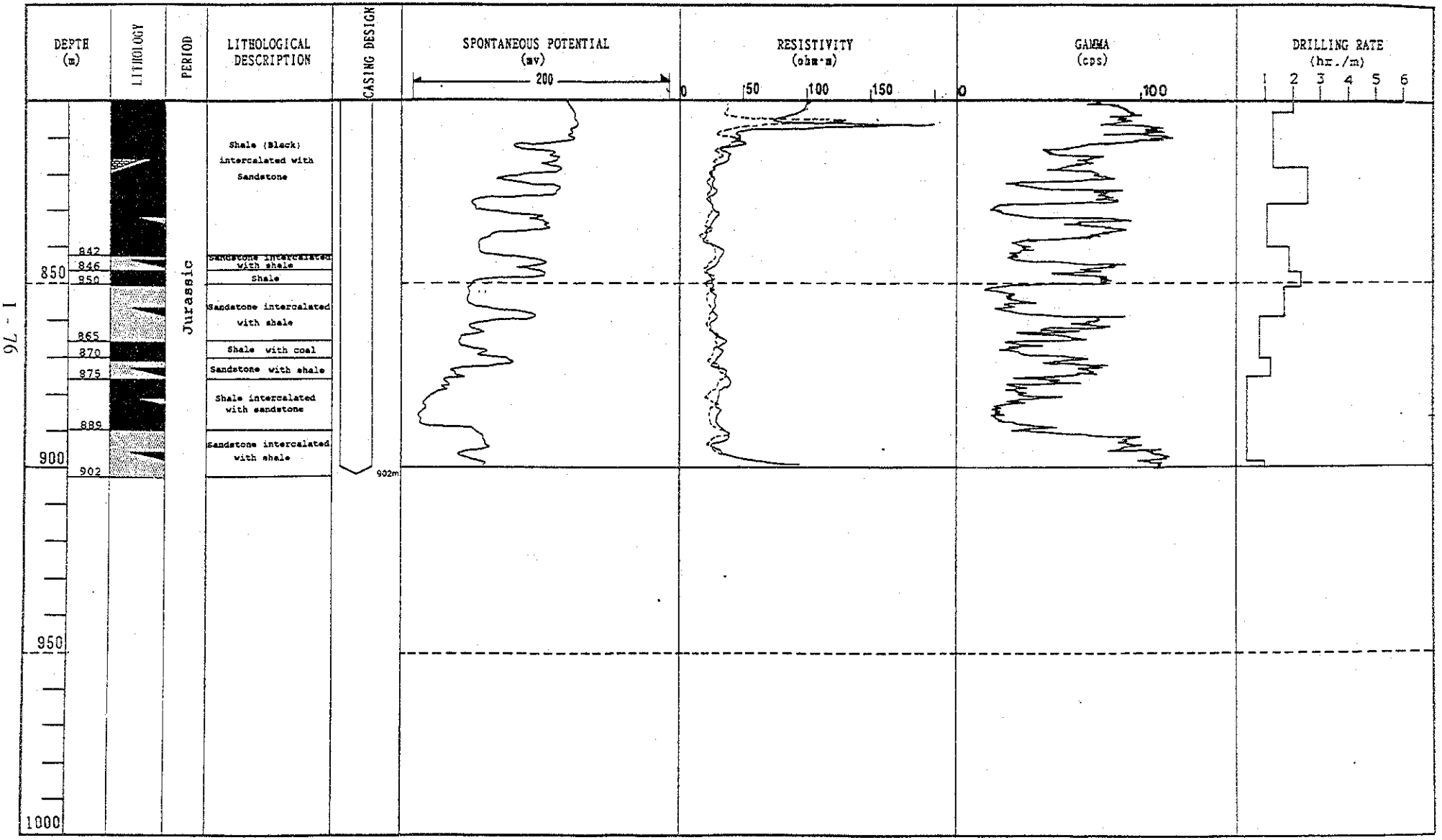


FIG. 2-2-12 (5) WELL DATA AND LITHOSTRAITGRAPHIC COLUMN

Sheet No. 5/5

Well No.19



For this reason, all collected well data of the Pre-Quaternary were interpreted using the following criteria:

1. Whether the lithologic description is available?
2. Whether the well logging data are available and reliable?
3 Whether the age determination of strata is available?
4 Whether the description of lithology corresponds to the well logging data?

Based on the interpretation of the existing data by the above criteria, they are classified into the following three categories:

1. Well data with the lithological description and the complete well logging information,
2. Well data with the lithological description with incomplete well logging information and
3. Well data with neither lithological description nor well logging information.

The data of the third group mentioned above were discarded from the further interpretation. The data classified into the first and the second categories were further interpreted to determine the lithological description and the age of strata in the lithologic profile by referring to the geologic columns established by Farag and Shata (1954) and obtained by the study team through the field investigation. Results of the fossil analysis undertaken by RIWR were also referred to for determining the age of the the strata (Tech Report II, Fossil Analysis).

All of the results were compiled into 126 pieces of the composite profiles including geologic columns as shown in Technical Report IV, Composite Column.

3. WATER LEVEL

3 WATER LEVEL

3-1 Introduction

Groundwater level is one of the key information for its resource assessment and control. The water level has a direct implication on the operation cost on the groundwater in the aquifers of the deep formations.

In this chapter all available data are interpreted and efforts are made to figure out a general feature of the groundwater level distribution of the aquifers of the Pre-Quaternary .

On the other hand, aquifers distributed in the northern part of the study area of the Quaternary were identified. A well survey was carried out to identify the general condition of water level distribution.

There is an abundance of water level data available for the well fields of the Wadi El-Arish alluvial plain and the coastal plain from Sheikh Zuwayid to Rafah. Especially for the well field of the Wadi El-Arish alluvial plain, an interpretation has been made of the water level change during the time sequence since 1954.

3-2 Water Level of Quaternary Aquifer

The water levels of existing wells were measured systematically and summarized in GMS in 1988 in the Wadi El-Arish alluvial plain and the coastal area from Sheikh Zuwayid to Rafah. A well survey was undertaken in the area from Bir El-Abd to Romana to locate existing wells tapping water from shallow aquifers in the sand dunes. All these data together with water level data at monitoring wells and test wells in the study area are a major data source of the water level interpretation in this section.

An interpretation is given to the old water level records indicating certain aspects of variations of groundwater levels in the Wadi El-Arish alluvial plain since 1954.

There are approximately 70 routine water level measurements in the Wadi El-Arish alluvial plain and another 100 in Sheikh Zuwayid and Rafah area.

These data distribute in rather limited areas in a high density. In many cases, different water levels were observed within a short distance. This may have been caused by the measurement of either the unrecovered static water levels (since most of the wells are production wells) or the measured water levels representing the different aquifers.

In order to draw the general features of the water levels of aquifers in the Quaternary, the well fields are screened by a 1 km^2 mesh representing the water level of each mesh by an average water level of all wells within the mesh (Fig. 3-2-1).

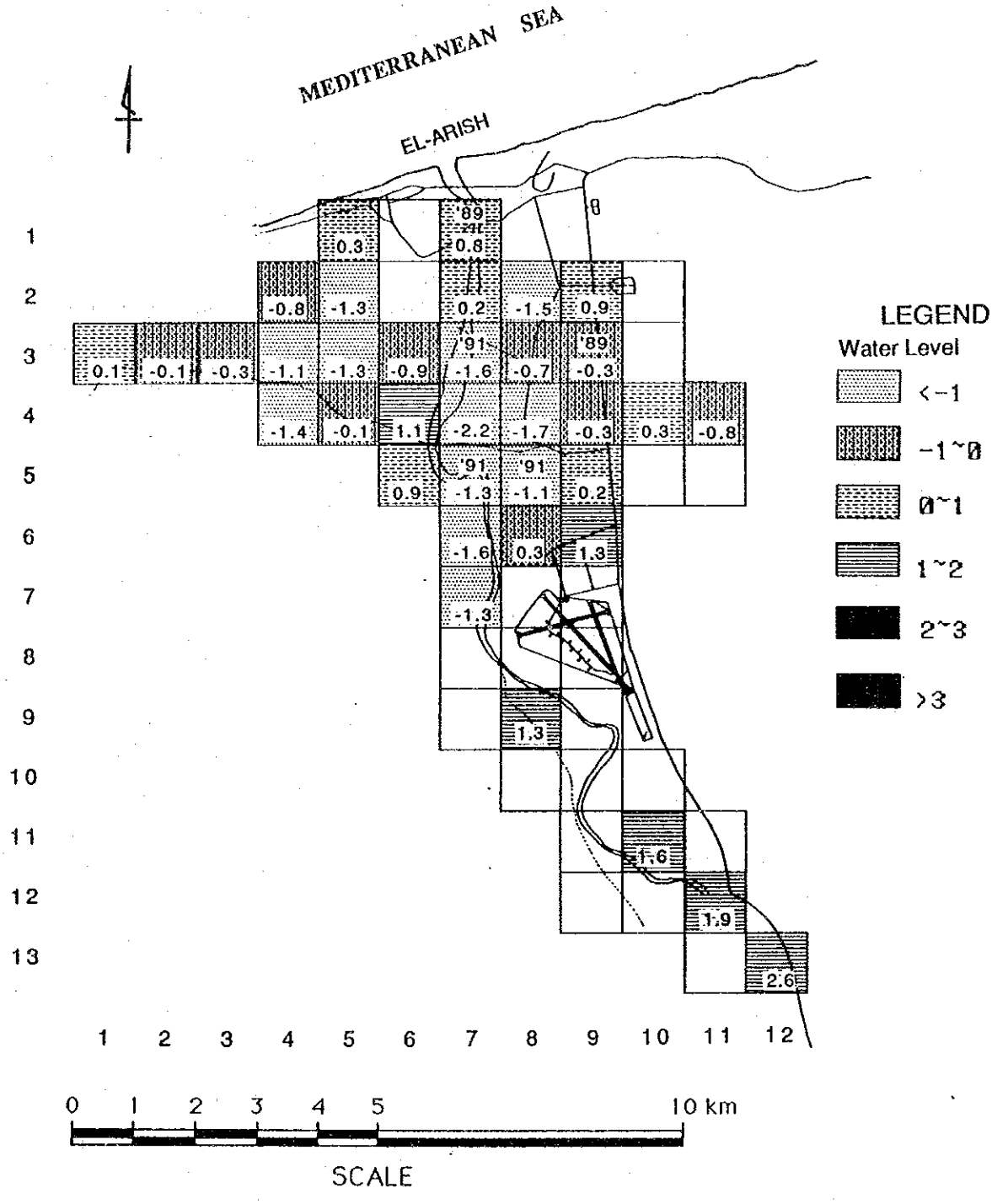


FIG. 3-2-1 AVERAGE WATER LEVEL AT EL - ARISH AREA IN 1988

3-2-1 El-Arish Area

The well field in the alluvial plain of the Wadi El-Arish has been intensively used for the water source for domestic and irrigation purposes. In this area there are about 170 wells in operation and a simultaneous water level survey was carried out by RIWR in 1988 at about 70 of them.

The well field of 27 km^2, coincident with the alluvial plain in the lowe stretch of the Wadi El-Arish, was meshed by one square kilometer grid, including a part of the coastal plain on the western side of El-Arish (Fig. 3-2-1).

Most of the meshes are filled by available data. However, some meshes are blank. These blank meshes are filled by additional data obtained from the test wells and monitoring wells as listed below:

Table 3-2-1 Water Level of Quaternary Aquifer

Replenished Grid	Well Number	Water level	Date
1-3	AR P6	0.63 m asl	1991
7-1	1-77	4.14 m asl	1991
7-2	1-83	0.20 m asl	Feb., 1989
7-3	AR P8	-1.28 m asl	1991
7-5	1-47	-1.31 m asl	Mar., 1989
8-4	AR T9	-1.13 m asl	1991

The highest water level (2.56 m asl) was found at the southern end of the meshed area at grid No. 12-13. The water level decreases towards the north. At grid No. 8-9 near the airport it was observed to be 1.33 m asl.

The water level in the area at the northern end of the airport is high in the east (grid No. 9-6, 1.34 m asl) and low in the west (grid No. 7-6, -1.59 m asl). This tendency of the water level declivity extends to the north at the confluence of the Wadi El-Mazaar to the Wadi El-Arish.

The water level at the confluence is 0.29 m asl at grid No. 10-4. It is much lower at grid No. 7-4 (-2.18 m asl). From this area to the north, the water level seems to follow a very moderate acclivity. The water level is 0.78 m asl in grid No. 7-1, and 0.92 m asl in grid No. 9-2. However, the water level in grid No. 8-2 is distinctively low (-1.49 m asl) in the area.

In the western side of El-Arish town relatively low water levels were observed in grids No. 4-3 and 4-4. The water level in the western end of the well field at grid No. 1-3 stays almost at the sea water level (0.12 m asl).

The water level obtained by the test wells drilled by RIWR indicates 0.63 m asl at the western end of the town and 1.2 m asl at the eastern end of the town along the coast.

3-2-2 Sheikh Zuwayid and Rafah Area

There are two well fields in this area; one is in a narrow strip (2 km wide) of coastal sand dunes along the coastal plain from Sheikh Zuwayid to Rafah facing to the Mediterranean and the other forms an elongated triangle of which the apex extends about 8 km to the west from its base along the international border with Israel on the eastern side of Rafah town (Fig. 3-2-2).

The size of the coastal sand dune well field is estimated to be about 34 km^2. The water levels of wells in the area around Sheikh Zuwayid ranged between 2 m asl and 2.5 m asl in 1988 (grid Nos. 7-12, 8-11 and 12 and 9-11). In the rest of the area, the water levels stay within a range between 0 m and 1 m asl, although some distinctively low water levels were also found. The water levels at grids No. 11-8 and 12-8 stay at a higher level in a range between 1.6 m and 1.8 m asl compared with the rest of the water levels, while the water level in grid No. 17-4 is rather low (-1.69 m asl). The water levels below the mean sea water level were found in grids Nos. 5-11, 6-10, 7-9 and 17-2. These grids locate on the sea shore of the Mediterranean.

In the well field located within the elongated triangular shaped area around Rafah town, the water levels were found in a range between 0.2 m and 1.5 m asl in the northern part and about 3 m asl

according to test well No. SR P 8 in the western end (grid No. 14-9). Although available data is scarce, the water level in the area south of Rafah town is in a range between 1.3 m and 2.35 m asl. However, the water level in grid No. 21-6 indicates a distinctively low level of -0.13 m asl. Although test well No. SR T12 in grid No. 21-7, adjacent to grid No. 21-6 on the south, indicates a water level of 1.5 m asl.

3-2-3 Bir El-Abd and Romana Area

There are many shallow wells distributing over an area of 400 km^2 in the area from Bir El-Abd to Romana. During the study, a well survey was carried out to determine the location and the elevation of the ground height and the water level of 246 shallow wells.

These wells distribute on the massive sand dunes and the depth to the water level from the ground surface is rather shallow. The highest water level of these wells was found at well No. JR 151 at Khiruba (3.9 m asl). Other high water levels were observed at well No. JR 31 (2.6 m asl) in the western part of El-Himeisa and at well No. JR 250 (2.7 m asl) in the eastern end of the survey area (Fig. 3-2-3).

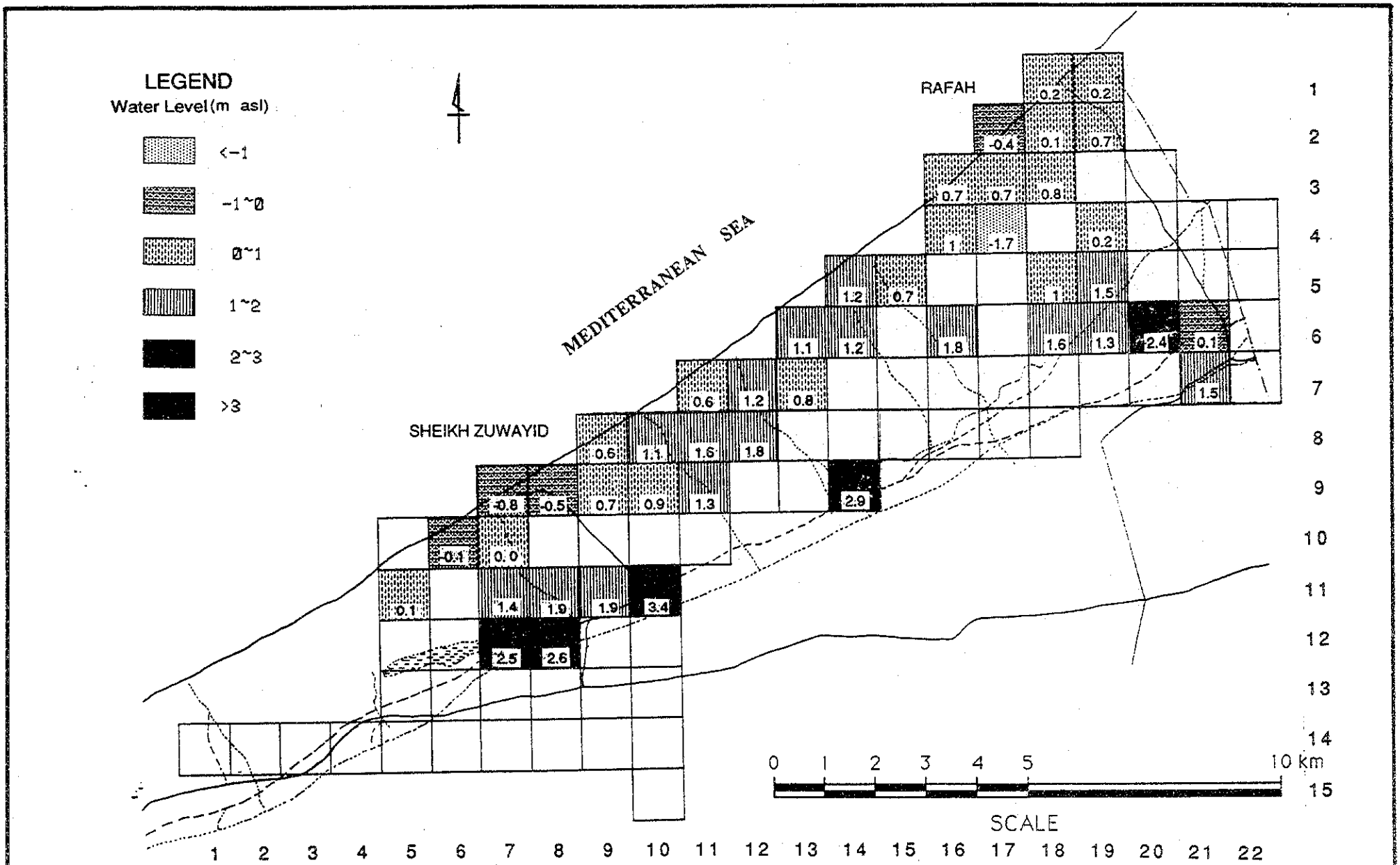


FIG. 3-2-2 AVERAGE WATER LEVEL AT SHEIKH ZUWAYID - RAFAH AREA IN 1988

The lowest water level was observed at well No. JR 251 (-1.5 m asl) at the western end of the survey area. Other low water levels were found at well No. JR 51 (1.4 m asl) and at well No. JR 255 (-1.4m asl).

As shown in Fig. 3-2-3, it seems that the high water level zone extends from the western end around well No. JR 250 through well No. JR 31, JR 88 and well No. JR 151 to well No. JR 227 somehow in parallel with the beach line. The water level is assumed to follow a very gentle declivity surface.

FIG. 3-2-3 WATER LEVEL IN BIR EL-ABD-ROMANA AREA