3.6. Hydrogeology

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3.6. Hydrogeology

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3. 6. Hydrogeology

3.6.1. General

In 1968 Sir W. Halcrow and Partners conducted a hydrogeological study over the trucial states inclusive of the Wadi Al Bassierah basin This is the sole systematic hydrogeological study so far conducted in the basin.

In this feasibility study, the hydrogeological study has been started in December 1979 covering the following items;

- ° General survey of groundwater use;
- ° Geological mapping inclusive of aero-photo interpretation;
- ° Geoelectric prospecting;
- ° Intake rate test;
- ° Groundwater mapping;
- ° Test well drilling inclusive of electric logging;
- ° Aquifer pumping test;
- ° Groundwater gauge installation; and,
- ° Groundwater sampling, chemical analyses and dating by environmental isotopes.

3.6.2. Present Groundwater Use

As for the surface water use in the basin, floods are diverted by intercepting drains, and supplied to farms in Dibba. This way of flood use for agricultural purpose is the sole surface water utilization presently made in the basin. Under the circumstances, it can be said that the water use in the basin mostly depends upon groundwater.

The coastal beach sand strip along the Oman Gulf, which is located on the downstream most of the basin and called Dibba Oasis, is one of the largest oases developed in the eastern coastal area since old days. The agriculture mainly for production of mango and date palm and fishery have afforded a livelihood to people in this oasis.

There are many shore-type oases of various scales in the eastern coastal area, i.e., Batina coast. These oases are mostly developed at wadi estuaries. The common features of these oases are as follows;

- Flows of groundwater converge at the sea water level in the sand beach strip;
- The elevation is low, and groundwater table is high; and,
- Soil conditions are favorable.

The scale of orchards in an oasis is naturally limited by the scale of its groundwater basin, or a groundwater quantity available. Therefore, each oasis has contained the maximum optimum population in proportion to the groundwater volume available since old days. It seems that groundwater resources had been utilized to the maximum extent possible prior to the recent introduction of new technology for groundwater exploitation with high capacity pumps. Groundwater-irrigated orchards have been recently expanded toward a higher portion of the coastal area. Moreover, the groundwater exploitation for the other purposes has been quite recently started. However, it can be said that such groundwater use is already an over-draft state.

Most cultivated lands are concentratedly located in Dibba though very small cultivated areas are scattered in the other areas. The field survey of present land use in Oman Dibba cannot be made, however, statistics and aero-photograph suggest that the total cultivated area is about 400 ha. Groundwater of shallow dug wells is utilized for irrigation and for domestic purposes in Dibba whereas spring-fed water is used for such purposes in mountain wadi areas. Shallow wells in Dibba have recently suffered from severe draw-down and salinization of groundwater. Under the circumstances, some of them have been already abandoned, and new wells have been dug in different points in stead. The statistics by the Ministry of Agriculture and Fisheries show that there are 741 wells except Oman Dibba. Wells for irrigation are mostly equipped with a fugal pump with a diameter of 3 to 4 inches. pumps for such wells are operated for two to four hours a day. The total volume of groundwater presently lifted is estimated about 2.9 MCM per year.

Most deep wells have been constructed these years. There were only nine deep wells in December 1979, however, the number of such wells arrived at 40 in September 1980. The total groundwater volume lifted from the major deep wells is estimated herein.

Domestic water has been supplied in full scale in Dibba since the Ministry of Electric Power and Water constructed water service facilities in 1978. At present, the domestic water of 200 to 300 gal/day or 900 to 1,300 lit/day is supplied to about 1,300 households from three deep wells and one shallow dug well, therefore, groundwater of 0.54 MCM/year is utilized in the entire Dibba.

As the sole large-scaled industry in the Wadi Al Bassierah basin, a marble tile factory has been operated since 1978 to which water is supplied from two deep wells. The water volume consumed here is not so large from 90 to 120 cu.m, that is, about 0.04 MCM/year.

The groundwater of 100 to 120 cu.m/day or about 0.04 MCM/year has been supplied from two deep wells to FAO experimental farm in Dibba since 1979,

In 1980 six deep wells were constructed in the upper and middle gravel plain to supply, by light truck, domestic water to six villages with the total population of about 1,800 in the mountain wadi areas. The daily yield of groundwater per well amounts to 20 to 60 cu.m, therefore, the total yield is estimated at 0.07 MCM/1year. A part of the groundwater is used for irrigation purpose.

The total groundwater quantity being consumed in the UAE and Oman is, therefore, estimated at 2.9 MCM/year as summarized below;

Present Water Use

	Country		Water Use (MCM)
Domestic Use	UAE	Population = 15,000 Marble Factory	0.55
	Oman	Population = 1,500	0.05
Agricultural Use	UAE	Vegetable = 50 ha Dates = 230 ha	0.30 1.04
	Oman	Dates = 210 ha	0.96
	Total		2.90

In addition, groundwater consumption by wild plants should be taken into account, however, judging from the depth of groundwater tables, it is considered that such consumption is very small since wild plants are deemed to depend much on soil moisture and dew.

3.6.3. Geoelecric Prospecting

The geoelectric prospecting was conducted with OHYO ESGI type equipment inclusive of the vertical and equi-depth soundings. The vertical sounding was performed in the Wenner method along eight observatory lines with 55 observatory points covering the whole gravel plain, and the equi-depth sounding was carried out along four observatory lines on the coastal strip and two lines at the proposed dam site. The total observatory line reaches 6,000 m. The location of these observatory lines and points are shown on Map 3.6-1.

(1) Vertical Sounding

The vertical sounding was conducted to the depth of 128 m in total in order to distinguish aquifers and to prospect a depth of the bed rock. ρ - a curves show three to four layers. However, it was impossible to detect the bedrock in the middle and lower portions of the gravel plain since the resistivity is extremely small specially in the lower portion.

The analytical results of this vertical sounding are shown, together with the drilling results, in Fig. A.3.6-46 to 3.6-48.

(2) Equi-Depth Sounding

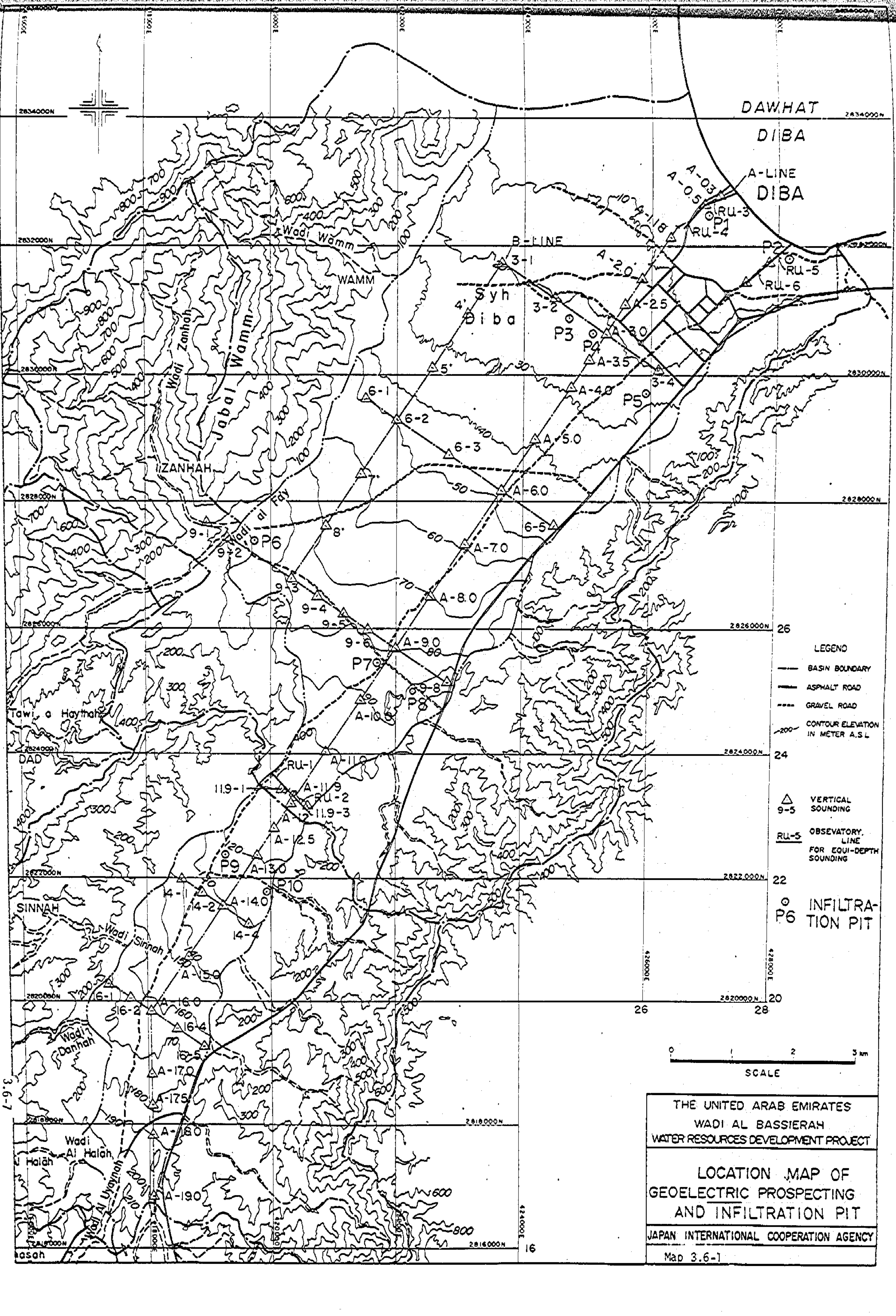
In order to study the distribution of sea water wedges and coastal sabkha, the equi-depth sounding was carried out for four lines with the total length of 2,000 m in the coastal area. Moreover, two lines with the total length of 1,000 m have been carried out on the proposed dam site to detect bedrock depth.

In this sounding, the electrode interval of 10 m was adopted. The observation was made at each 10 m depth to the 100 m depth. In principle, the four electrode arrangement were taken, that is, CPPC, PCCP, CCPP and PPCC. The analytical results are shown in Fig. A.3.6-1 and 3.6-2.

The above-mentioned figure shows the resistivity at the damsite. This resistivity map, together with the geological log of TW-10, suggests that the lower layer having a high resistivity of some 100 ohm/m is correlative with the bedrock.

Fig. A.3.6-2 shows results of the equi-depth sounding along the observatory lines nearly set at perpendiculary to the coastal line. In general, the coastal area is being in a high salinity area, the resistivity is less than some 10 ohm/m. The layer into which the sea water intrudes seems to have a resisitivity less than 5 ohm/m.

As shaded on the map, the sea water intrusion shows typical wedge shapes. It is not clear whether the lenticular high resistivity zone in the salt water wedge detected on the observatory lines RU 5 and V 6 is a consolidated hard sabkha or a fresh water lens.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DIBA
B-LINE
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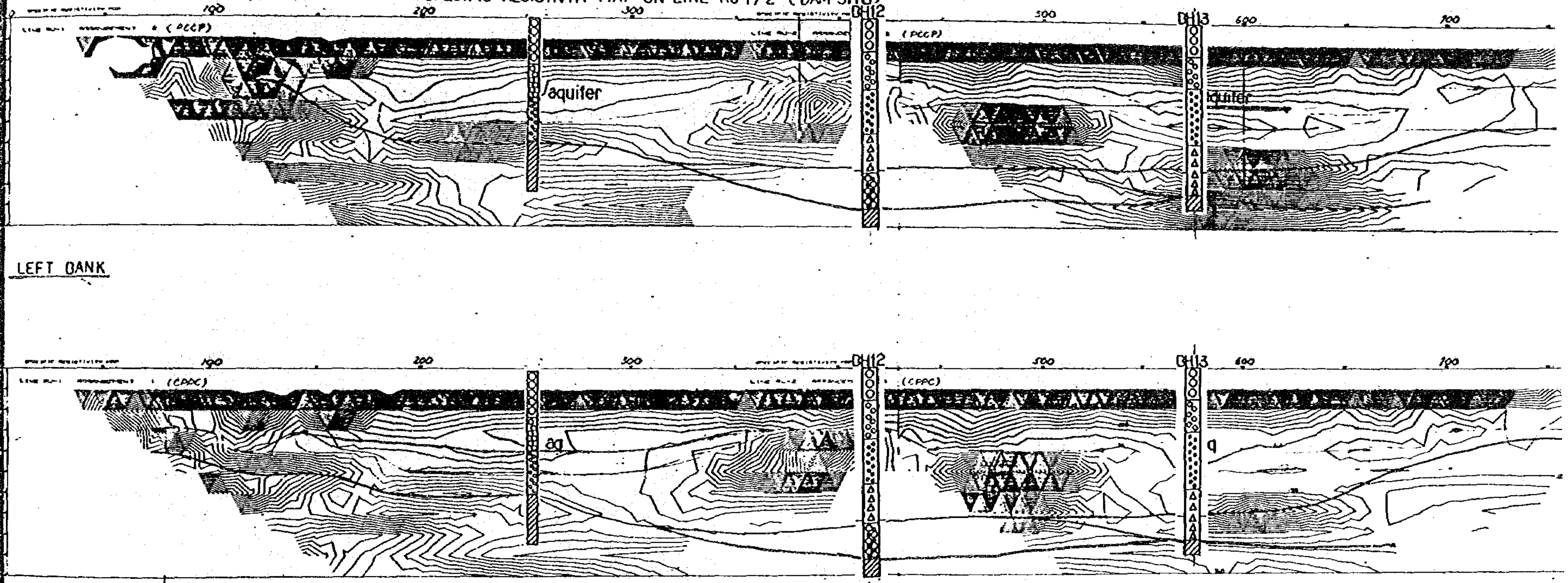
Wadi Wamm
Jabal Wamm
Wadi Zanhah
ZANHAH
Wadi al Fay
Tawi a Haythah
DAD
SINNAH
Wadi Sinnah
Wadi Danhah
Wadi Al Halah
Wadi Al Uyaynah
LEGEND
BASIN BOUNDARY
ASPHALT ROAD
GRAVEL ROAD
CONTOUR ELEVATION IN METER A.S.L
VERTICAL SOUNDING
OBSEVATORY LINE FOR EQUI-DEPTH SOUNDING
INFILTRATION PIT
SCALE
THE UNITED ARAB EMIRATES
WADI AL BASSIERAH
WATER RESOURCES DEVELOPMENT PROJECT
LOCATION MAP OF GEOELECTRIC PROSPECTING AND INFILTRATION PIT
JAPAN INTERNATIONAL COOPERATION AGENCY
Map 3.6-1

FIG. A.3.6-1 SPECIFIC RESISTIVITY MAP ON LINE RU 1/2 (DAM SITE)



A.3.6-1 SPECIFIC RESISTIVITY MAP ON LINE RU 1/2 (DAM SITE)

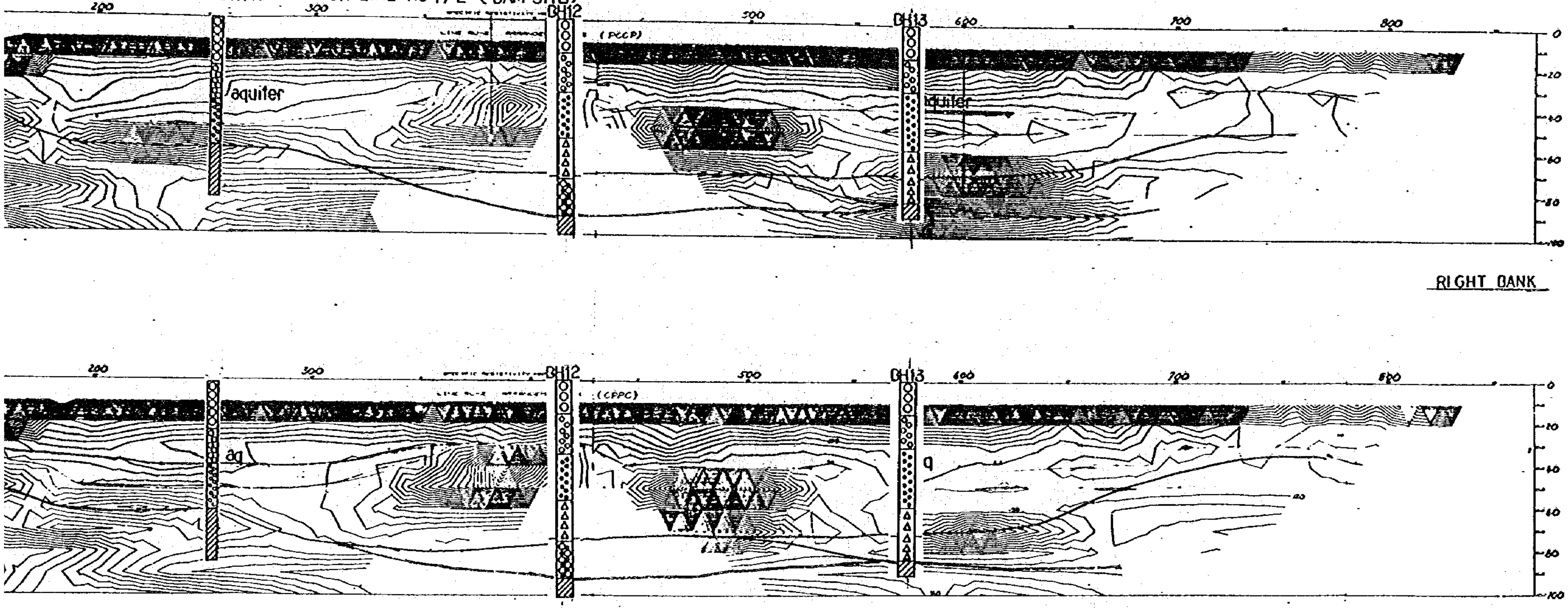
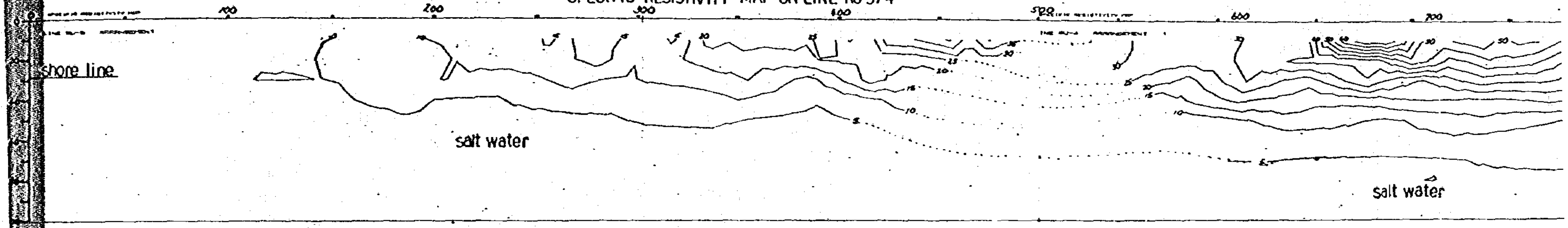
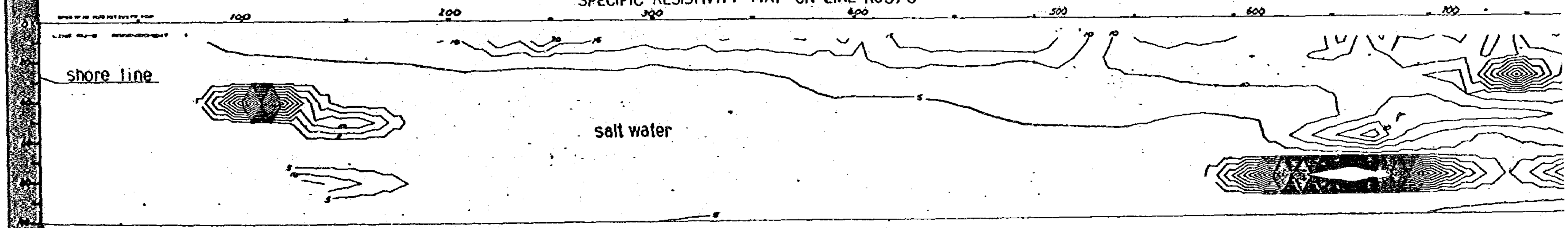


FIG. A.3.6-2

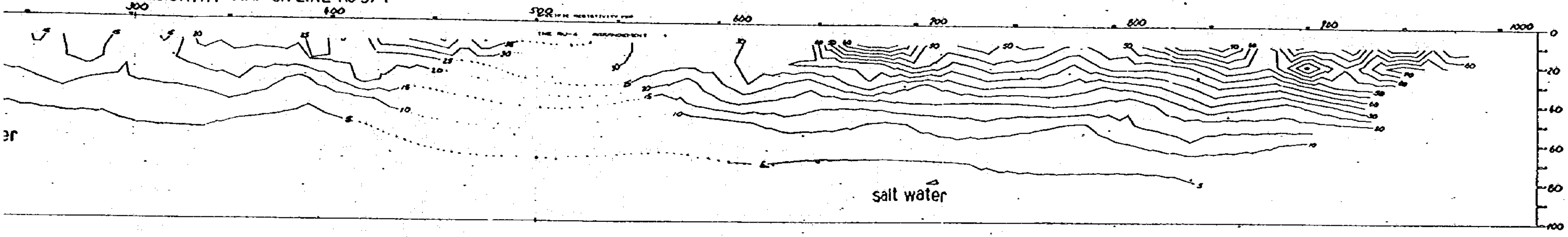
SPECIFIC RESISTIVITY MAP ON LINE RU3/4



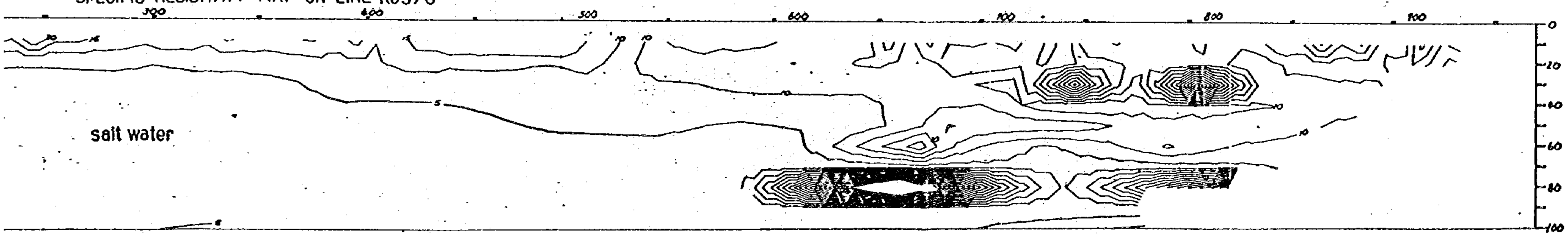
SPECIFIC RESISTIVITY MAP ON LINE RU5/6



SPECIFIC RESISTIVITY MAP ON LINE RU 3/4



SPECIFIC RESISTIVITY MAP ON LINE RU5/6



3.6.4. Intake Rate Test

The test was conducted at ten pits dug in three typical groundwater recharging areas, that is, the existing river route, fan and coastal areas. The location of test pits is shown in Map 3.6-1. As for the methodorology, pits with a diameter of 40 to 60 cm and a depth of 40 to 60 cm was employed. The analytical results except these of the lateral percolation are shown in Fig. A.3.6-3 and 3.6-4, and are summarized in Fig. A.3.6-5. As Fig. A.3.6-5 shows, the intake rate is, as a rule, extremely large at 0.5 cm/min (7.2 m/day) on the existing river route and 0.2 cm/min (2.9 m/day) on the fan and sand beach strip.

Intake rate of water to soils is an important parameter for studying irrigation method, irrigation duration and its efficiency. The soil survey made previously covers 13 selected points (seven points in the existing agricultural lands and six points in the gravel plain) and in the Wadi Al Bassierah basin, intake rate was measured by cylinder method at the points located closely to the above and the points at the selected sample farms.

FIG. A.3.6-3

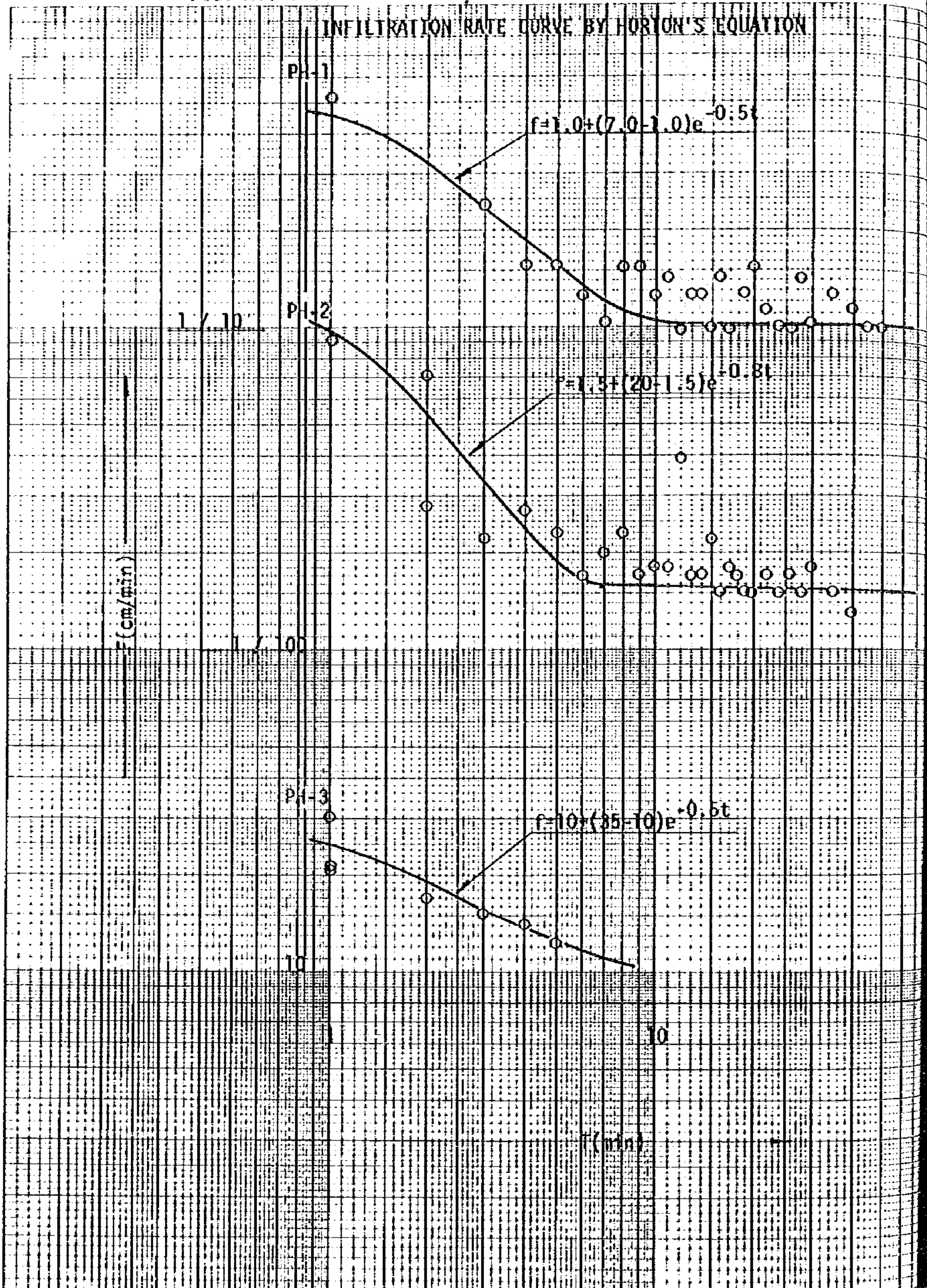
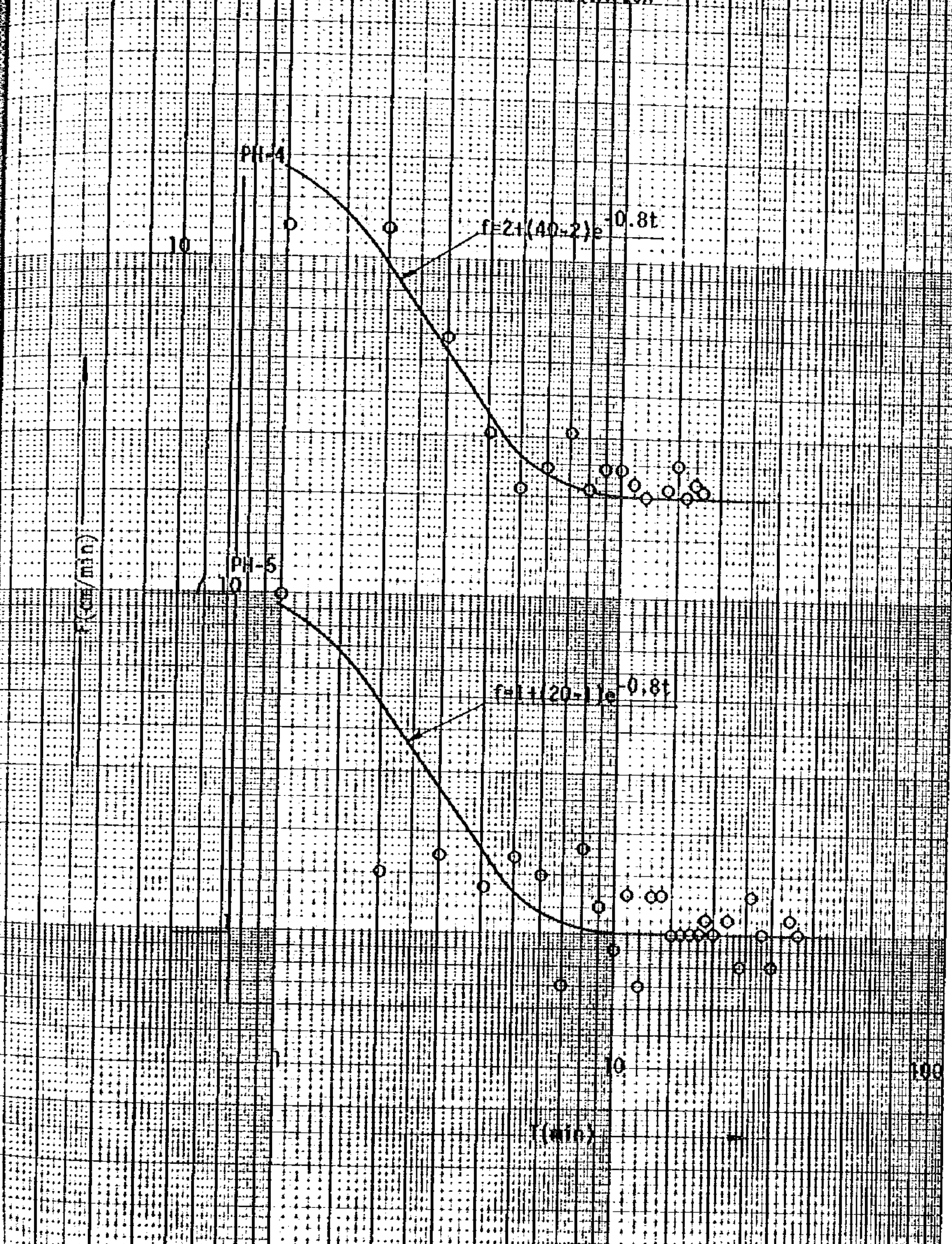

INFILTRATION RATE CURVE BY HORTON'S EQUATION
PH-1
f=1.0+(7.0-1.0)e-0.5t
1 / 10
PH-2
f=1.5+(20-1.5)e-0.8t
f(cm/min)
1 / 100
PH-3
f=10+(35-10)e-0.6t
10
1
10
T(min)

FIG. A.3.6-4

INFILTRATION RATE CURVE BY HORTON'S EQUATION



SEKIREI NO. 408 C

FIG. A.3.6-5
INFILTRATION RATE CURVE BY HORTON'S EQUATION

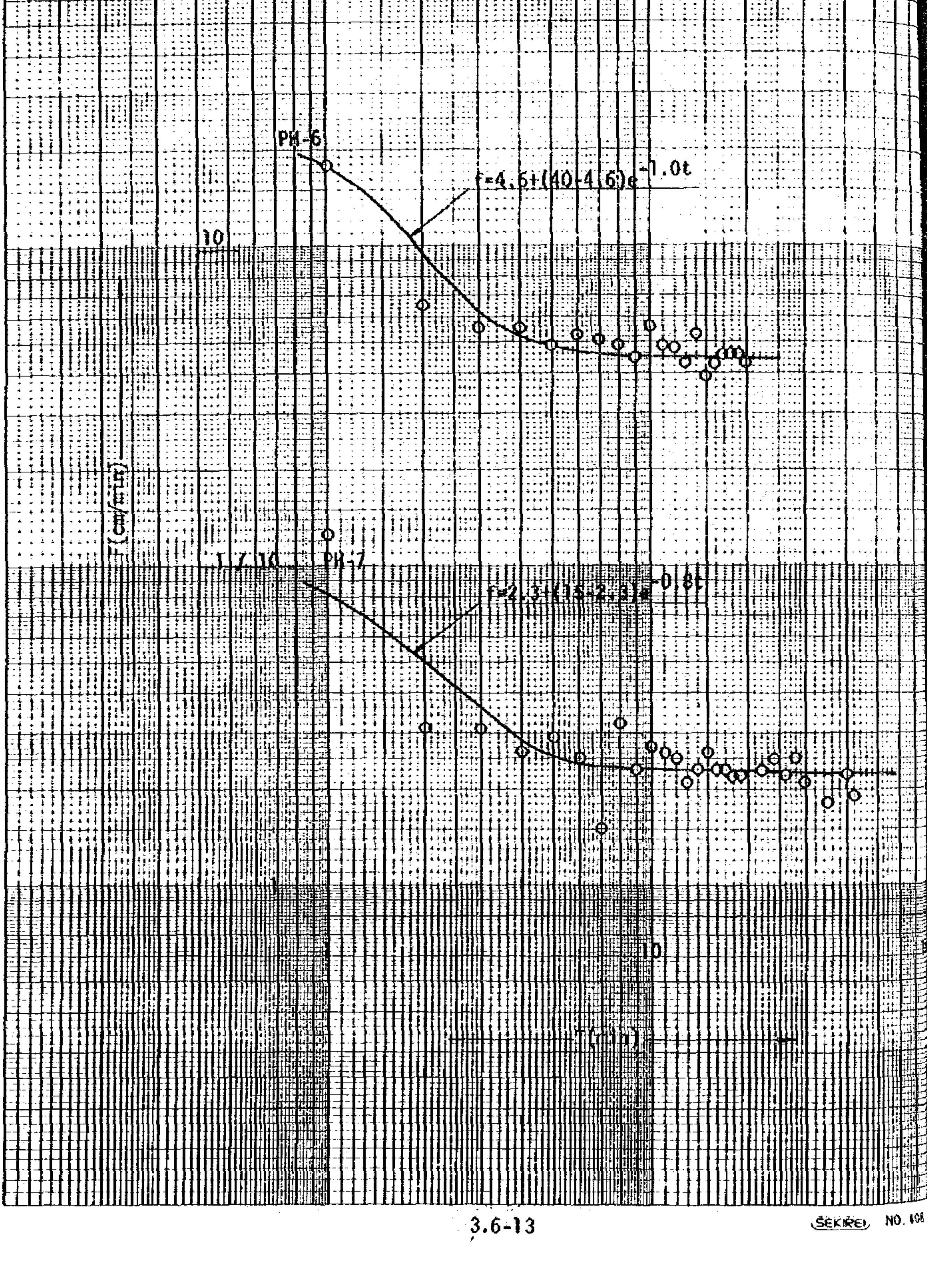


FIG. A.3.6-6
INFILTRATION RATE CURVE BY HORTON'S EQUATION

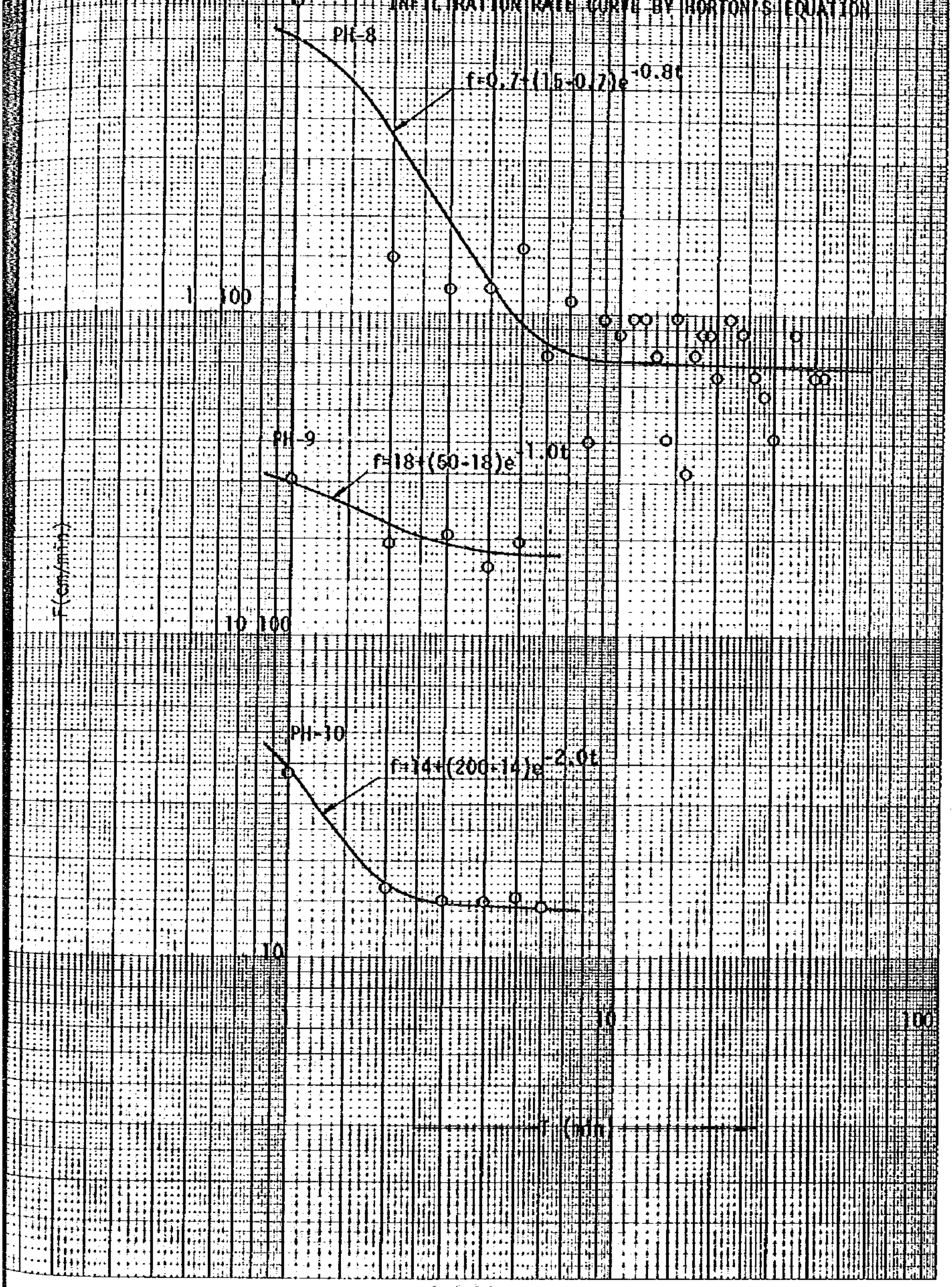
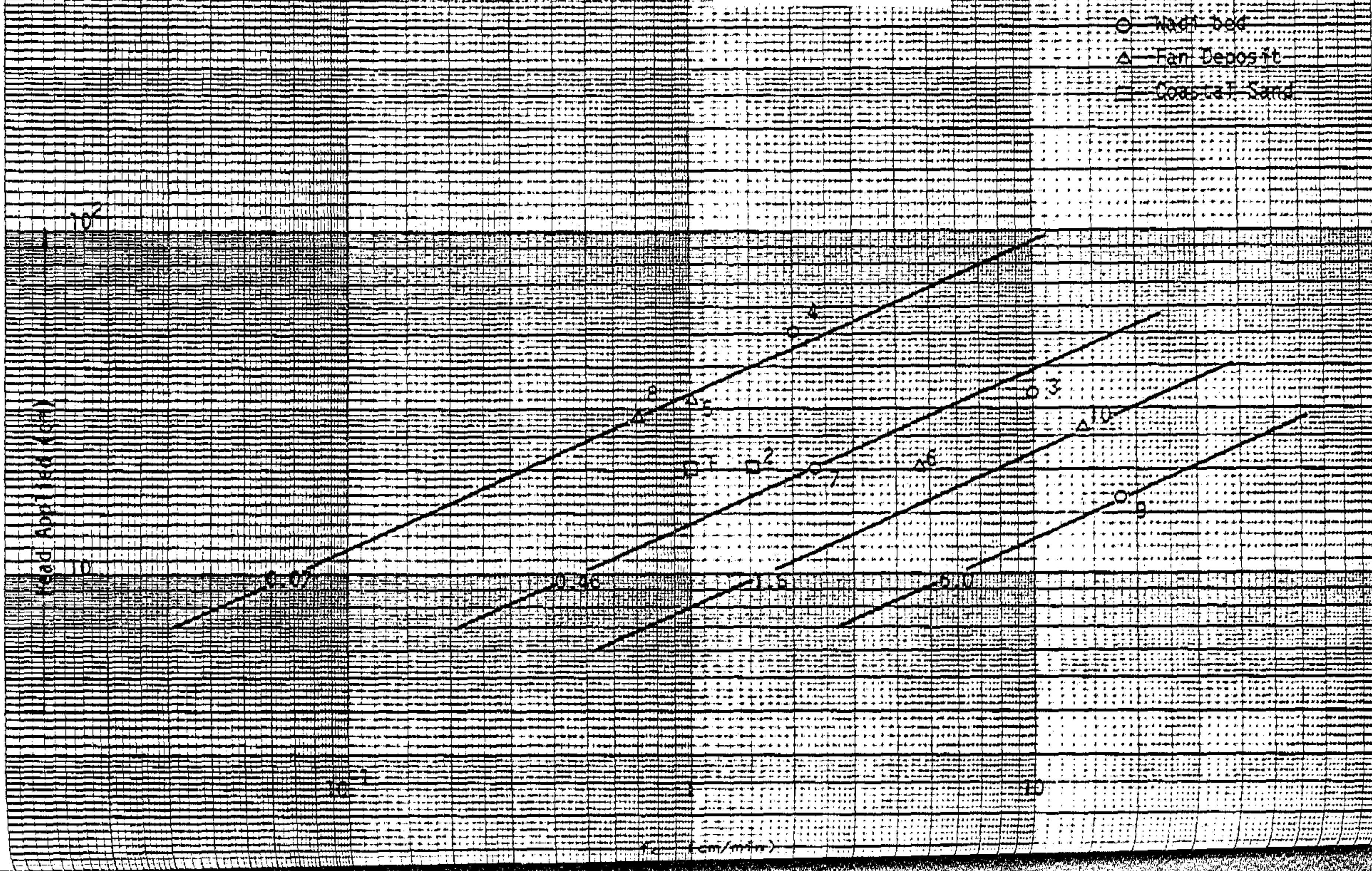


FIG. A.3.6-7 RELATION BETWEEN CONSTANT INFILTRATION RATE (f_c) AND APPLIED HEAD

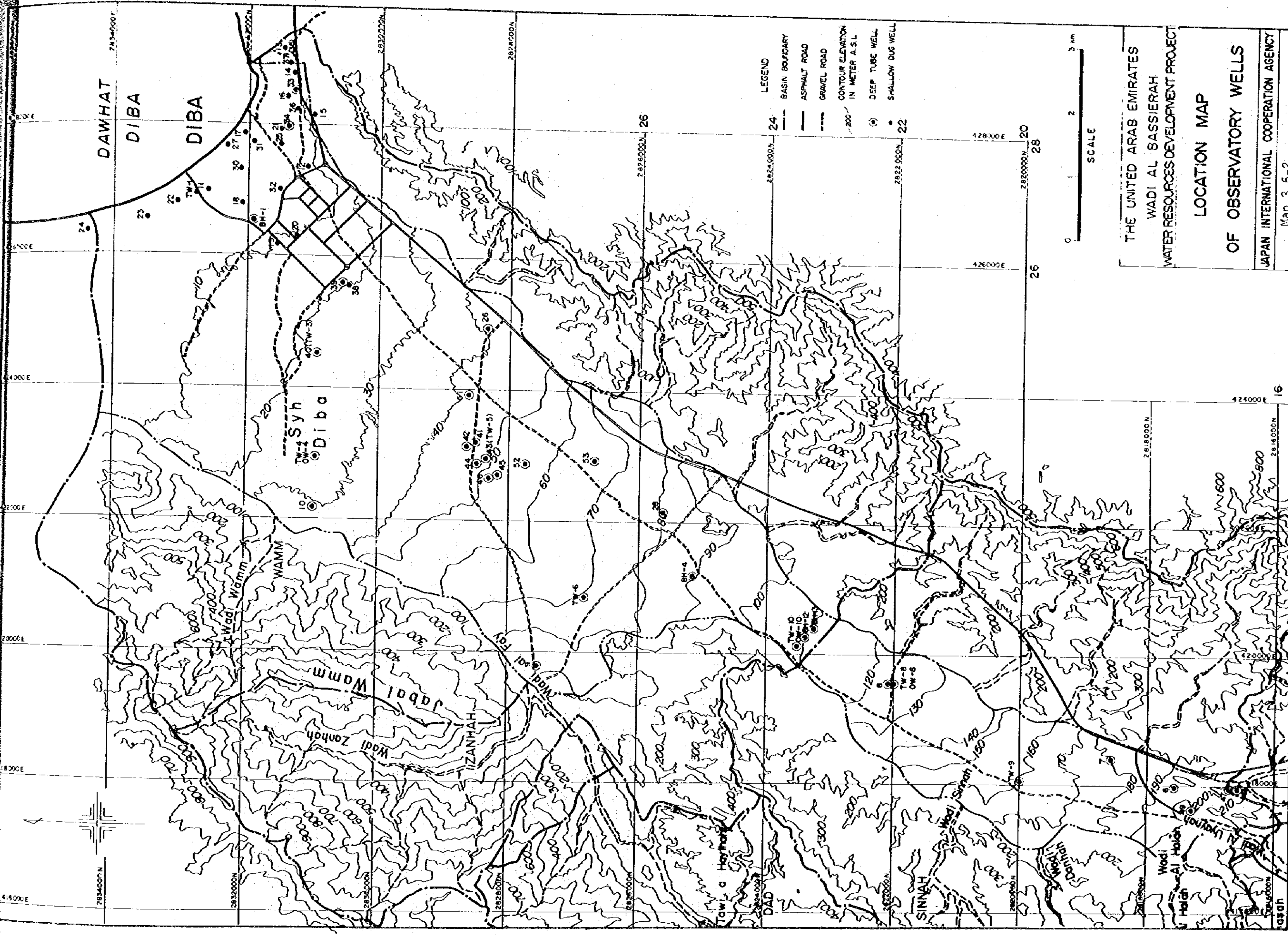


3.6.5. Groundwater Mapping

The simultaneous observation of groundwater inclusive of water level, water temperature and electric conductivity was conducted four times from February to december, 1980 at 60 selected existing wells in total. The location of such wells is shown in Map 3.6-2. Out of the observation results, these observed in February, July and December, 1980 are shown in Map 3.6-3 to Map 3.6-11.

Since leveling is not yet made, the elevations adopted in Map 3.6-3 depend upon map reading and measurement with altimeter. The water-table slope in the lower gravel plain is exptremely small at only 1/2,700 on an average whereas that of the upper gravel plain is so steep at 1/67. This big difference of water-table slopes changes at about 2 km downstream of the proposed dam site, probably due to the difference in permeability of the aquifers.

Map 3.6-7 shows the electric conductivity distribution of groundwater. In general, this kind of maps indicates both the water quality distribution and the flow regime of groundwater. The electric conductivity of groundwater in the coastal strip is high at 2,000 to 6,000 micro moh/cm in comparison with the averaged electric conductivity of less than 1,000 micro moh/cm in the other areas, which proves the sea water intrusion into the coastal strip has occurred. It should be noted that the groundwater around the water supply tower and F.A.O. experimental farm has an electric conductivity of less than 500 micro moh/cm. The low conductivity line like this is also observed in the upper gravel plain. The clean groundwater is deemed to be young water brought about by recent floods. The distribution of groundwater temperatures, which is similar to the distribution of the electric conductivity, is shown in Map 3.6-9. Since the measurement of groundwater temperature was made in summer it seems that a higher temperature was read in the younger groundwater, and vice verse. In other words, old groundwater or groundwater contaminated with sea water had a low temperature.


THE UNITED ARAB EMIRATES
WADI AL BASSIERAH
WATER RESOURCES DEVELOPMENT PROJECT
LOCATION MAP
OF OBSERVATORY WELLS
JAPAN INTERNATIONAL COOPERATION AGENCY
Map 3.6-2
LEGEND
BASIN BOUNDARY
ASPHALT ROAD
GRAVEL ROAD
CONTOUR ELEVATION IN METER A.S.L.
DEEP TUBE WELL
SHALLOW DUG WELL
SCALE
DAWHAT
DIBA
DIBA
Syh Diba
WAMM
Wadi Wamm
Jabal Wamm
Wadi Fay
Wadi Zanhah
ZANHAH
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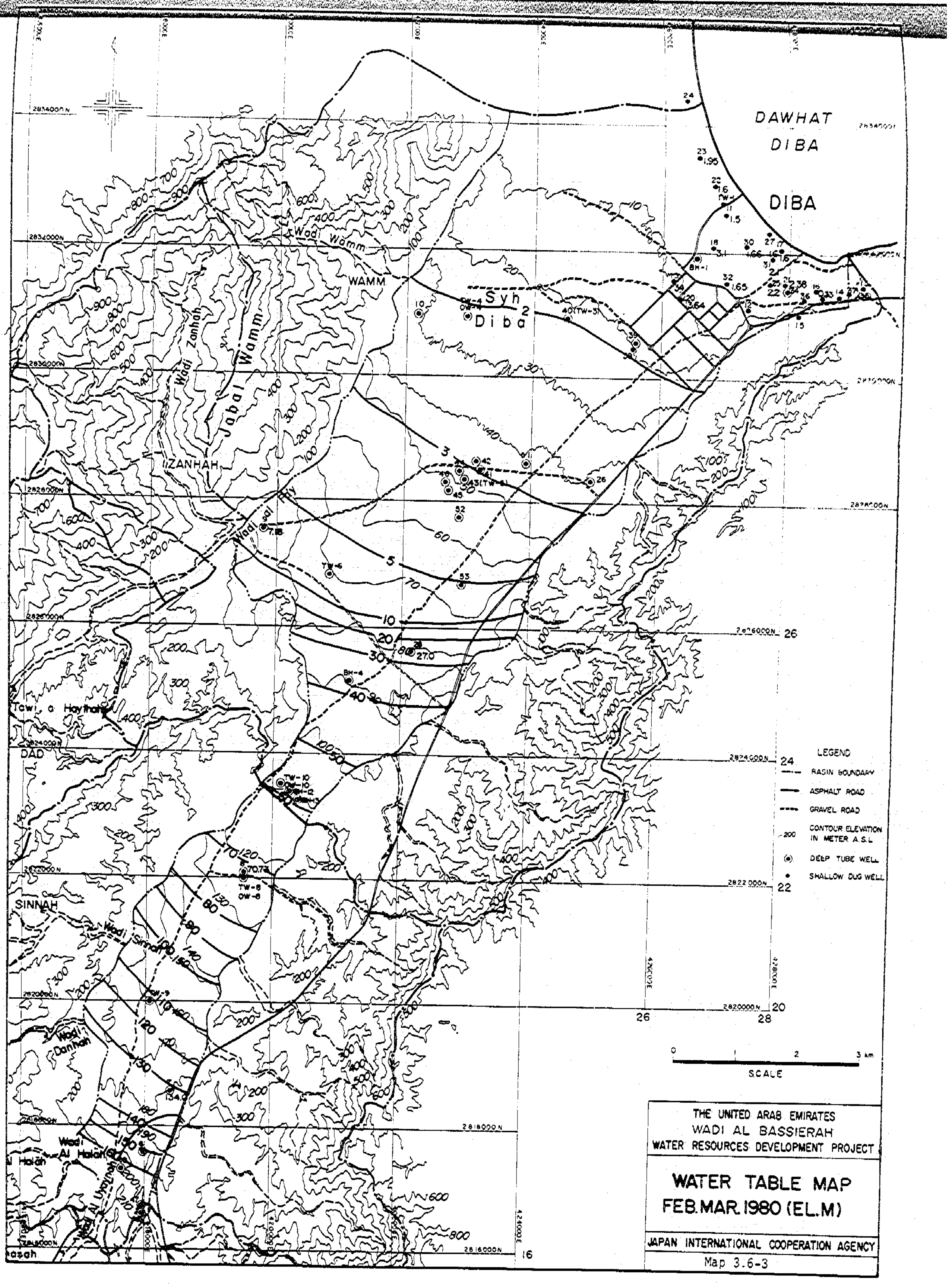
SINNAH
Wadi Sinnah
Wadi Damhah
Wadi Al Halah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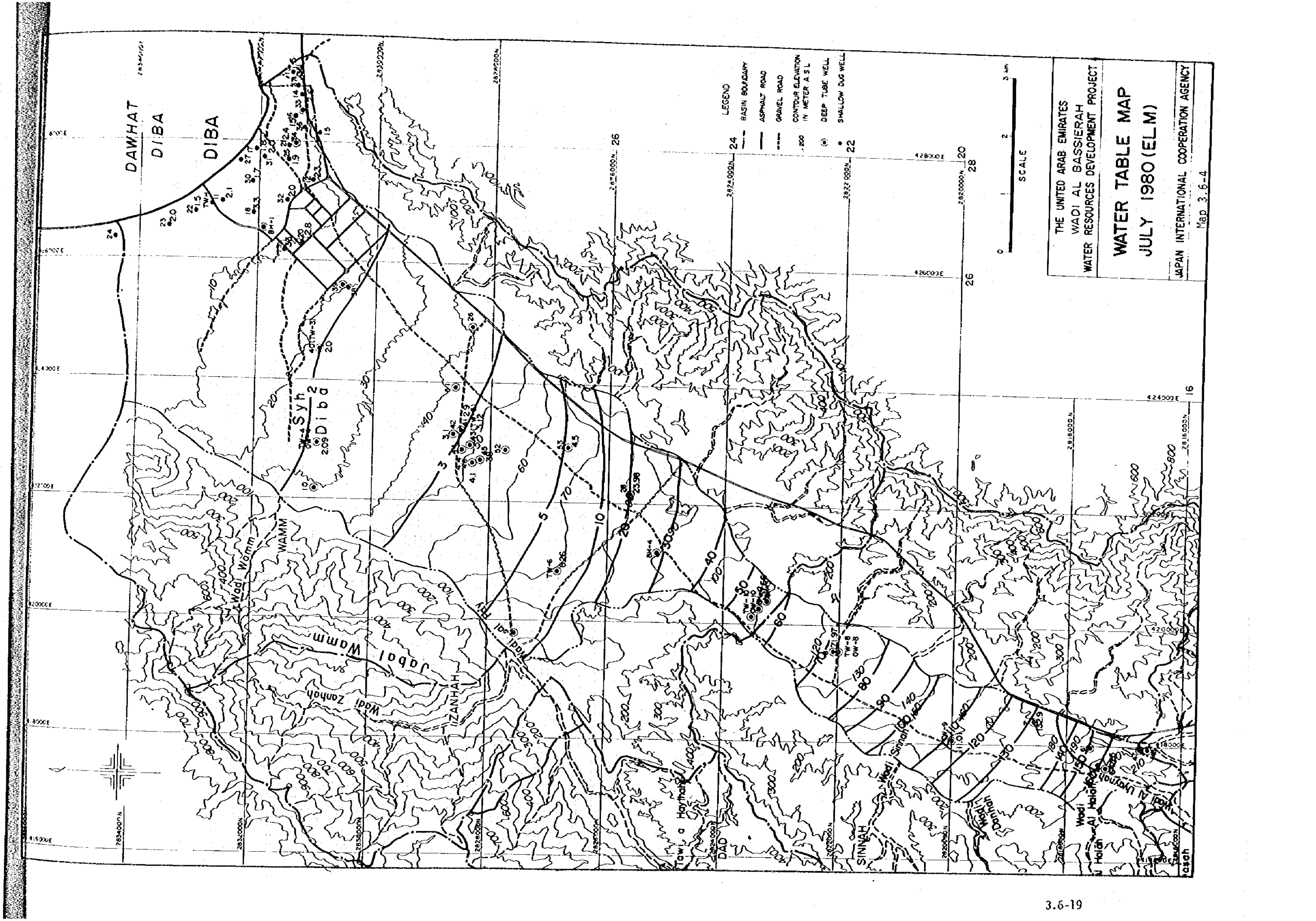
Wadi Wamm
Wadi Zanhah
Jabal Wamm
ZANHAH
Wadi al Fay
Tawi a Haythah
DAD
SINNAH
Wadi Sinnah
Wadi Danhah
Wadi Al Halah
LEGEND
BASIN BOUNDARY
ASPHALT ROAD
GRAVEL ROAD
CONTOUR ELEVATION IN METER A.S.L.
DEEP TUBE WELL
SHALLOW DUG WELL
SCALE
0 1 2 3 km
THE UNITED ARAB EMIRATES
WADI AL BASSIERAH
WATER RESOURCES DEVELOPMENT PROJECT
WATER TABLE MAP
FEB.MAR.1980 (EL.M)
JAPAN INTERNATIONAL COOPERATION AGENCY
Map 3.6-3



THE UNITED ARAB EMIRATES
WADI AL BASSIERAH
WATER RESOURCES DEVELOPMENT PROJECT
WATER TABLE MAP
JULY 1980 (ELM)
JAPAN INTERNATIONAL COOPERATION AGENCY
Map 3.6-4
LEGEND
BASIN BOUNDARY
ASPHALT ROAD
GRAVEL ROAD
CONTOUR ELEVATION IN METER A.S.L
DEEP TUBE WELL
SHALLOW DUG WELL
SCALE
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2
3 km
DAWHAT DIBA
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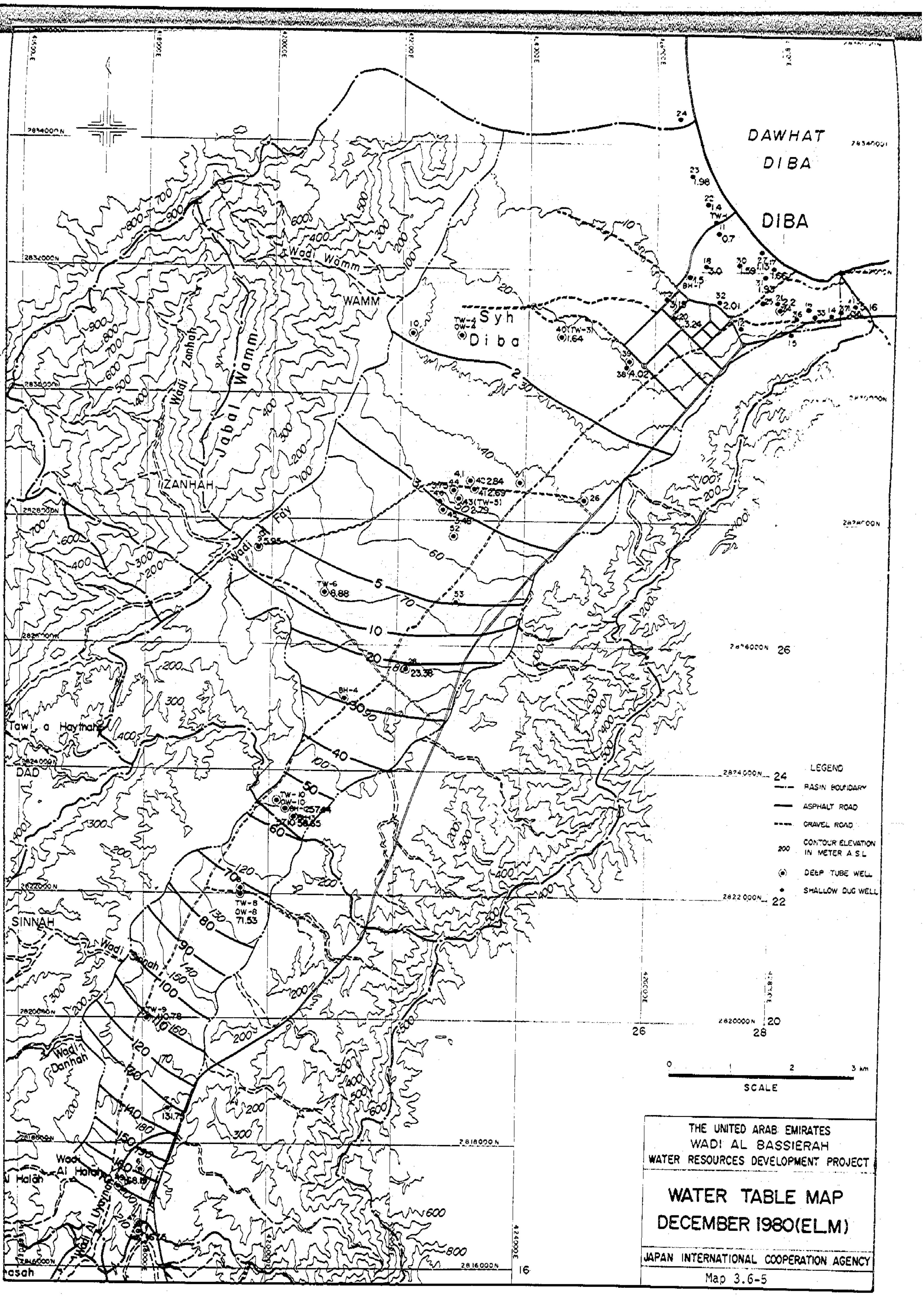
Wadi Wamm
Jabal Wamm
Wadi Zanhah
ZANHAH
Wadi Sal
DAD
SINNAH
Wadi Sinnah
Wadi Danhan
Wadi Al Holan


THE UNITED ARAB EMIRATES
WADI AL BASSIERAH
WATER RESOURCES DEVELOPMENT PROJECT
WATER TABLE MAP
DECEMBER 1980(EL.M)
JAPAN INTERNATIONAL COOPERATION AGENCY
Map 3.6-5
LEGEND
BASIN BOUNDARY
ASPHALT ROAD
GRAVEL ROAD
CONTOUR ELEVATION IN METER A.S.L.
DEEP TUBE WELL
SHALLOW DUG WELL
SCALE
3 km
DAWHAT DIBA
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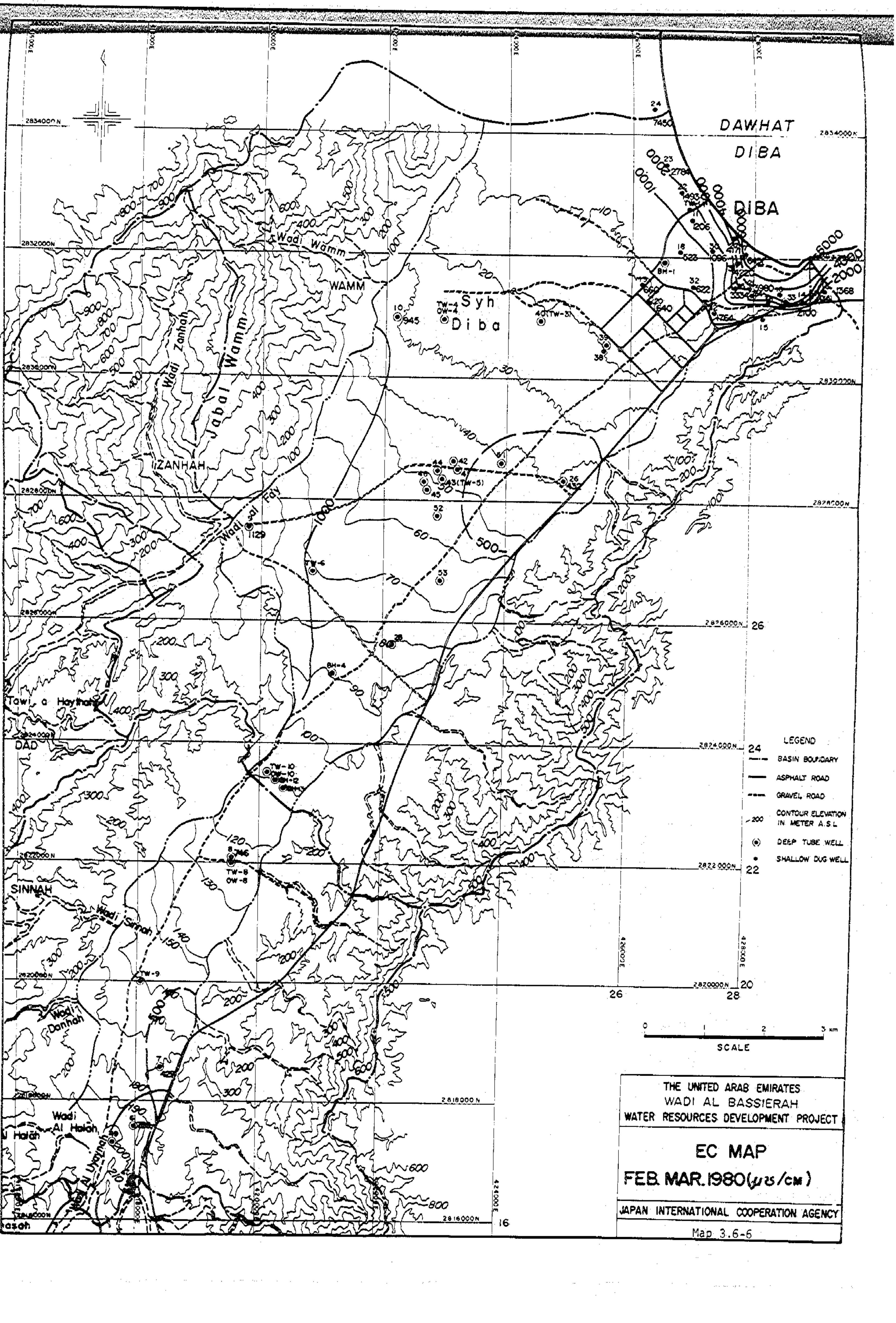
Syh Diba
WAMM
Wadi Wamm
Jabal Wamm
Wadi Zanhah
ZANHAH
Wadi Fay
Tawi a Haythah
DAD
SINNAH
Wadi Sinnah
Wadi Dannah
Wadi Al Halah
Wadi Al Uraynah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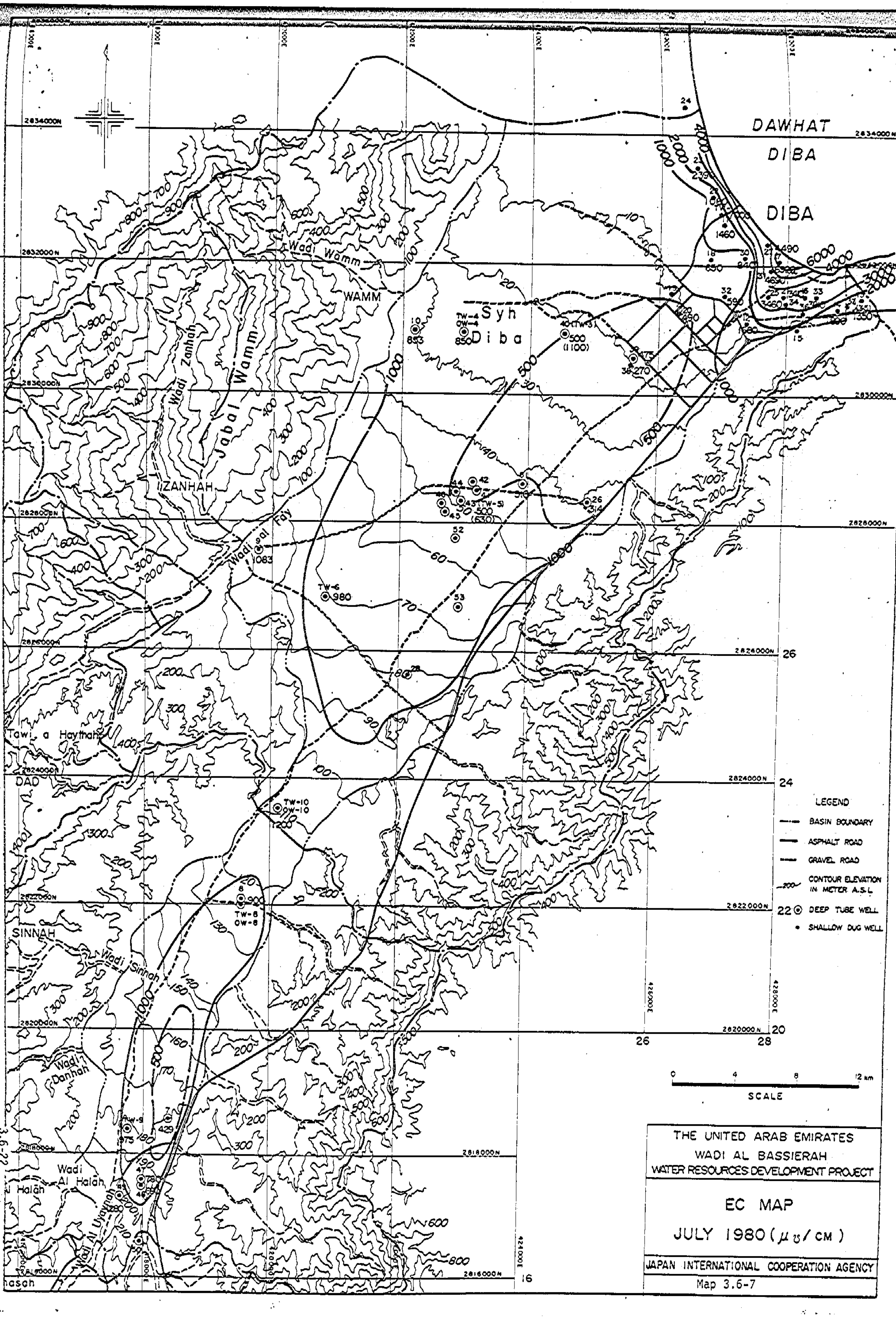
Wadi Wamm
Jabal Wamm
Wadi Zanhah
IZANHAH
Wadi al Fay
Tawi a Haythah
DAD
SINNAH
Wadi Sinnah
Wadi Danhah
Wadi Al Halah
Wadi Al Uyaynah
LEGEND
BASIN BOUNDARY
ASPHALT ROAD
GRAVEL ROAD
CONTOUR ELEVATION IN METER A.S.L.
DEEP TUBE WELL
SHALLOW DUG WELL
SCALE
0 1 2 3 km
THE UNITED ARAB EMIRATES
WADI AL BASSIERAH
WATER RESOURCES DEVELOPMENT PROJECT
EC MAP
FEB. MAR. 1980 (μs/cm)
JAPAN INTERNATIONAL COOPERATION AGENCY
Map 3.6-6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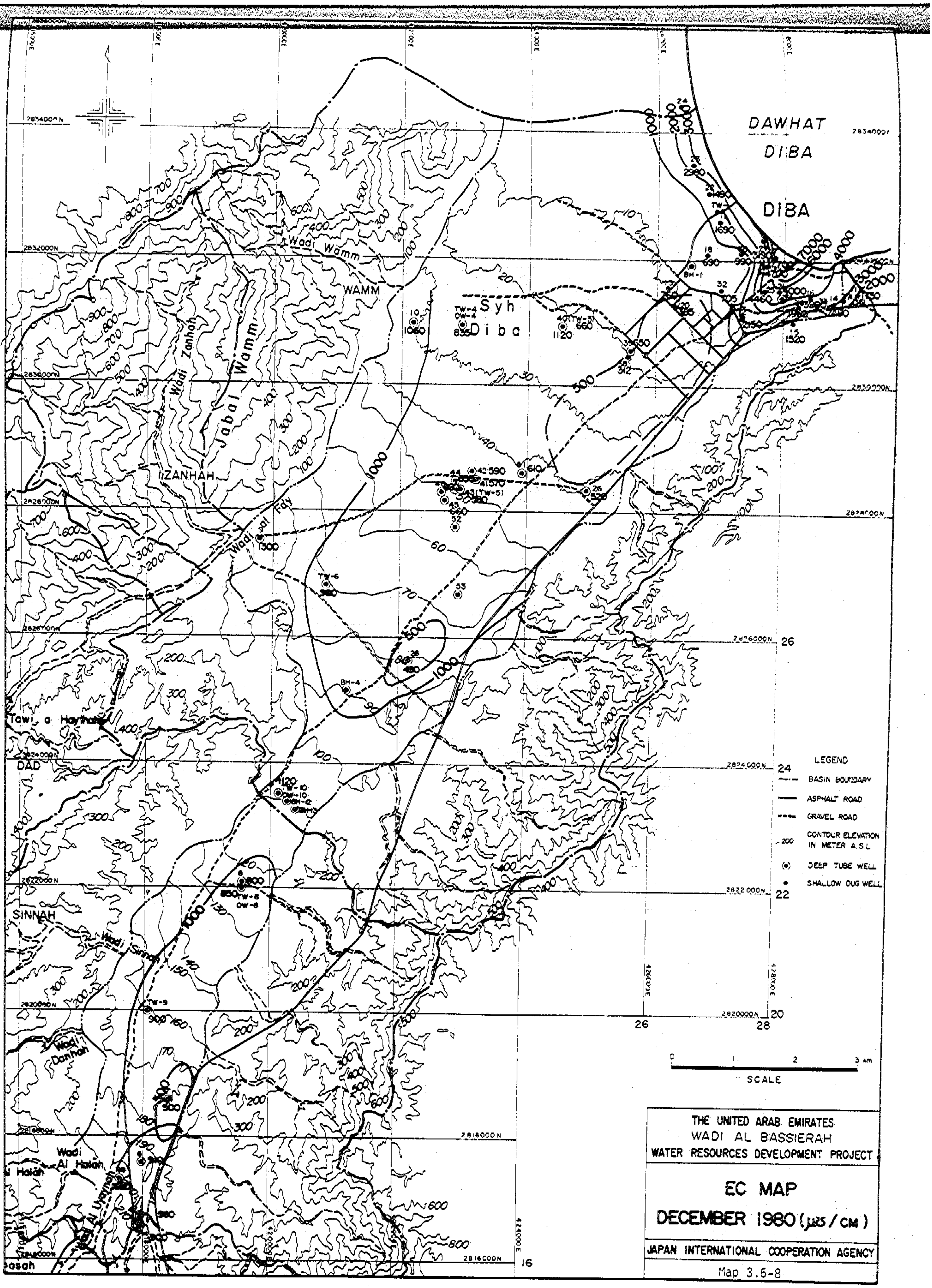
Jabal Wamm
Wadi Zanhah
ZANHAH
Wadi al Fay
Tawi a Haythah
DAD
SINNAH
Wadi Sinnah
Wadi Danhah
Wadi Al Halah
Halah
Wadi Al Uyaynah
LEGEND
BASIN BOUNDARY
ASPHALT ROAD
GRAVEL ROAD
CONTOUR ELEVATION IN METER A.S.L.
22 DEEP TUBE WELL
SHALLOW DUG WELL
SCALE
THE UNITED ARAB EMIRATES
WADI AL BASSIERAH
WATER RESOURCES DEVELOPMENT PROJECT
EC MAP
JULY 1980 (μ℧/CM)
JAPAN INTERNATIONAL COOPERATION AGENCY
Map 3.6-7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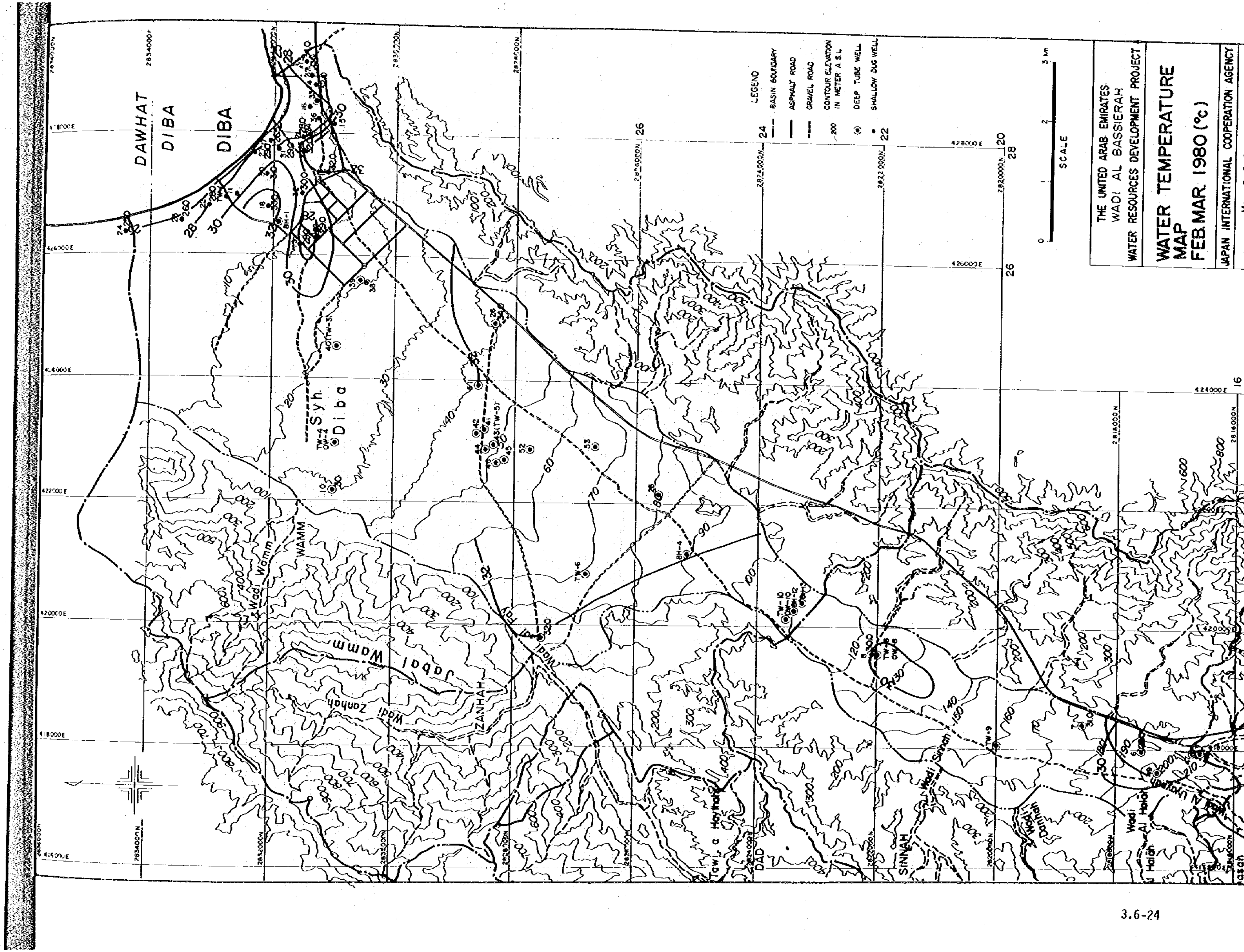
Jabal Wamm
Wadi Zanhah
ZANHAH
Wadi al Fay
Tawi a Haythah
DAD
SINNAH
Wadi Sinnah
Wadi Danhah
Wadi Al Halah
Al Halah
Wadi Al Uyaynah
Masah
LEGEND
BASIN BOUNDARY
ASPHALT ROAD
GRAVEL ROAD
CONTOUR ELEVATION IN METER A.S.L
DEEP TUBE WELL
SHALLOW DUG WELL
SCALE
0
1
2
3 km
THE UNITED ARAB EMIRATES
WADI AL BASSIERAH
WATER RESOURCES DEVELOPMENT PROJECT
EC MAP
DECEMBER 1980 (μS / CM)
JAPAN INTERNATIONAL COOPERATION AGENCY
Map 3.6-8


THE UNITED ARAB EMIRATES
WADI AL BASSIERAH
WATER RESOURCES DEVELOPMENT PROJECT
WATER TEMPERATURE MAP
FEB.MAR. 1980 (°c)
JAPAN INTERNATIONAL COOPERATION AGENCY
Map 3.6-9
LEGEND
BASIN BOUNDARY
ASPHALT ROAD
GRAVEL ROAD
CONTOUR ELEVATION IN METER A.S.L.
DEEP TUBE WELL
SHALLOW DUG WELL
SCALE
DAWHAT DIBA
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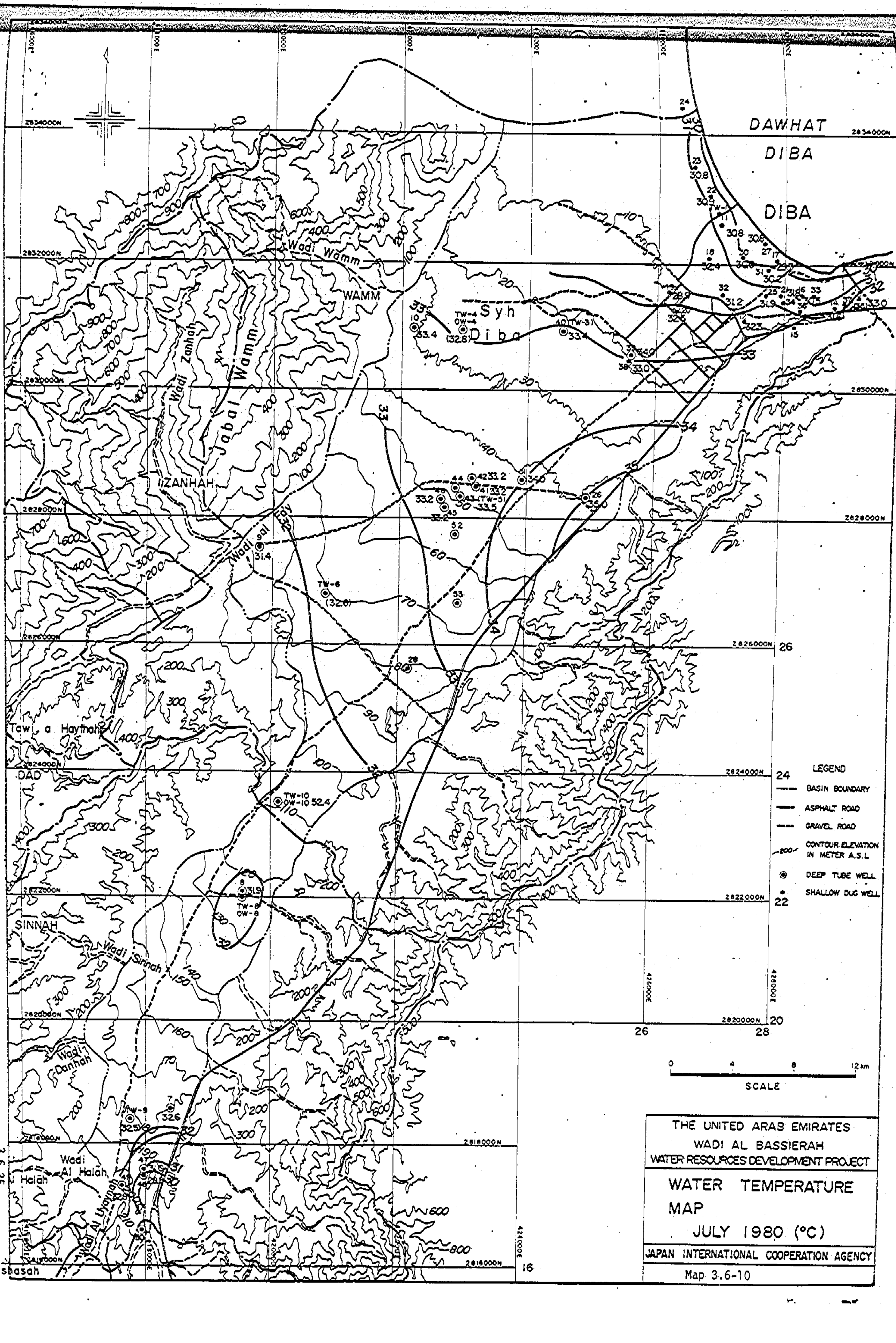
Wadi Al Halah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Jabal Wamm
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ZANHAH
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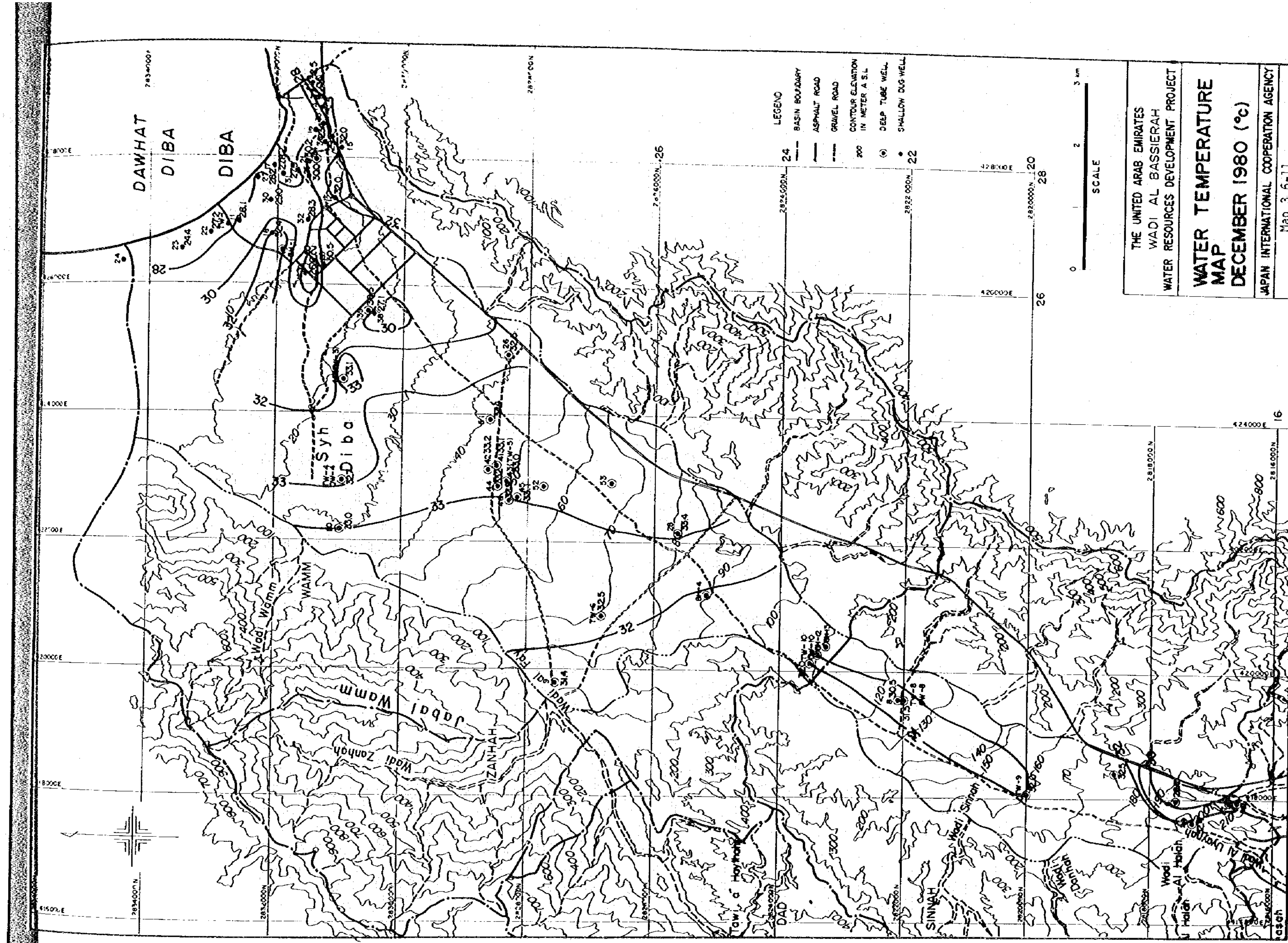
Tawi a Haythah
DAD
SINNAH
Wadi Sinnah
Wadi Danhah
Wadi Al Halah
Halah
Wadi Al Uyaynah
shasah
LEGEND
BASIN BOUNDARY
ASPHALT ROAD
GRAVEL ROAD
CONTOUR ELEVATION IN METER A.S.L
DEEP TUBE WELL
SHALLOW DUG WELL
SCALE
0 4 8 12 km
THE UNITED ARAB EMIRATES
WADI AL BASSIERAH
WATER RESOURCES DEVELOPMENT PROJECT
WATER TEMPERATURE MAP
JULY 1980 (°C)
JAPAN INTERNATIONAL COOPERATION AGENCY
Map 3.6-10


THE UNITED ARAB EMIRATES
WADI AL BASSIERAH
WATER RESOURCES DEVELOPMENT PROJECT
WATER TEMPERATURE MAP
DECEMBER 1980 (°C)
JAPAN INTERNATIONAL COOPERATION AGENCY
Map 3.6-11
LEGEND
BASIN BOUNDARY
ASPHALT ROAD
GRAVEL ROAD
CONTOUR ELEVATION IN METER A.S.L.
DEEP TUBE WELL
SHALLOW DUG WELL
SCALE
DAWHAT DIBA
DIBA
Syh Diba
WAMM
Wadi Wamm
Jabal Wamm
Wadi Zanhah
ZANHAH
DAD
SINNAH
Wadi Sinnah
Wadi Danhan
Wadi Al Halah