No. 16

FEASIBILITY REPORT
ON
KAHLAA RICE FARM PROJECT
IN
THE REPUBLIC OF IRAQ

(APPENDIX)

MARCH, 1980

JAPAN INTERNATIONAL COOPERATION AGENCY

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Table 1-1 Personnel to Whom the Team Contacted

Mr. Abdull Jlah Abdull Sabber	Commercial Assistant, Grain Board
Mr. Saad Salim Al-Sato	Vice Laboratories Manager, Grain Board
Mr. Abcd Al-Kadem Mekarb Al-Mayer Al-Kabeer	Chief of Field Department, State Establishment of Sugar
Mr. Muklis Barakat	Mechanical Engineer, Agriculture Machinery Station B.G.W.
Mr. Aziz Shamkhi Jouber	Agriculture Engineer, General Body of Agriculture Applied Research
Mr. Wagih Y. Saji	Agriculture Engineer, General Body of Agriculture Applied Research
Dr. Mohammed Abid Alsaidy	Department of Food Technology Faculty of Agriculture, University of Baghdad
Mr. Khalok M. Kamil	Horticulture Division, Planning Department
Dr. Mohammed A. Al-Najim	Dean of Agricultural College, University of Basra
Dr. Abed Al-Wahhb Esmoeel Allam	Technical Advisor, Amara State Sugar Cane Farm
Mr. Ali Salman	Chief of Agricultural Research Division Amara State Sugar Cane Farm
Mr. Kalaf Mehara	Chief of Rental Station of Machinery Missan
Mr. Sabih Hannon	Amarah Irrigation Project, Topographic survey at Rice Project in Al-Kahlaa
Dr. Ibram M. Hbib	Soil Reclamation Expert, Amara Sugar Cane Factory
Mr. Abusu Mohamad	Assistant Directorate General, Maintenance and Operation of Irrigation Project, Ministry of Irrigation
Mr. Zuherir Sharif	Hydrological Engineer, Maintenance and Operation of Irrigation Project, Ministry of Irrigation

Mr. Adib Matti	Section Chief of Topographic Section, State Organization for Minerals, Directorate General of Geological Survey and Mineral Investigation
Mr. Faik Nassir Hussain	Head Master of Najah State Rice Mill
Mr. Farong Abdul-Koder	State Establishment for Design and Studies, Ministry of Irrigation
Mr. Sabah	Assistant Director, Project Office of Irrigation Studies of Amara
Mr. Ibahim Salein	Assistant Director, Directorate of Missan Irrigation and Drainage Project
Mr. Karam Dashti	Assistant Director, Office of Missan Road and Bridge, Ministry of Housing and Construction
Mr. Hussam Ab Rahman	Manager of Engineering Department Missan Oil Directorate, Ministry of Oil
Mr. Helal Laftah	Division Chief, Missan Meteological Office
Mr. Khalat Husain	Electric Engineer, Directorate of Missan Electric Distribution Abus
Mr. Asaad Abdl Hessier	Technical Director, the State Company for Asbestos and Plastic Industries
Mr. Mohamad Mosu	Assistant of Director, Khalis Agriculture Administration Office
Mr. Jabbar Mahmood Jasim	Manager of Soil Department, Leaching and Planting Division for Lower Khalis
Mr. Tariq Hadad	Directorate General of Technical Assistance, State Establishment for Agricultural Design and Construction

Table 1-2 Data List Used for Study

A. Maps

1. Controlled Mosaic Photo Maps, (Scale 1/10,000) 10 sheets, 1962, Topo-survey Department

2. Aerial Photograph (Scale 1/35,000), 31 sheets, 1962 Topo-survey Department

3. Topographical Map (Scale 1/10,000)

4. Land Use Map (Scale 1/10,000), Soil Survey Office

5. Topographic Map of Sample Area (Scale 1/2,000), General Survey Department

6. Administration Map of Missan Province

B. Meteorology and Hydrology

Meteorology

1. Meteorological Data observed at Amara Sugarcane Factory (1965 - 1975)

2. Meteorological Data observed at Amara Meteorological Office (1973 - 1979)

Hydrology

3. Records on Water Level and Discharge Observed at the Kahlaa Regulator (1974 - 1979)

4. Records on Water Level observed at Al Kahlaa Gauging Station (1978 - 1979)

5. Irrigation Improvements in the Amara Area, Final Planning Report, Volume II, Hydrology (1963), by M. Allahwerdi & Assoc-Iraq, CEKOP-Poland, Baghdad, Iraq, 1965

6. - do -, Volume II, Appendix A, B.

7. Hydrological Survey of Iraq, Main Report, 1963, Harza Engineering Co., Chicago, Binnie & Partners, London

8. Mujar Al-Kabir River Quality, Amara Irrigation Office

C. Soil

1. Soil Survey Manual, USDA 1951

2. Diagnosis and Improvement of Saline and Alkali Soils, USDA 1954

3. Soil Survey Interpretation, ILRI 1975

4. A Framework for Land Evaluation, FAO 1973

5. Approaches to Land Classification, FAO 1974

6. Land Evaluation for Rural Purposes, ILRI 1973

7. Manual of Land Classification for Irrigation, Soil Institute of Iran 1970

8. Soil and Soil Conditions in Iraq, Dr. P. Buringh 1960

9. Studies on Salt Movement by Capillarity in Stratified Mesopotamian Alluvial Soils, SOSLR 1977*

10. Drainage and Soil Reclamation of Maisan Cane Sugar Project, 1970

11. The Soils of Lower Mesopotamian Plain and Their Suitability for Sugarcane Plantation (draft) 1979*

12. Proposals for the Development of the Rice State Farm in the Lower Khalis Project, Khalis Agr. Adm. 1977*

13. Irrigation Improvement in Amarah Area vol. III, CEKOP 1966

14. Flora of Iraq, vol. I Introduction Ed. Evan Guest 1966

15. Soils of the World, J. Papadakis 1969

16. Salinity Seminar Baghdad, FAO 1971

17. Seminar on Waterlogging in relation to Irrigation and Salinity Problems, FAO 1964

18. International Source-Book on Irrigation and Drainage of Arid Lands in relation to Salinity and Alkalinity, FAO/UNESCO 1967

19. An International Source Book-Irrigation, Drainage and Salinity, FAO/UNESCO 1973

20. Prognosis of Salinity and Alkalinity, FAO 1976

21. Drainage of Salty Soils, FAO 1973

22. Salinity Problems in the Arid Zones, Arid Zone Research UNESCO 1961

23. Reclamation of Salt Affected Soils in Iraq, ILRI 1963

24. Arid Zone Irrigation, Bruno Yaron et al 1973

25. Calcareous Soils, FAO 1973

26. Water Quality for Agriculture, FAO 1976

27. Drainage for Agriculture, Amer. Soc. Agron. 1974

28. A History of Land Use in Arid Regions, Arid Zone Research UNESCO 1961

29. Utilization of Saline Water, Arid Zone Programme UNESCO 1954

30. Guide Book to Research Data for Arid Zone Development, Arid Zone Research UNESCO 1957

31. Development of Arid and Semi-arid Lands: Obstacles and Prospects, UNESCO 1977

32. Controled Mosaic Photo-maps (Scale 1:10,000)

33. Aerial Photographs (Scale 1:35,000)

34. Soil Classification Map in Bahathe Area (Scale 1:10,000)

D. Agriculture and Agriculture Machine

1. Flora of Iraq, Volume I

2. Flora of Iraq, Volume II

3. Flora of Iraq, Volume IX

4. Poisonus Plants of Iraq

5. Monograph on the Cucurbitacene (Reference only)

6. The Wheat Response to Nitrogen and Phosphorus Contents of Soil, No.3, Feb. 1977

7. Evaluation of Soil Fertility and its Effect on Yield of Regional Crops in Lower Mesopotamian Plain, No.4, Jan. 1977

8. Evaluation Maps of Fertility of Some Iraqi Soils and the Response of Regional Crops to Fertilizers in Farm Fields, No.36, Sept. 1977

9. Amber Rice Plantation

10. Development of Rice Farming in Iraq

11. Final Report for Rice Experiment, 1975 (Arabic)

12. Modern Method of Paddy Cultivation at Middle South Region in Iraq (Arabic)

13. Central Statistic Organization Index Number for Agricultural Crops in Iraq for the years 1961 to 1977, Feb. 1978 (Reference only)

14. Characteristics of Paddy Varieties, Wheat and Barley, General Body of Agriculture Applied Research

15. Input Materials for Each Crop per Hectare at Present, Missan Agricultural Office

16. Efficiency of Farm Operation, Agriculture Machinery Station, B.G.W.

E. Irrigation and Drainage

1. Irrigation Improvements in the Amara Area, Final Planning Report, Volume I. Irrigation and Drainage, by M. Allahwerdi & Assoc-Iraq, CEKOP-Poland, Baghdad, Iraq, 1965

2. - do -, Volume II. Hydrology (1963)

3. - do -, Volume II. Hydrology, Appendix A.

4. - do -, Volume II. Hydrology, Appendix B.

5. Interim Planning Report on Irrigation Improvements in Amara Area, Volume I. General Sketch of Irrigation and Drainage, M. Allahwerdi & Assoc-Iraq and CEKOP-Poland, Baghdad, Iraq

6. Interim Planning Report, Volume IV. Foundation Explorations

7. Preliminary Design Memorandum on Irrigation Improvement in the Amara Area, by H. Allahwerdi & Assoc-Iraq, CEKOP-Poland

8. Hydrological Survey of Iraq, Main Report, 1963, Harza Engineering Co., Chicago, Binnie & Partners, London

9. Five-day and Monthly Statistics of River Gauge Reading for the Year 1970, (issued as Irrigation Directorate General Technical Circular)

10. Amara Barrage and Drainage System Projecting the Amara Town, July 1966, Polservice, Polish Consulting Engineers, Baghdad, Iraq.

11. Summary of Monthly Precipitation at Stations in Iraq, 1887 to 1958, Hydrological Survey of Iraq, May 1959

12. Discharge for Selected Gauging Stations in Iraq, 1930 - 1956, Hydrological Survey of Iraq, May 1958

13. Progress under Planning, 1972, the Ministry of Planning, the Republic of Iraq

14. Consumptive Use for Agricultural Crops (Table), Amara Irrigation Office, Ministry of Irrigation

15. Drainage and Soil Reclamation of Missan Sugarcane Project, Dr. Ibrahm M. Hbib

16. Drainage and Soil Reclamation of Maisan Sugarcane Project, Dr. Ibram M. Hbib

17. Consumptive Use for Agricultural Crops, Amara Irrigation Office

18. Water Requirement of Irrigated Agriculture Crops, Dr. G.M. Kavaz

19. Institute of Natural Resources & Researches

20. Analysis Results of Sampled Soil for Upland Crop Irrigation, Laboratory of Applied Research, Abu-Ghraib

F. On-farm and Design

1. Present and Future Programs of Land Reclamation of Al-Edawiyah Reclamation Project, Missan Sugarcane Company

2. Land Reclamation of Khalis Project, Khalis Agriculture Administration Office

3. Standard Land Reclamation in Iraq, State Organization for Soils and Land Reclamation

4. Design Manual for High Way Engineering, State Organization of Road and Bridge

5. Drawings showing the Present Oil Pipe Line Facilities, Missan Oil Department

6. Present Status of Electric Condition, Missan Electric Distribution Office

7. Cost of Plastic Draine Pipe, State Company for Asbestos and Plastic Industries

8. Information on Project Implementation, State Establishment for Agriculture Design and Construction

9. Unit Costs of Wages, Materials and Equipments, State Organization for Soils and Land Reclamation

G. Economy

1. Index Numbers for Agricultural Crops in IRAQ
for the Years 1961 - 1977 - Feb. 1978
Central Statistical Organization

2. Statistical Pocket Book, 1974
Central Statistical Organization

3. Annual Abstract of Statistics, 1977
Central Statistical Organization

4. Economics of Agricultural Sector in Iraq 1976

5. FAO Commodity Projections, 1985
FAO, Rome, 1978

6. World Development Report, 1978
The World Bank, August 1978

Table 2-1 Plain, Mountainous and Desert Areas

Details	Area (sq.km)	Percent (%)
Plain (including marshes and lakes)	132,500	30.2
Terrain land	42,500	9.7
Mountain	92,000	21.0
Desert	167,000	38.0
Half of the neutral zone	3,522	0.8
Territorial waters	924	0.2
Total	438,446	100.0

Source: Annual Abstract of Statistics, 1977.
Central Statistical Organization

Table 2-2 Population of Iraq 1927-1977

(Unit: '000 persons)

Year	Total	Male	Female
1927 1/	2,968	1,512	1,456
1934 1/	3,380	1,688	1,692
1947 2/	4,816	2,257	2,559
1957 3/	6,340	3,185	3,155
1965 3/	8,097	4,133	3,964
1970 4/	9,440	4,754	4,686
1971	9,750	4,910	4,840
1972	10,074	5,074	5,000
1973	10,413	5,244	5,169
1974	10,765	5,422	5,343
1975	11,124	5,603	5,521
1976	11,505	5,795	5,710
1977 5/	12,029.7	6,224.2	5,805.5

Note: 1/ Figures of 1927 and 1934 are based on general registration of population.
2/ Census of 1947 excluding Iraqis abroad.
3/ Census of 1957 and 1965 including Iraqis abroad.
4/ Figures of the years 1970-76 are estimated not including Iraqis abroad.
5/ Primary results of general population census 17/10/1977 exclude Iraqis abroad.

Source: Annual Abstract of Statistics, 1977

Table 2-3 Population Estimate, Governmental Statistic Data, 1976

(Unit: '000 persons)

Governorates	Density per sq.km	Area in sq.km	Total Population
Nineveh	28	41,320	1,158
Salah Al-Deen	17	21,326	356
Al-Ta'meen	47	9,426	439
Diala	35	19,047	663
Baghdad	604	5,023	3,036
Al-Anbar	5	89,540	405
Babylon	103	5,103	565
Kerbela	5	52,856	243
Al-Najaf	13	26,834	354
Al-Qodisiya	46	8,569	395
Al-Muthanna	4	49,206	184
Thi-Qar	45	13,668	617
Wasit	23	17,922	409
Maysan	25	16,774	419
Basrah	46	19,702	897
Autonomous Region:			
D'hok	34	6,374	217
Arbil	34	14,428	492
Al-Sulanimaniya	40	16,482	656
Total	27	434,000	11,505

Table 2-4 Gross Domestic Product, National Income and Per Capita Income at Current Prices

Year	Per Capita Income (I.D.)	Per Capita Income (US$)	National Income (Million I.D.)	G.D.P. (Million I.D.)
1967	89.6	303	754.2	937.7
1968	96.9	327	840.6	1,062.6
1969	98.4	332	879.2	1,103.3
1970	103.9	351	956.9	1,197.3
1971	110.9	375	1,081.3	1,375.0
1972	115.8	391	1,166.9	1,388.5
1973	135.6	458	1,412.1	1,587.5
1974	278.9	942	3,002.5	3,347.7
1975 1/	337.2	1,139	3,750.5	3,970.5
1976 1/	387.2	1,308	4,478.8	4,582.8

Note: 1/ preliminary estimation

Source: Annual Abstract of Statistics 1977

Table 2-5 Trend of GDP

Item	GDP (Unit: Million I.D.) 1973	1974	1975	1976	Percentage(%) 1973	1974	1975	1976
Agriculture	225.9	232.1	297.3	348.7	14.2	6.9	7.5	7.6
Mining	574.3	2,030.7	2,287.7	2,475.1	36.2	60.7	57.6	54.0
Industry	157.6	176.1	238.5	324.5	9.9	5.3	6.0	7.1
Construction	57.6	69.1	91.3	355.1*	3.6	2.1	2.3	7.7
Electric & Water	16.0	13.7	17.7	22.5	1.0	0.4	0.4	0.5
Transport. Commerce etc.	224.2	337.2	412.7	580.3	14.1	10.1	10.4	12.7
Service	331.9	488.8	625.3	476.5	20.9	14.6	15.7	10.4
Total	1,587.5	3,347.7	3,970.5	4,582.7	100.0	100.0	100.0	100.0

Source: Annual Abstract of Statistics 1976, 1977.

Note: * include houses.
GDP is current value.

Table 2-6 National and per Capita Income

Year	Population (Million)	National Income (Million Dinar)	Per Capita Income (Dinar)	Agricultural Population (Million)	Agricultural Income (Million Dinar)	Per Capita Income in Agricultural Sector (Dinar)	Contribution of Agricultural Sector to National Income (%)
1962	7,321	526.4	71.9	3,514	148.0	42	28.1
1963	7,554	525.3	69.5	3,523	111.0	32	21.1
1964	7,798	624.9	80.1 (80.5)	3,925	133.0	34	21.3
1965	8,047	684.5	85.1	3,935	153.2	39	22.4
1966	8,308	741.7	89.3	3,945	163.4	41	22.0
1967	8,580	758.4	88.4	3,959	188.8	48	24.9
1968	8,860	845.0	95.4 (96.9)	3,966	196.0	49	23.2
1969	9,149	885.1	96.7	3,977	191.0	48	21.6
1970	9,440	962.0	101.9(103.9)	3,987	206.9	52	21.5
1971	9,750	1,103.7	113.2(110.9)	3,998	188.0	47	17.0
1972	10,074	1,217.8	120.9(115.8)	4,008	301.1	75	24.7
1973	10,413	N.A.	N.A. (135.6)	4,019	284.6	71	N.A.
1974	10,763	N.A.	N.A. (298.9)	4,029	303.4	75	N.A.

Source: Ministry of Planning, annual abstract of statistics, 1973, 1974.
Figures in parenthesis are based on Statistical Abstract, 1975.

Table 2-7 Real Growth Rate of GDP (Constant Price, 100 in 1969)

	1969-74 (%)	1964-74 (%)
Agriculture, Forestry, Fishery	0.8	4.5
Oil	5.6	4.5
Other Mining	5.1	6.6
Industry	8.6	7.1
Construction	13.6	6.3
Electric, Water Supply	10.0	10.2
Transportation	3.3	2.1
Wholesale, Retail, Hotel etc.	4.4	3.4
Financing, Insurance etc.	10.9	9.2
House	3.8	6.4
Administration, Security	11.8	8.3
Service	12.6	8.8
GDP	6.8	5.4

Source: Statistical Abstract, 1975

Table 2-8 Cropping Area and Production of Wheat

Year	Cropping Area ('000 ha)	Production ('000 ha)	Yield/ha (ton)
1970	1,759	1,236	0.704
1971	948	822	0.868
1972	1,915	2,625	1.372
1973	1,156	957	0.828
1974	1,633	1,339	0.820
1975	1,408	845	0.600
1976	1,499	1,312	0.876
1977	858	696	0.812

Source: Annual Abstract of Statistics

Table 2-9 Cropping Area and Production of Paddy

Year	Cropping Area ('000 ha)	Production ('000 ha)	Yield/ha (ton)
1970	74.6	180	2.416
1971	109.1	307	2.812
1972	94.1	268	2.848
1973	64.0	157	2.448
1974	31.4	69	2.204
1975	29.9	61	3.024
1976	52.4	163	3.116
1977	63.5	199	3.156

Source: Annual Abstract of Statistics

Table 2-10 Oil and Gross Export Values

(Unit: Million I.D.)

Year	Gross export (A)	Oil export (B)	percent (%) (B)/(A)
1971	402.0	379.2	94.3
1972	368.9	340.3	92.2
1973	587.8	555.3	94.5
1974	1,949.1	1,921.0	98.6
1975	2,450.2	2,414.6	98.5
1976	2,737.9	2,691.4	98.3
1977	2,853.8	2,807.3	98.4

Source: IMF, International Financial Statistics Jan., 1979.

Table 2-11 Agricultural Production and Total Exports Except Oil (in million I.D.)

Year	Total Export Except oil (1)	Agricultural Export (2)	Dates Export	Ratio of Agr. Export to Total Export (2)/(1)	Ratio of Dates Export to Total Agr. Export
1964	15.2	12.6	6.1	82.7	48.6
1965	18.1	13.6	5.7	75.6	41.9
1966	21.4	17.2	6.4	80.4	37.5
1967	18.5	12.9	6.7	70.2	51.9
1968	21.4	14.5	6.4	67.8	44.4
1969	22.0	16.5	7.4	75.1	54.1
1970	16.5	16.5	9.2	73.2	55.8
1971	22.7	14.6	6.9	64.1	47.8
1972	28.6	20.4	10.2	71.5	50.0
1973	32.5	17.4	10.0	53.6	57.5
1974	28.1	N.A.	N.A.	-	-

Source: Ministry of Economy, Study of the Agricultural Production Obstacles, Part 2.

Table 2-12 Trade of Agricultural Products

(Unit: Million I.D.)

Year	Export (A)	Import (B)	Balance (A) - (B)	Ratio (A)/(B)
1964	12.6	55.7	-43.1	22.7
1965	13.6	54.6	-41.0	25.0
1966	17.2	52.1	-34.8	33.1
1967	12.9	47.9	-34.9	27.1
1968	14.5	49.2	-34.6	29.5
1969	16.5	49.8	-33.3	33.1
1970	16.5	56.7	-40.1	29.1
1971	14.6	69.0	-54.4	21.2
1972	20.4	70.3	-49.8	29.0
1973	17.4	86.9	-69.4	20.1
1974	N.A.	N.A.	-N.A.	N.A.

Source: Ministry of Economy Study of Agricultural Production Obstacles.

Table 2-13 Wheat Production and its Import/Export, 1970 to 1977

Year	Production (ton)	Import (ton)	Export (ton)
1970	1,235,690	90,000	0
1971	822,300	955,000	0
1972	2,625,300	61,000	28,000
1973	956,788	154,000	143,000
1974	1,338,900	672,000	6,000
1975	845,400	512,000	4,000
1976	1,312,400	-	-
1977	695,700	-	-

Table 2-14 Paddy Production and its Import/Export, 1970/1977

Year	Production (ton)	Import (ton)	Export (ton)
1970	180,150	2,000	0
1971	306,700	97,000	0
1972	267,830	33,000	0
1973	156,620	16,000	0
1974	69,280	198,000	0
1975	60,540	120,000	0
1976	163,360	-	-
1977	199,240	-	-

Source: Agricultural crops in Iraq for the years 1961 to 1977, Annual Abstract Statistics, 1975-1976, (FAO Trade Year Book)

Table 2-15 Number of Agricultural Cooperatives and of their Members and Paid Capital from 1961 to 1975

Year	Number of Cooperatives	Number of Members	Paid up Capital (I.D)	Reserve Capital (I.D)	Credit from Agr. Bank (I.D)
1961	17	2,306	2,078	494	-
1962	50	3,217	8,397	2,034	-
1963	65	7,312	11,404	3,102	-
1964	225	29,497	28,699	7,778	-
1965	298	39,244	56,377	16,612	52,379
1966	367	47,725	76,167	26,919	96,688
1967	410	54,750	100,746	41,999	125,119
1968	473	62,976	111,296	59,155	262,775
1969	608	76,171	145,925	73,604	412.665
1970	786	107,797	213,880	87,096	1,150,245
1971	831	126,968	267,581	154,899	1,797,828
1972	986	160,148	342,653	260,383	2,198,852
1973	1,155	186,288	466,707	321,616	2,784,412
1974	1,386	217,723	589,563	420,874	2,905,356
1975	1,652	239,644	699,547	495,475	7,553,147

Source: Directorate-General of Agricultural Cooperation and Production.

Table 2-16 Number of Cooperative Farmers Association Attached to the Agricultural Administration and the Agricultural Project Body until 1977

Number of the Administration Body	Number of Members	Number of Association
Khalis	7,555	38
Musayab	3,317	17
Abughraib	11,927	92
Ishaki	8,178	48
Dujaila	3,122	15
Projects body	13,717	73
Total	47,816	283

Source: Annual Abstract of Statistics, 1977.

Table 2-17 Number of Collective Farms, Members and Area of Their Works

Year	Number of Farms (Persons)	Members (Persons)	Total Area (Donums)
1972	6	490	24,160
1973	35	3,601	234,427
1974	72	11,253	534,920
1975	78	10,543	576,392
1976	79	9,857	634,079
1977	79	8,540	723,435

Source: Annual Abstract of Statistics, 1977.

Table 2-18 State Farms

Farm	Area (Donums)
Swaira	151,000
Abu Graib	7,632
Letifiya	4,000
Na'ii	15,000
Muradiya	3,500
Hawija	13,500
Beni Sa'ad	90,000
Swib	23,000
Total	307,632

Source: Statistical Pocket Book, 1974

Table 3B-1 Monthly Rainfall at Amara City

(Unit: mm)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1965 1/	-	-	-	-	-	0	0	0	Tr.	20.2	1.2	1.1	-
1966	38.7	43.7	20.2	5.3	Tr.	0	0	0	0	27.0	0	6.0	140.9
1967	22.3	36.2	0.2	0	21.0	0	0	0	0	3.5	64.6	11.6	159.4
1968	1.2	5.3	0	54.7	2.9	0	0	0	0	0	7.7	9.2	81.0
1969	115.4	5.6	26.5	80.4	30.8	0	0	0	0	Tr.	2.1	6.7	267.5
1970	61.2	6.1	4.2	0	0	0	0	0	0	Tr.	1.0	4.5	77.0
1971	16.2	15.8	16.0	58.7	0.5	0	0	0	0	0.8	28.1	16.1	152.2
1972	57.6	9.0	42.6	18.5	2.4	0	0	0	0	0	2.5	64.5	197.1
1973	3.5	46.0	0	4.0	Tr.	0	0	0	0	0	0.5	72.7	126.7
1974	70.8	79.5	25.5	6.5	0	0	0	0	0	0	5.5	146.5	334.3
1975 2/	47.5	28.9	0.7	10.1	17.7	0	0	0	0	0	1.7	101.5	208.1
1976	59.5	44.0	15.9	47.7	14.2	0	0	0	0	1.9	0	37.8	221.0
1977	23.3	13.9	61.1	8.0	5.1	0	0	0	0	26.2	29.5	60.3	227.4
1978	46.3	25.1	7.8	0	0	0	0	0	0	Tr.	11.9	16.7	107.8
1979	28.5	7.0	7.9	Tr.	22.3	Tr.	-	-	-	-	-	-	-
Mean	42.2	26.2	16.3	21.0	8.4	0	0	0	0	5.7	11.2	39.7	170.7
Distribution (%)	25	15	10	12	5	0	0	0	0	3	7	23	100

Note: 1/ Data during the period of 1965 to 1974 are those of Amara Sugarcane Factory.
2/ Data since 1975 are those observed at Amara Meteorological Office.

Table 3B-2 Mean Monthly Air Temperature at Amara City

(Unit: °C)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
1965 1/	-	-	-	-	-	32.8	34.8	34.7	30.5	27.0	18.0	12.9	-
1966	14.9	15.5	19.1	23.4	30.6	35.1	35.1	35.8	32.4	24.2	19.5	13.8	25.0
1967	11.1	9.8	16.7	22.5	28.8	31.3	34.5	32.8	30.4	25.8	18.1	10.5	22.7
1968	10.0	11.8	18.3	22.5	30.3	34.1	36.5	33.5	30.7	25.3	19.0	13.4	23.8
1969	10.0	12.2	21.0	22.6	29.5	32.6	32.9	32.7	30.7	26.9	16.5	13.9	23.5
1970	10.7	14.9	19.0	25.4	30.7	33.7	34.2	33.5	29.6	24.4	20.1	10.7	23.9
1971	11.4	12.7	19.2	22.8	30.9	32.2	35.2	33.5	30.0	22.6	17.0	11.0	23.2
1972	8.8	10.5	16.8	23.3	26.5	33.2	33.7	34.4	30.4	25.8	16.6	8.5	22.4
1973	10.9	20.2	19.7	25.2	33.5	32.3	36.2	36.9	33.0	29.5	17.7	13.3	25.7
1974	10.5	11.5	18.1	22.5	30.6	34.1	34.9	-	32.0	24.9	19.0	11.0	-
1975	10.2	12.9	17.5	24.5	30.9	34.9	36.2	34.8 2/	32.8	23.2	16.3	11.0 2/	23.8
1976 2/	11.0	12.0	15.4	22.9	-	29.3	34.6	34.5	31.4	26.4	19.2	15.0	-
1977	8.6	15.5	19.5	23.1	31.0	34.9	35.9	36.2	32.9	24.0	26.3	14.7	25.2
1978	11.6	14.8	18.9	24.5	29.9	33.3	36.2	33.7	31.9	27.0	14.7	15.4	24.3
1979	13.0	16.4	18.3	20.7	29.5	35.0	-	-	-	-	-	-	-
Mean	10.9	13.6	18.4	23.3	30.2	33.3	35.1	34.4	31.3	25.5	18.4	12.5	23.9

Note: 1/ Data during the period of 1965 to 1975 are based on those at Amara Sugarcane Factory.

2/ Data during the period of 1976 to 1979 are based on those at Amara Meteorological Office. In 1975, mean values are obtained by using maximum and minimum temperature observed at Amara Meteorological Office.

Table 3B-3 Mean Monthly Maximum Temperature at Amara City

(Unit: °C)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
1965 1/	-	-	-	-	-	41.8	44.6	44.6	41.2	32.1	25.9	21.6	-
1966	22.8	21.4	26.1	30.9	38.8	44.5	44.7	46.4	41.9	33.0	29.3	21.9	33.5
1967	18.7	15.4	24.5	29.9	36.3	39.2	43.3	42.1	40.6	34.9	23.2	17.9	30.5
1968	16.1	19.0	25.4	29.2	37.1	42.0	45.9	43.6	41.2	35.1	26.6	20.1	31.8
1969	16.5	18.2	27.4	28.5	36.8	40.4	40.9	41.7	40.7	35.9	25.4	21.7	31.2
1970	16.5	22.7	26.3	33.6	38.7	42.2	43.7	43.5	40.9	35.0	29.1	18.2	32.5
1971	20.1	21.1	27.4	29.5	38.8	40.1	43.6	42.8	42.3	33.1	24.6	17.5	31.7
1972	14.5	17.4	22.8	29.6	33.6	40.5	41.5	43.9	40.5	36.6	25.2	13.6	30.0
1973	18.5	23.5	27.1	32.2	38.9	42.2	44.5	47.2	43.1	38.6	26.0	19.9	33.5
1974	16.4	17.3	23.7	29.1	38.1	42.5	43.9	-	41.6	35.5	28.0	16.9	30.3
1975	16.2	19.4	24.9	32.1	38.4	42.5	45.1	44.0 2/	42.6	32.9	24.4	15.2	31.5
1976 2/	15.2	16.8	20.6	28.6	-	42.5	42.5	43.4	40.8	34.7	27.4	21.0	30.3
1977	12.9	22.7	25.9	29.6	38.4	43.3	44.6	45.5	42.7	31.3	24.2	19.1	31.7
1978	18.1	21.0	25.7	31.8	38.2	41.8	45.0	42.9	41.9	36.2	22.4	20.9	32.2
1979	18.0	22.6	24.9	32.8	36.7	42.7	-	-	-	-	-	-	-
Mean	17.2	19.9	25.2	30.5	37.6	41.9	43.8	44.0	41.6	34.6	25.8	19.0	31.8

Note: 1/ Data are based on records observed at Amara Sugarcane Factory.

2/ Data are based on records observed at Amara Meteorological Office.

Table 3B-4 Mean Monthly Minimum Temperature at Amara City

(Unit: °C)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
1965 1/	-	-	-	-	-	23.0	25.4	25.4	21.5	17.1	10.6	5.3	-
1966	8.6	9.2	12.0	15.2	21.5	25.2	25.2	25.2	21.9	17.3	11.3	6.7	16.6
1967	4.7	4.2	9.8	14.0	20.8	22.9	25.7	23.7	20.8	17.9	13.2	5.3	15.3
1968	4.1	5.4	11.1	15.6	23.4	26.0	27.3	23.7	20.9	17.0	12.9	8.3	16.3
1969	6.8	6.1	14.8	17.2	22.0	24.5	25.1	24.0	21.0	18.3	9.4	8.0	16.4
1970	6.1	7.9	12.0	17.1	21.6	24.4	25.9	23.4	19.5	15.7	13.2	5.8	16.1
1971	4.9	5.9	12.0	15.3	23.6	24.4	26.9	24.6	19.5	13.8	10.4	5.6	15.6
1972	3.8	4.5	11.8	17.7	20.7	25.0	26.2	24.9	21.2	16.9	9.4	4.3	15.5
1973	4.2	10.5	11.9	17.3	22.7	25.9	27.4	26.4	23.1	17.3	11.2	7.1	17.1
1974	5.8	6.8	13.1	16.6	22.5	25.5	25.9	-	22.2	15.5	11.7	6.8	15.7
1975	6.1	7.7	10.1	17.5	21.4	26.2	27.4	25.5 2/	23.4	14.1	11.1	6.7 2/	16.4
1976 2/	6.7	7.1	10.1	17.2	-	16.1	26.6	25.6	21.9	18.0	11.0	8.9	15.4
1977	4.2	8.3	13.0	16.6	23.5	26.4	27.2	26.8	23.0	16.7	10.4	7.0	16.9
1978	5.1	8.5	12.1	17.2	21.6	24.7	27.4	24.4	21.8	17.7	7.0	9.9	16.5
1979	7.9	10.2	11.6	8.5	22.2	27.3	-	-	-	-	-	-	-
Mean	5.6	7.3	11.8	15.9	22.1	24.5	26.4	24.9	21.6	16.7	10.9	6.8	16.2

Note: 1/ Data during the period of 1965 to 1975 are based on observations at Amara Sugarcane Factory.
2/ Data are based on records observed at Amara Meteorological Office.

Table 3B-5 Mean Monthly Relative Humidity at Amara City

(Unit: %)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
1965 1/	-	-	-	-	-	48	48	52	52	55	65	73	-
1966	72	79	67	58	51	45	47	50	52	64	61	62	59
1967	69	75	53	50	49	39	34	40	41	42	71	76	53
1968	68	65	65	68	62	53	55	52	50	66	70	80	63
1969	84	74	69	70	60	53	58	56	56	63	66	76	65
1970	88	75	67	62	50	47	50	51	56	63	72	83	64
1971	83	71	59	65	58	57	56	57	65	70	79	74	66
1972	86	75	72	68	56	47	47	52	51	59	68	87	64
1973	69	66	56	54	48	44	43	46	47	52	58	75	55
1974	83	79	77	64	51	45	51	-	60	66	59	81	-
1975	78	71	59	59	45	39	39	-	48	55	69	-	-
Mean	78	73	64	62	53	52	48	51	53	60	67	77	62

Note: 1/ Data are based on those observed at Amara Sugarcane Factory.

Table 3B-6 Mean Monthly Pan Evaporation at Amara City

(Unit: mm)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1965 1/	-	-	-	-	-	528.0	564.2	486.7	414.0	260.4	159.0	136.4	-
1966	117.8	131.6	257.3	345.0	576.6	711.0	576.6	657.2	405.0	288.3	138.0	117.8	4,322.2
1967	111.6	72.8	201.5	261.0	403.0	501.0	573.5	502.2	354.0	232.5	96.0	65.1	3,374.2
1968	68.2	89.6	198.4	207.0	282.1	471.0	452.6	483.6	372.0	204.6	96.0	71.3	2,996.4
1969	49.6	84.0	148.8	201.0	328.6	369.0	406.1	341.0	240.0	179.8	96.0	89.9	2,533.8
1970	93.0	98.0	195.3	276.0	520.8	591.0	531.0	530.1	357.0	282.1	132.0	83.7	3,690.0
1971	130.2	120.4	198.4	246.0	368.9	453.0	554.9	610.7	459.0	223.2	150.0	124.0	3,638.7
1972	96.1	86.8	179.8	492.0	303.8	462.0	474.3	390.6	363.0	248.0	129.0	62.0	3,287.4
1973	105.4	114.8	177.9 2/	234.0	347.2	444.0	458.8	399.9	369.0	201.5	135.0	89.9	3,077.4
1974	71.3	67.2	105.4	180.0	322.4	456.0	421.6	436.2 2/	321.0	179.8	114.0	55.8	2,730.7
1975	49.6	70.0	167.4	192.0	356.5	531.0	551.8	492.6 2/	336.0 2/	192.2	117.0	52.7	3,108.8
1976 2/	55.8	92.4	130.2	198.0	266.9	497.7	544.7	438.3	357.0	188.8	156.0	83.7	3,009.5
1977 2/	58.9	120.4	204.6	195.0	340.7	504.0	540.3	431.8	388.5	213.9	-	77.5	-
1978 2/	83.7	100.8	192.2	224.7	323.3	394.8	377.6	468.7	357.0	204.6	141.0	77.5	2,948.9
1979 2/	71.3	123.2	192.2	207.9	245.2	422.1	-	-	-	-	-	-	-
Monthly Mean	83.0	98.0	182.1	247.1	356.1	489.0	502.0	476.4	363.8	221.4	127.6	84.8	3,231.3
Daily Mean	2.7	3.5	5.9	8.2	11.5	16.3	16.2	15.4	12.1	7.1	4.3	2.7	-

Note: 1/ Data during the period of 1965 to 1975 are based on observations at Amara Sugarcane Factory.

2/ Data are based on records observed at Amara Meteorological Office. But values are converted into pan evaporation (Class A).

Table 3B-7 Monthly Wind Direction Frequencies at Amara City[1/] 1975 to 1976

(Unit: %)

Year	Direction	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Mean
1975	N	17	4	17	12	8	12	3	2	8	8	6	3	8
	NE	3	3	2	4	4	0	1	0	1	0	1	1	2
	E	9	11	10	9	10	3	1	3	6	4	13	18	8
	SE	8	12	11	15	11	1	2	2	4	6	12	14	8
	S	5	10	5	11	7	4	1	2	3	6	6	3	5
	SW	1	3	2	7	2	1	1	4	3	1	1	1	2
	W	22	16	10	16	9	8	14	13	13	11	10	19	14
	NW	27	22	28	16	32	67	67	67	42	45	38	24	40
	Calm	8	19	15	10	17	4	10	8	20	19	13	17	13
1976	N	2	1	3	3	5	6	1	1	5	5	4	6	4
	NE	5	2	3	3	4	1	0	1	1	3	3	5	4
	E	12	13	17	18	9	2	1	1	1	10	9	25	10
	SE	12	15	17	20	7	2	3	1	2	16	5	11	9
	S	8	5	6	8	6	3	0	2	6	8	3	5	5
	SW	5	2	2	4	8	2	1	4	4	5	7	4	4
	W	30	21	22	17	22	22	39	58	29	22	30	20	27
	NW	18	31	20	18	26	59	56	30	51	27	32	21	31
	Calm	8	14	10	9	13	4	1	2	1	4	7	3	6

Note: 1/ Data are based on records observed at Amara Meteorological Office.

Table 3B-8 Monthly Wind Direction Frequencies at Amara City[1/] 1977 to 1978

(Unit: %)

Year	Direction	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Mean
1977	N	4	2	3	3	8	2	2	4	6	7	10	5	5
	NE	3	2	4	3	7	2	2	2	2	5	7	4	4
	E	12	11	15	16	11	3	1	3	4	10	8	13	9
	SE	9	13	19	19	4	3	3	3	3	8	2	10	8
	S	3	2	5	7	9	4	5	9	6	8	2	8	6
	SW	3	2	1	5	4	4	2	6	3	3	1	1	3
	W	24	20	20	16	15	33	38	40	19	28	23	18	24
	NW	34	38	29	26	37	46	45	32	55	22	38	25	35
	Calm	8	9	4	5	5	3	2	1	2	9	9	16	6
1978	N	2	4	4	3	2	2	2	0	4	4	3	4	3
	NE	2	3	7	3	2	1	1	0	2	2	2	3	2
	E	17	11	14	3	3	2	8	0	1	12	2	11	7
	SE	14	18	13	13	3	0	12	0	2	10	1	13	8
	S	2	4	4	7	5	4	8	0	1	10	1	3	4
	SW	1	4	5	3	2	4	8	1	2	2	0	1	3
	W	17	16	16	22	32	26	22	49	31	9	29	11	23
	NW	30	28	25	32	42	47	25	45	41	12	28	25	32

Note: 1/ Data are based on records observed at Amara Meteorological Office.

Table 3B-9 Mean Monthly Wind Direction Frequencies at Amara City

(Unit: %)

Year	Direction	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Mean
(1975-1978)	N	6	3	7	5	6	6	2	2	6	6	6	5	5
	NE	3	3	4	3	4	1	1	1	2	3	3	3	3
	E	13	12	14	12	8	3	3	2	3	9	8	17	9
	SE	11	14	15	17	6	2	5	2	3	7	5	12	8
	S	5	5	5	8	7	4	4	3	4	8	3	5	5
	SW	3	3	3	5	4	3	3	2	3	4	2	2	3
	W	23	17	17	18	20	21	28	40	23	18	23	17	22
	NW	26	29	26	22	34	54	48	44	47	27	34	23	34
	Calm	10	14	10	10	11	6	7	4	9	18	16	16	11

Table 3B-10 Mean Monthly Wind Speed at Amara City

(Unit: m/sec)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Mean
1975	2.5	2.7	2.9	2.3	2.5	6.1	5.1	5.4	2.6	2.5	2.4	2.9	3.3
1976	3.6	3.9	3.4	3.6	3.8	6.8	9.1	6.6	5.7	4.3	3.4	3.5	4.8
1977	3.8 1/ (14.0)	3.7 (12.5)	5.2 (16.5)	5.0 (29.0)	5.3 (22.5)	7.7 (25.0)	7.6 (25.0)	6.1 (22.5)	5.8 (20.0)	3.6 (12.5)	3.1 (14.0)	3.1 (8.0)	5.0
1978	3.2 (12.0)	3.7 (10.0)	3.7 (21.0)	4.1 (20.0)	5.1 (16.0)	5.7 (22.0)	4.7 (24.0)	6.9 (20.0)	5.2 (33.0)	1.8 (-)	2.2 (8.0)	2.5 (13.0)	4.1
1979	3.0 (16.0)	2.8 (17.5)	3.1 (20.0)	4.2 (21.0)	3.8 (20.0)	6.0 (30.0)	-	-	-	-	-	-	-
Mean	3.2	3.4	3.7	3.8	4.1	6.5	6.6	6.3	4.8	3.1	2.8	3.0	4.3

Note: 1/ Figures in bracket show the maximum instantaneous wind speeds.

FIGURE 3B-1 CLIMATE AT AMARA CITY

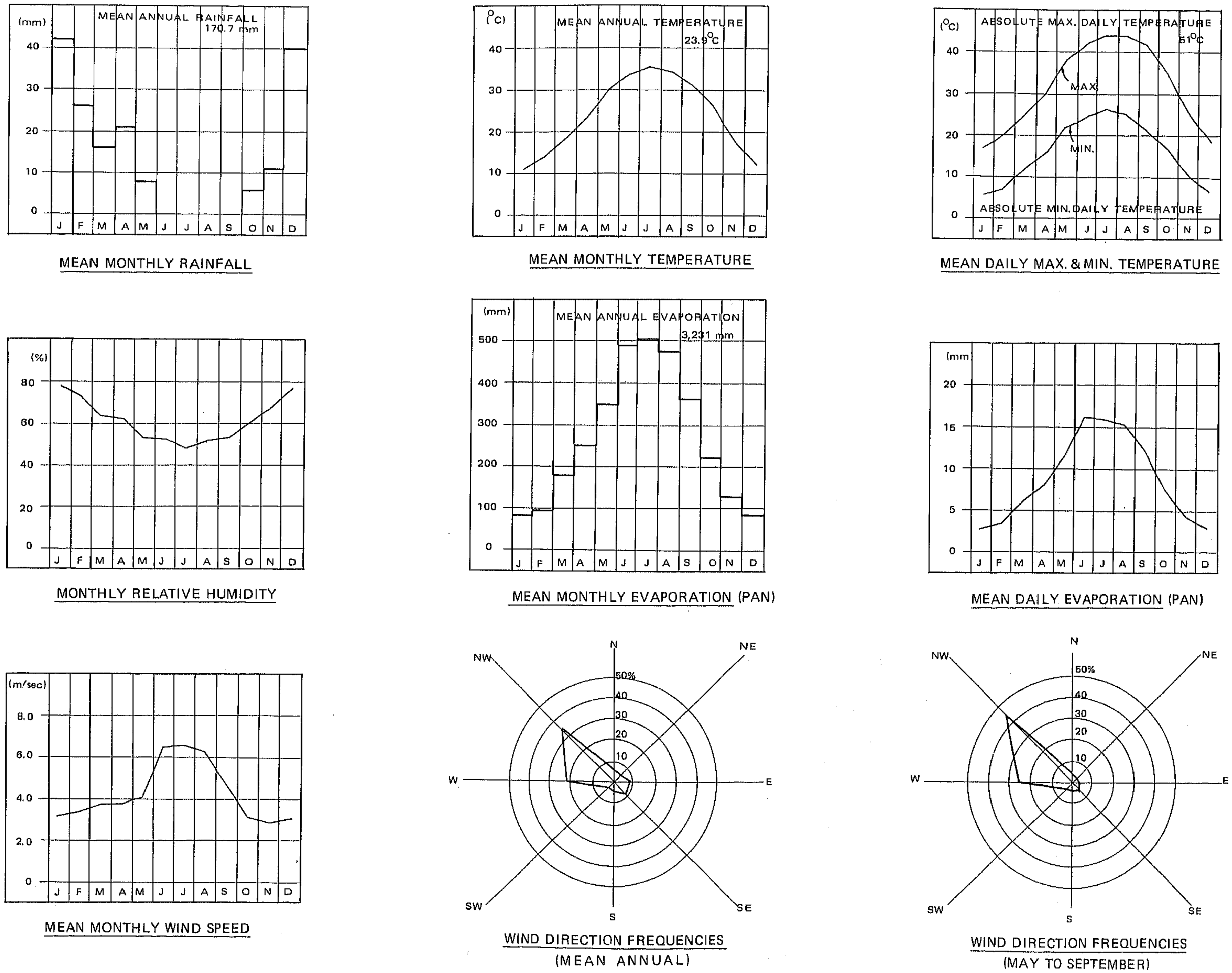


FIGURE 3B-2 LOCATION OF STAFF GAUGES

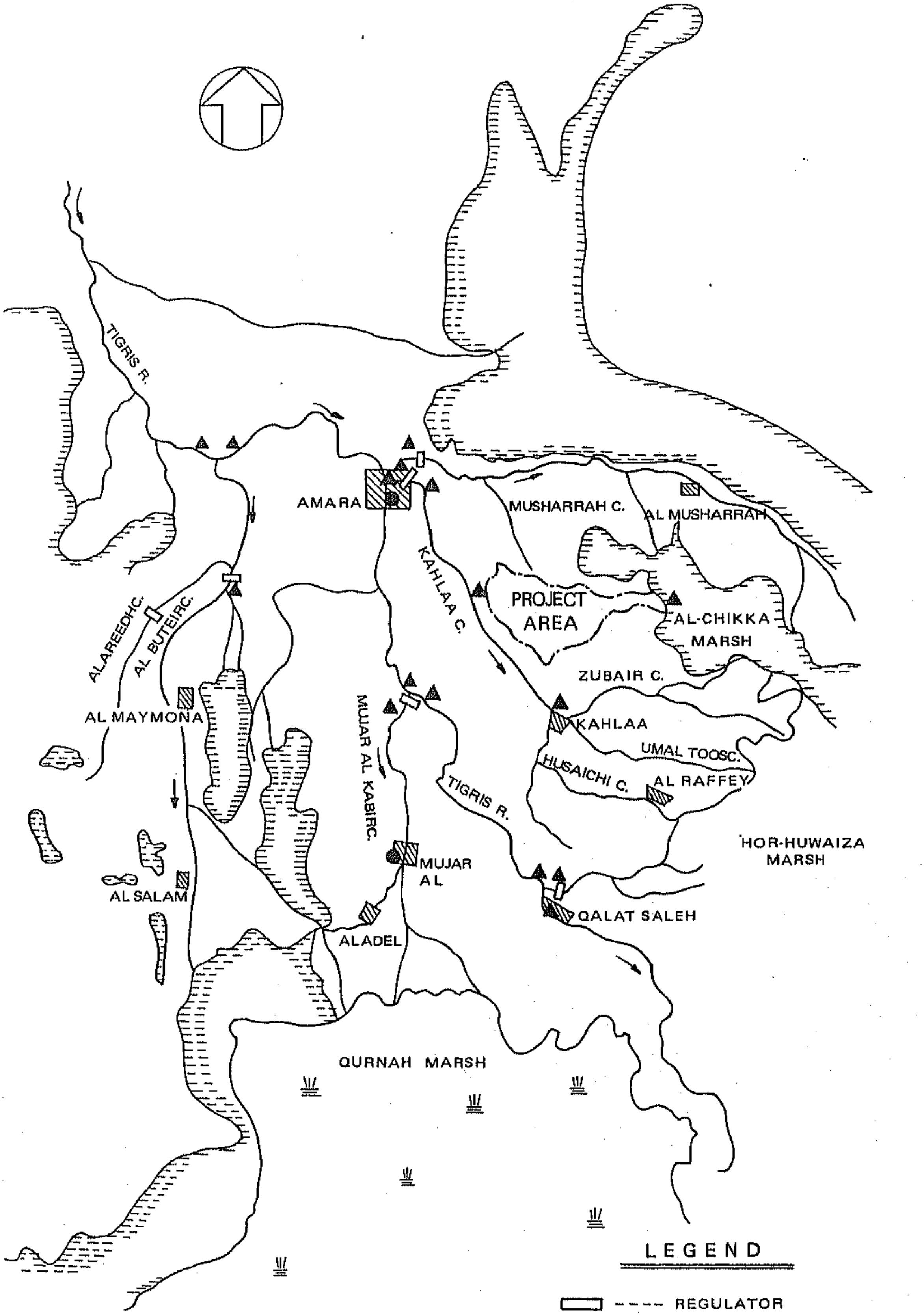
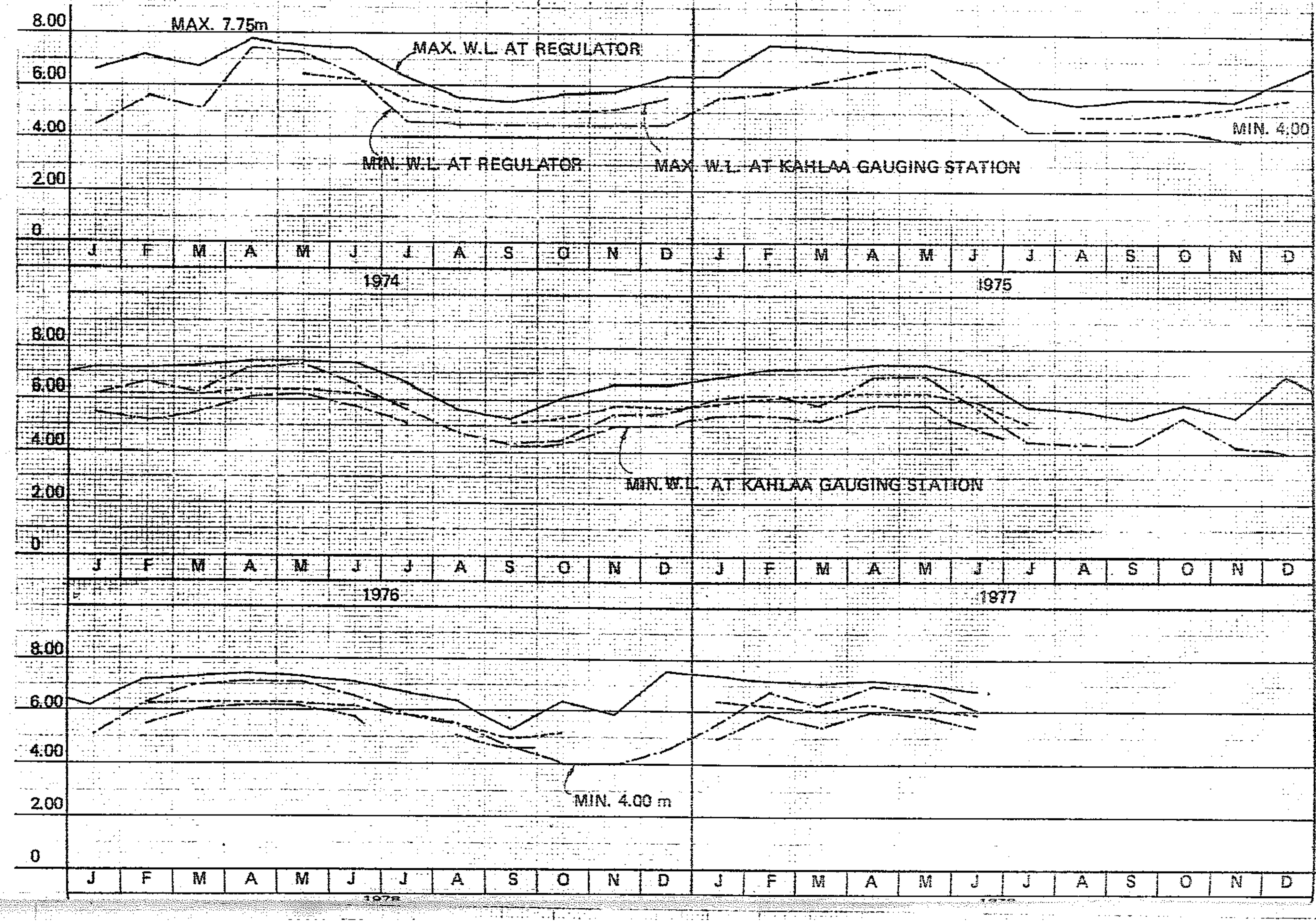


FIGURE 3B-3 MONTHLY FLUCTUATION OF RIVER STAGE



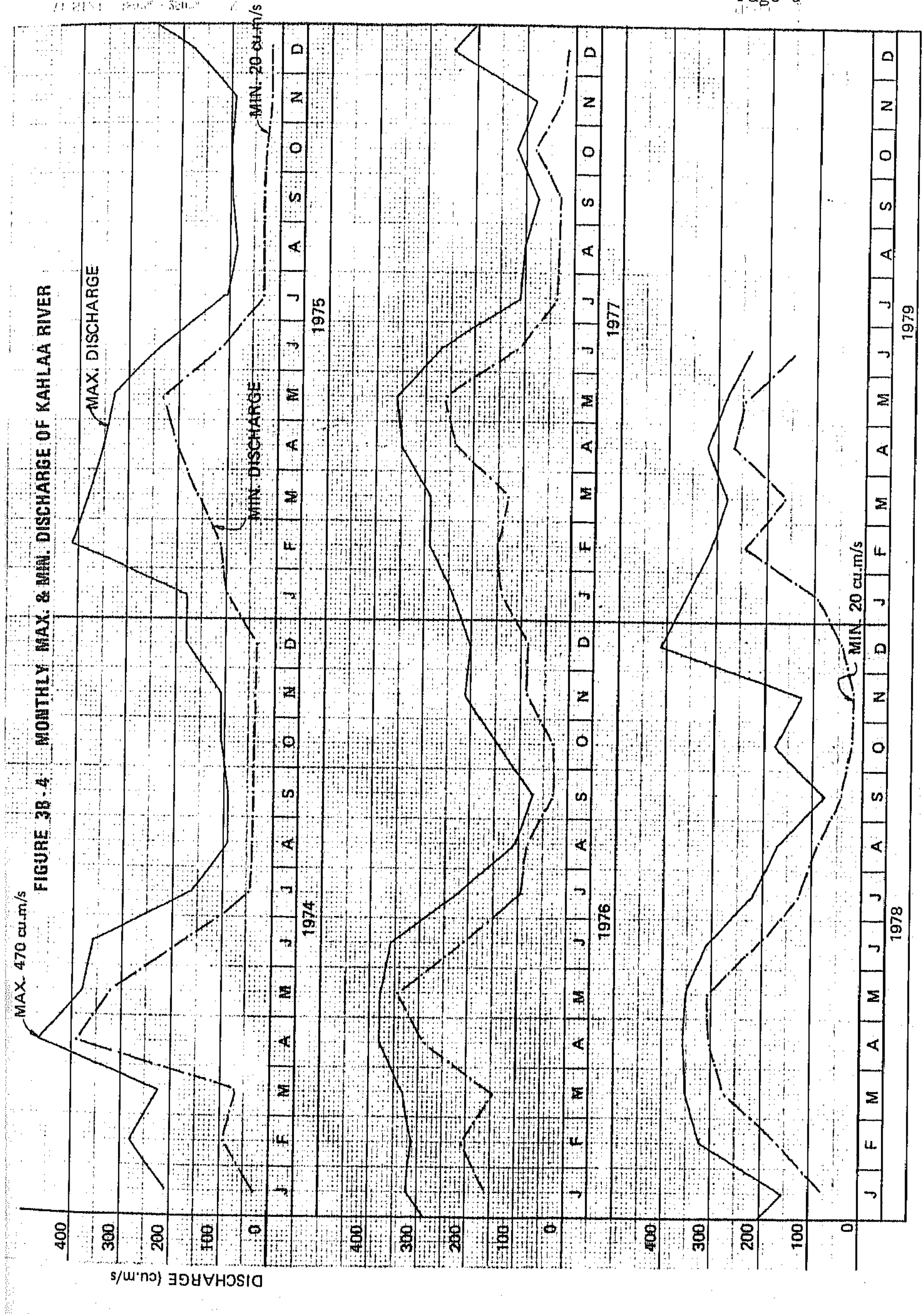


FIGURE 3B-4 MONTHLY MAX. & MIN. DISCHARGE OF KAHLAA RIVER

FIGURE 3B-5 WATER LEVELS CONTROLLED BY KAHLAA REGULATOR
(OBSERVATION: DOWNSTREAM OF THE REGULATOR, 1977)

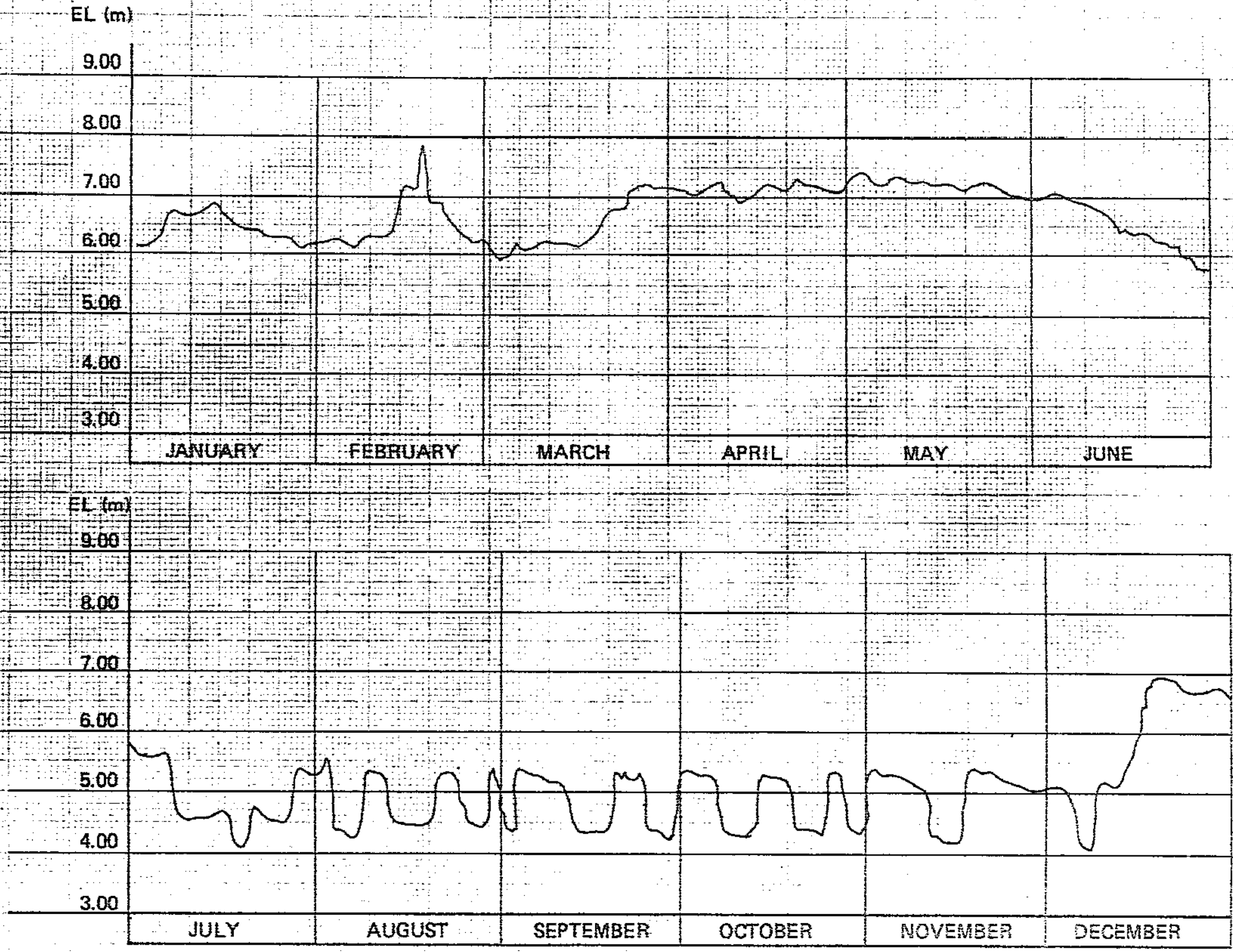


FIGURE 3B-6 WATER TABLE ISOBATH MAP
(ISOBATH IN M BELOW GROUND SURFACE (S=1:50,000)
OBSERVED IN JULY, AUG., 1979)

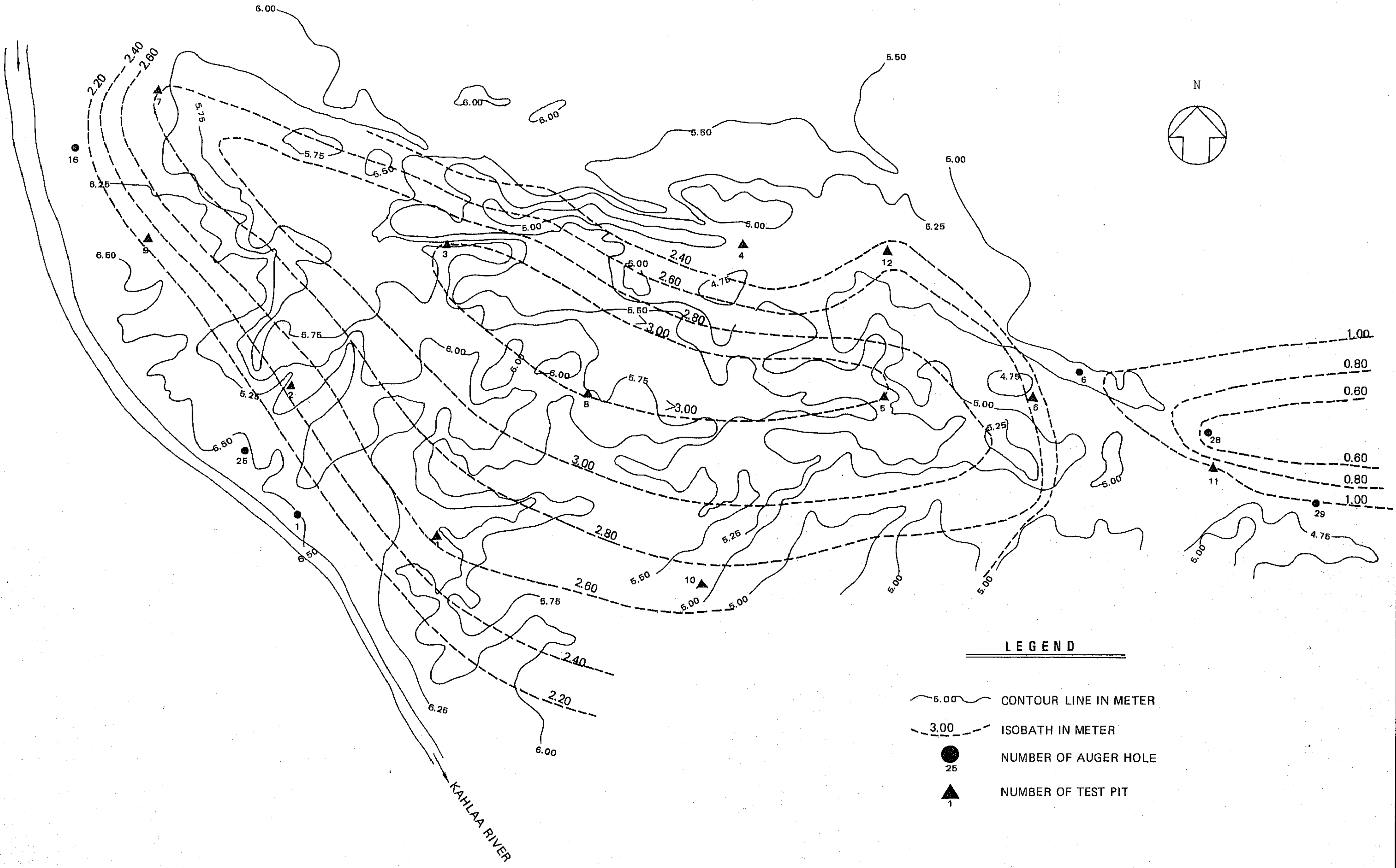


Table 3B-11 Water Quality of Tigris River at Amara City[1]

Year	Item	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1972	SAR[2]	-	1.33	-	-	-	-	-	2.86	-	-	1.60	-
	EC (Micromho/cm)[3]	-	950	-	-	-	-	-	1,350	-	-	850	-
	Salt Content (ppm)[4]	-	608	-	-	-	-	-	864	-	-	544	-
1973	SAR	1.4	1.48	0.95	1.46	0.80	-	-	-	2.15	2.08	2.0	-
	EC	910	850	570	700	470	-	-	-	1,010	1,000	1,100	-
	Salt Content	582	544	365	448	301	-	-	-	646	640	704	-
1974	SAR	1.38	1.20	1.27	0.94	-	1.12	1.18	1.81	2.22	2.37	1.54	-
	EC	780	730	1,020	600	-	590	950	1,360	1,240	950	947	-
	Salt Content	499	467	653	384	-	378	608	870	794	608	478	-
1975	SAR	-	1.50	-	0.67	-	0.91	1.52	2.16	2.56	2.08	-	2.28
	EC	-	815	-	430	-	510	720	1,100	1,140	1,075	-	1,405
	Salt Content	-	522	-	275	-	326	461	704	730	688	-	899
1976	SAR	1.59	1.06	1.22	0.87	-	0.60	1.13	1.89	1.91	1.82	1.31	1.67
	EC	738	695	659	515	-	396	540	763	832	817	677	866
	Salt Content	472	445	422	330	-	253	346	488	532	523	433	554
1977	SAT	1.77	1.71	1.47	0.98	0.90	0.57	1.61	-	-	2.28	2.84	3.02
	EC	620	760	675	485	590	565	1,000	-	-	1,350	1,150	1,500
	Salt Content	397	487	432	311	378	362	640	-	-	864	736	960
1978	SAR	1.12	0.80	1.23	0.57	0.75	0.98	1.86	-	-	-	-	-
	EC	715	580	605	465	355	625	540	-	-	-	-	-
	Salt Content	458	371	381	298	227	400	346	-	-	-	-	-
	Mean EC	753	769	706	533	472	537	750	1,143	1,056	1,038	945	1,257

Note: 1/ Observations were made by Amara Irrigation Office.
3/ EC stands for electrical conductivity.
2/ SAR stands for sodium absorption rate.
4/ A raito of salt content to EC is 0.64.

FIGURE 3B-7 (A) RELATION BETWEEN EC OF RIVER WATER AND RIVER DISCHARGE

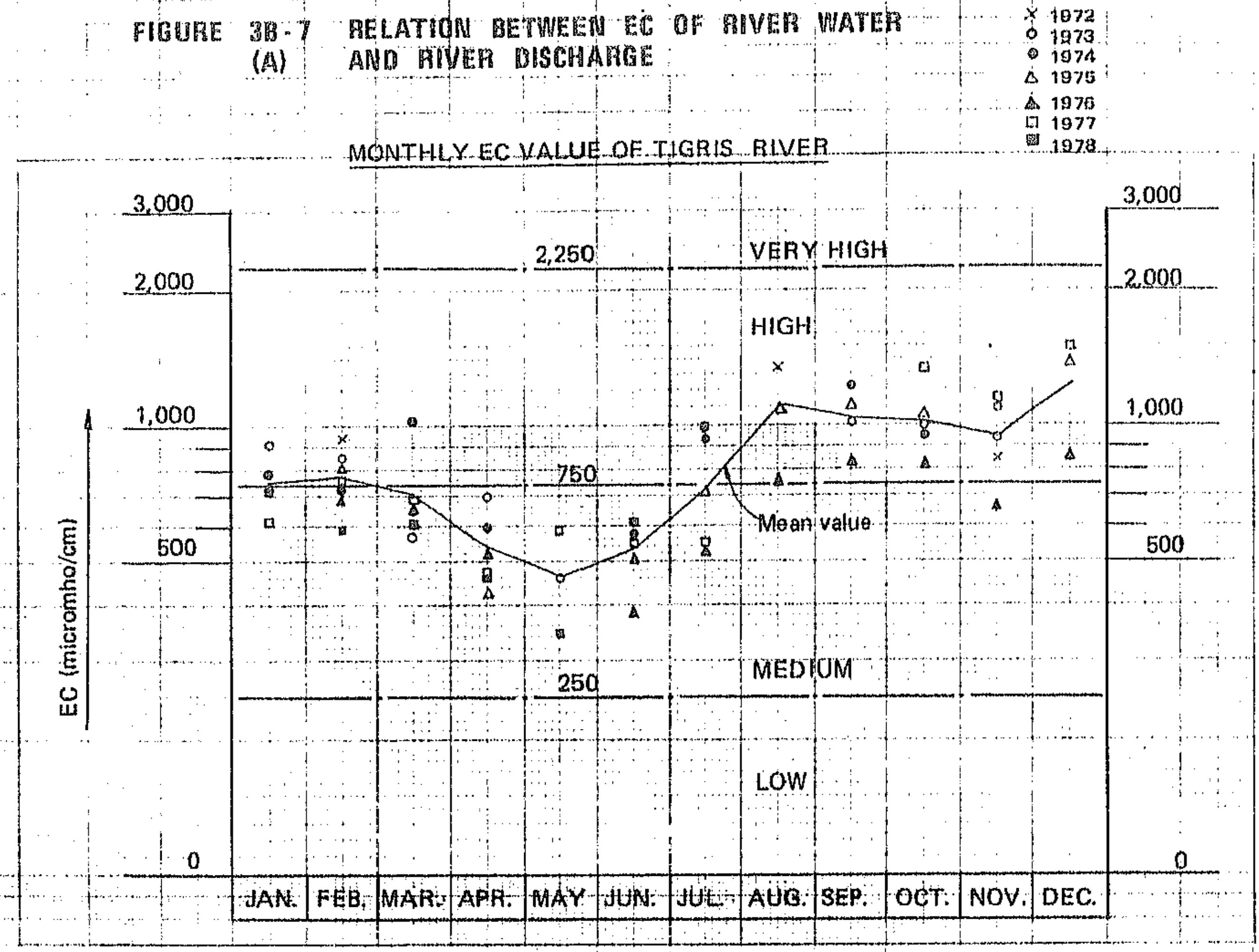
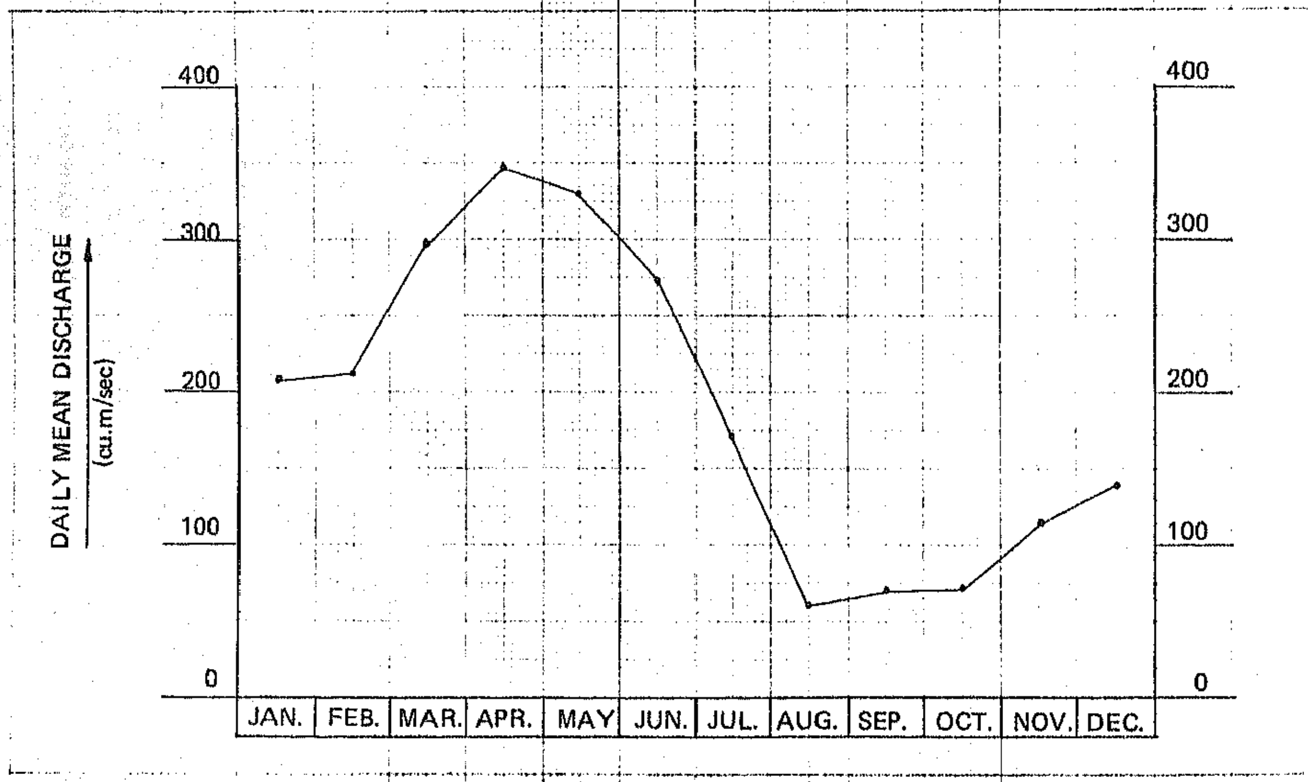


FIGURE 3B-7 (B) DAILY MEAN DISCHARGE OF KAHLAA RIVER



NOTE: THE ABOVE OBSERVATIONS WERE MADE AT THE AMARA IRRIGATION OFFICE

FIGURE 3B-8 CLASSIFICATION OF IRRIGATION WATER

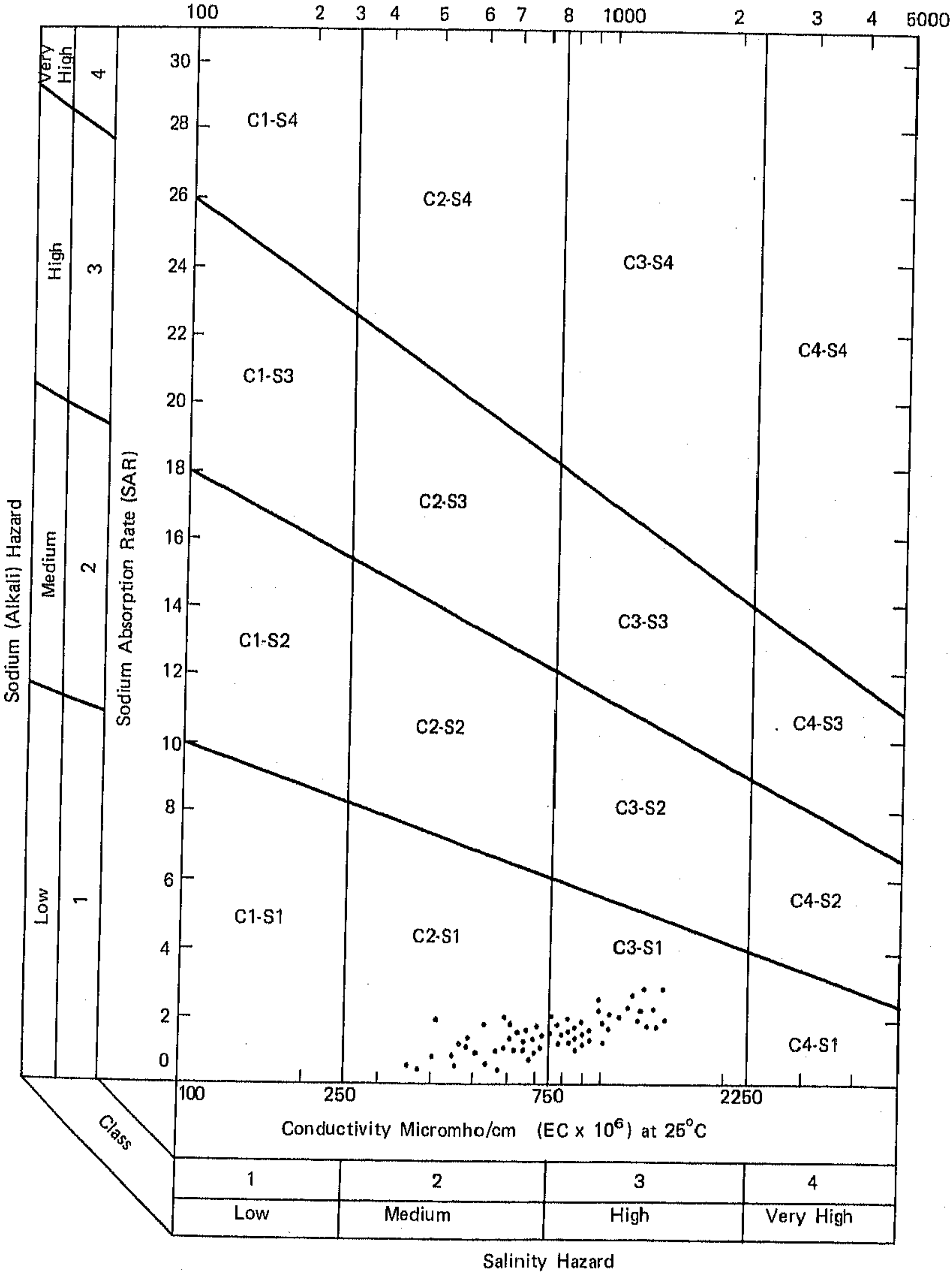


FIGURE 3B-9 LOCATION MAP OF WATER SAMPLING FOR EC MEASUREMENTS AND BEARING CAPACITY TEST

(S = 1 : 50,000)

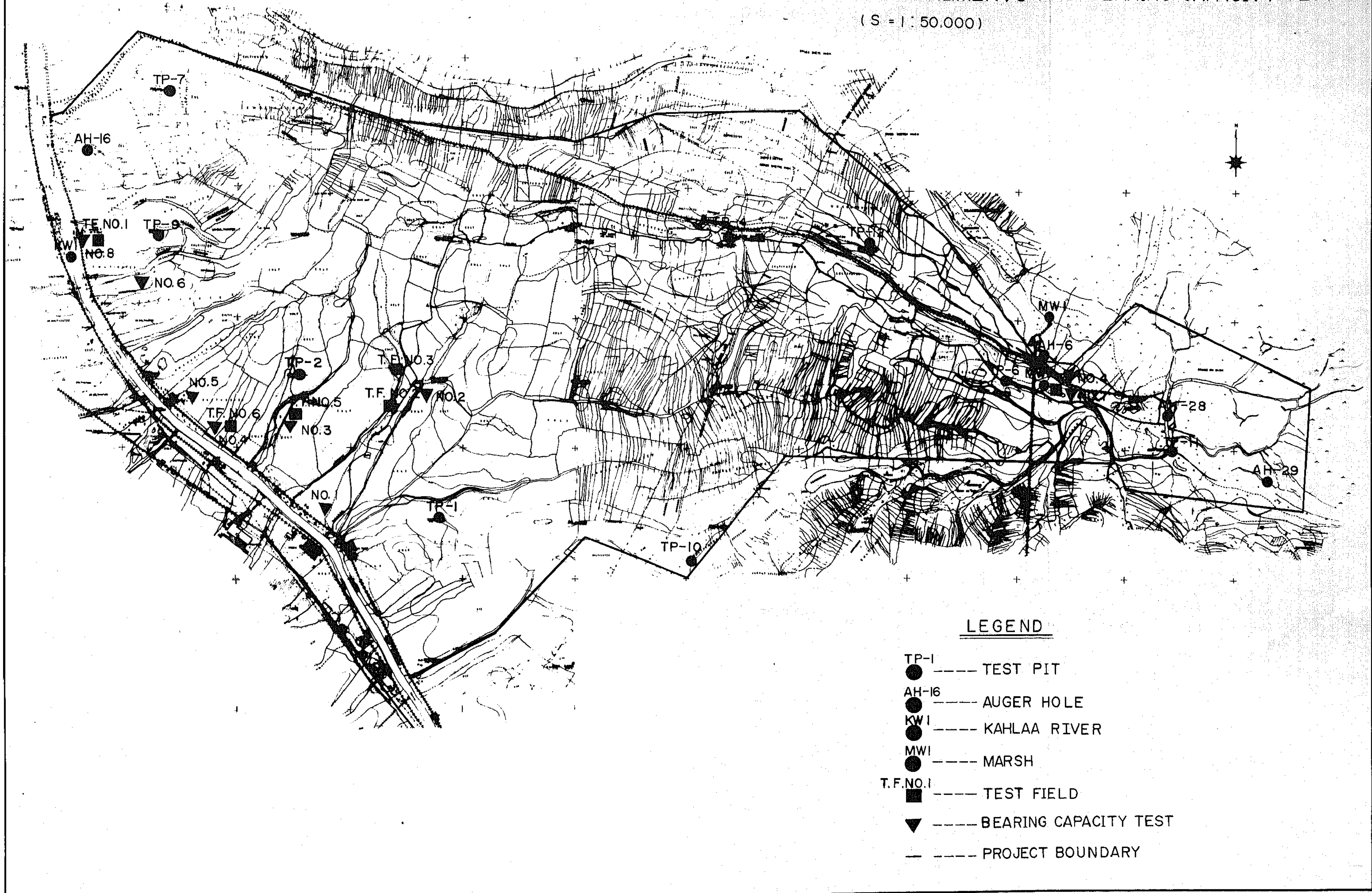


FIGURE 3B-10 AMARA IRRIGATION PROJECT MAP

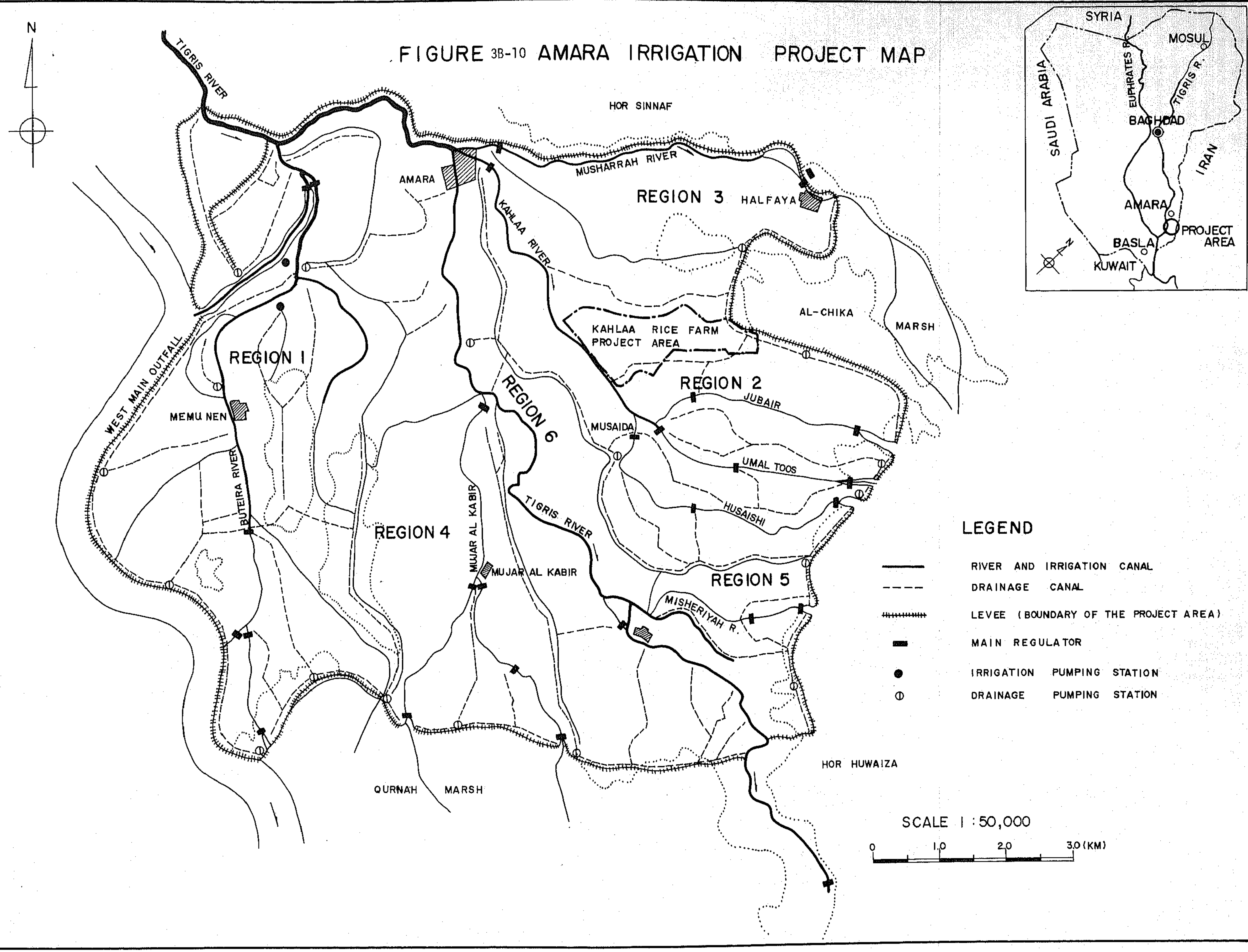


Table 3B-12 Salinity (EC) of Water within the Project Area (1)

Item	Measured Date	EC 1/ (mmho/cm)	Water Temperature (°C)	Location 2/
1. Kahlaa River Water	1978 Dec. 28	0.67	-	KW1
	1979 Feb. 5	0.61	13	-do-
	Jul. 5	0.82	25	-do-
2. Irrigation Water in the Field	1979 Jan. 13	0.93	14	Test Field No.1
	14	0.93	15	-do-
	30	1.34	17	Test Field No.2
	31	1.10	20	Test Field No.3
	Feb. 1	1.98	23	-do-
	2	1.00	20	-do-
	Jul. 5	0.79	32	Near Kahlaa River
	5	0.96	32	Near Marsh
	9	0.99	35	Test Field No.4
	19	1.05	30	Test Field No.5
	22	0.94	28	Test Field No.6
3. Marsh Water	1978 Dec. 28	2.78	-	MW1
	1979 Jan. 24	3.16	-	-do-
	Feb. 5	1.34	12	-do-
	Jul. 28	2.08	28	MW2

Note: 1/ Figures are those at 25°C

2/ Refer to Fig. "Location Map of Water Sampling for EC Measurements."

Table 3B-13 Salinity (EC) of Water within the Project Area (2)

Item	Measured Date	EC 1/ (mmho/cm)	Water Temperature (°C)	Location 2/	Water Table below Ground Surface (m)
4. Ground Water	1978 Nov. 7	11.70	-	TP-1'	1.4
	Dec. 13	14.03	17	-do-	1.5
	Dec. 13	5.54	16	TP-3'	2.8
	Dec. 13	9.23	24	AG No.4'	1.6
	Dec. 13	8.08	21	AG No.5'	1.0
	Dec. 28	13.88	-	TP-1'	1.4
	1979 Jan. 15	8.73	-	TP-1'	0.6
	Jan. 24	6.30	-	TP-3'	2.2
	Feb. 5	9.41	13	TP-1'	-
	Feb. 5	5.43	12	TP-3'	-
	Jul. 3	28.50	-	TP-1	2.7
	4	33.80	-	TP-2	2.5
	10	16.50	-	AH-6	0.95
	21	10.80	-	TP-4	1.65
	26	21.80	-	TP-6	2.80
	31	11.40	-	TP-7	2.80
	Aug. 1	7.30	-	AH-16	0.70
	6	26.50	-	TP-9	2.28
	11	7.40	-	TP-10	2.75
	13	6.20	-	TP-11	1.29
	13	27.60	-	AH-28	0.48
	14	9.90	-	AH-29	1.05
	18	20.00	-	TP-12	2.75

Note: 1/ Figures are those at 25°C.

2/ Refer to Fig. "Location Map of Water Sampling for EC Measurements."

Table 3B-14 Ionic Composition of Water within the Project Area

Item		Kahlaa River(1)	Ground Water[2/]	Marsh Water(1)	Marsh Water(2)
Sampled Data		Dec.28,1978	-do-	-do-	Jul.28,1979
PH		7.9	8.1	8.1	8.2
Calcium	(Ca)[1/]	4.8	24.0	10.0	2.4
Magnesium	(Mg)[1/]	2.0	72.0	10.4	7.2
Sodium	(Na)[1/]	2.9	92.0	14.8	13.5
Potassium	(K)[1/]	0.07	0.89	0.15	-
Choloride	(Cℓ)[1/]	2.2	59.0	15.0	13.8
Sulphate	(SO_4)[1/]	4.8	114.0	16.0	7.2
Bicarbonate	(HCO_3)[1/]	2.6	5.6	4.8	1.6
Carbonate	(CO_3)[1/]	0	0	0	0.8

Note: 1/ Unit: me/ℓ
2/ Test Pit No.1'

Table 3B-15 Comparison of River and Sea Water Composition

Item	Tigris[1/]	Mujar Al Kabir[2/]	Shatt Al Arab[1/]	Sea Water[1/]
Location[3/]	Baghdad	Amara	Basra	
Ca	1.6	2.7	4.0	220.0
Mg	2.4	1.6	3.4	122.0
Na	2.8	2.7	3.7	524.0
Cℓ	0.9	1.5	3.6	588.0
SO_4	5.6	1.8	3.6	64.0
HCO_3	0.8	-	2.6	2.4
CO_3	0.3	-	1.0	1.0

Note: 1/ Data Source: Salinity Seminar, Baghdad, FAO, 1971
2/ -do- : Mujar Al Kabir Water Quality
3/ Unit: me/ℓ

3B-3. Silt Content of River Water

Generally, the silt content varies widely and seasonally in compliance with the river discharge, i.e., during the low river stages in summer season the content becomes low, on contrary, during the high stages in winter to spring season, increases exponentially.

Regarding the Kahlaa river, no observation on the silt content has been made. However, in the Mujar Al-Kabir river which is located at the opposite site of the Project area, the silt content was measured.

The results show that the river silt load ranges 2.3 g/lit during December to 0.01 g/lit during July and 75% of the water samples presents more than 1.0 grams per lit.

On the other hand, according to Dr. P. Buringh's "Soils and Soil Conditions in Iraq" the Tigris river water usually contains silt of 0.17 to 2.3 grams per lit.

Concerning effect on desilting, measurements of the silt content were made for water into and out of the reservoir provided at the Amara Sugar Cane Factory.

The figures in the following table reveal that at the time of high silt content, the reservoir are efficiently functioning as a desilting basin.

Table 3B-16 Effect of Desilting Reservoir

Sampling Date	Silt Content (g/lit) Into Reservoir	Out of Reservoir	Silt Content (%) Dropped in Reservoir
1968 Sep. 25	0.092	0.078	15
Oct. 10	0.096	0.056	41
Oct. 30	0.070	0.070	0
Nov. 12	0.148	0.074	50
Nov. 25	0.378	0.059	85
Dec. 10	2.810	0.150	94
Dec. 25	1.810	0.074	96
1969 May 4	1.143	0.124	89

Source: Amara Sugarcane Factory.

3B-4. Soil and Land Classification

1. Introduction

The study has been carried out with special attention paid to the problems of soil salinity. Natural drainage conditions, groundwater conditions, present land use and soil suitability for agricultural development of the Project area are throughly analyzed.

The soil survey has been carried out;

i) To review the reports on the soil survey which have been previously conducted in the Project Area;

ii) To re-examine the present soil conditions, especially soil salinity; and,

iii) To collect the data for preparing and compiling the soil maps necessary for the feasibility study.

As to the field survey, topographic maps with the scale of 1:10,000 prepared by the D.G. of Survey were used as the base map. The aerial photographs with the scale of 1:35,000 taken in 1962 by Topo-Survey Department were referred as well.

During the field survey in 1979, totally 12 points of test pit and 32 points of auger hole were investigated, in addition to 3 test pits and 10 auger holes made in 1978. The soil samples taken from different layers as well as groundwater samples were delivered to the "Soil and Water Testing Laboratories, SOSLR, Abu-Ghraib" for physical and chemical analyses.

The location of test pits and auger holes are shown in Fig. 3B-11.

2. Geology and Topography

The genesis of the Amarah region is directly associated with the development of the Amarah delta, and therefore with the accumulation of the suspended material carried by river water into the shallow lakes. The general base level for the region is the Hammer Lake which collects waters flowing down from the shallow marshes bordering the delta plain on the South.

The whole region has a pattern of a nearly level delta plain sloping gradually from north-west to south-east. Its highest lands lie near the river levees of which altitudes range from 6.5 to 7.0 m. The lowest area is located in the southeast and permanently or seasonally submerged under water of which altitudes range from 4.0 to 4.5 m.

The development of the delta is reported to date back to the sixteenth century. It has been closely associated with the formation of the eastern branch of the Tigris. The abundant Tigris waters met in the region and formed an extensive shallow lake. On having entered the lake, the velocity of the water flow reduced and the carrying capacity delined resulting an accumulation of the waterborn solids at the estuary. In this way the process of forming of an inland delta started with its numerous arms.

The river waters carrying the suspended solids on entering the shallow lakes, deposit the coarser material on both sides of the stream. This process results in the formation of under water levees advancing into the lake. They are usually build up of very fine sand and silt.

In the first stage the levees are low, unstable and easily cut by the river's current. Hampering the natural flow, they cause the river to branch off numerous channels. Alongside each of the new water ducts, new layers of sand and silt are deposited forming further dykes. The development of these new levees is facilitated by water vegetation, reeds and sedges. They check the velocity of current on the flanks of the stream, thus decreasing the carrying capacity of the water.

Bottom stretches of land left among separate underwater levees become in time sedimentation hollows. At first they are submerged under water but as the delta develops they are cut off by the rising levees from the lake and become delta depressions. The Hor Al-Chikke is considered as delta depressions. Both the delta depressions and the extensive Hor surrounding the Amarah plain are covered with a dense net of narrow levees consisting of coarse deposits build up on the clayey bottoms of the lakes.

The Tigris enters the region from the north-west as a wide river and it splits up into 5 major canals, that is, Buteira, Musharrach, Kahlaa, Mujar El-Kabeer and Micheriyah. Each of the canals branches off a number of lesser irrigation ducts either natural or artificial. All these canals distribute the waters of the Tigris into the irrigated lands, and the excess water being absorbed by the shallow depressions. Simple irrigation systems of the early historic times used probably the natural water ducts provided by flood streams. Later on, separate canals were dug through the river levees at most suitable places. Part of water was used for irrigation and the excess was absorbed by the Hor. Alongside and in the close vicinity of the irrigation canals, the coarse particles were deposited near the water duct while fine material was carried away into the basin. This process resulted in the formation of further elevations called the irrigation levees. With time the bottoms of the irrigation canals have been silting up and in order to preserve the irrigation system, the canals had to be dragged and cleaned up regularly. The excavated alluvial have been accumulating along both sides of the canal.

The vast uniform river basins became covered with numerous irrigation levees consisting of excavated and sedimented alluvial, resulting in the formation of smaller basins called irrigation basins. The irrigation basins consist of younger irrigation sediments having a texture of silty loam, silty clay loam or silty clay. Within the irrigation basins, a number of seasonally inundated outflowless hollows are found which are called irrigation depressions.

As the delta front advances into the lake its main arms become rivers, flowing in the flat plain and eroding the shores on both sides of their streams. Owing to the seasonal sedimentation at the bottom of the river, the river bed is being constantly raised and water flows over the levees discharging onto the plain during the seasonal high flow. Flowing over the levees, water loses its speed and consequently its carrying capacity. The reduction of flow speed causes a grading out of the water-born sediments. The coarser materials carried by the flood waters are deposited near the river bed, forming new relatively high river levees. Finer sediments are deposited behind the levees with a gentle slope towards the depression. The finest particles are carried by the flood water farther down and spread over the depression.

After a period of time, the landscape of the area becomes that of river levees, vast lakes, basins and numerous depressions of various sizes. This natural landscape has been considerably changed and transformed by irrigation works on the areas of the basins as well as by the natural processes such as changes of the river beds and irregular flood discharge.

The next factor in determining soil conditions in the area constitute the uncontrolled floods. These uncontrolled floods delta is generally formed in the upper sections, but also in the meandering lower sections of the rivers.

The flood waters overflowing the levees annually during high flows at a certain section of the river have created a number of gullies or seasonal ducts which perform definite functions, that is, carrying, absorbing, collecting and discharging the bulk of flood waters.

An important factor influencing soil conditions in the area is the shifting of river beds. The river beds in the area are not deep, but they are rather broad. As aging of the river, levees are formed on both sides of the current and the river beds are gradually raised above the level of the basin. In certain circumstances the waters of a meandering river break the levees and form a new river bed situated at lower level than the old one. In a period of time new levees are created and developed resulting in a rise of the new bed above the surrounding plain. The old, abandoned river bed and the old levees made up of coarse materials are eroded by rain or by winds and then covered with new fine sediments carried by high flow water during the floods. So it is often possible to find in the river basins, fine sediments at the upper layers of the soil profile overlaying the coarse material of the old river beds.

3. Characteristics of Soils

All soils in the area fall in a category of the inland delta deposits having common soil characteristics as a whole, while the size of soil particles varies place to place due to the different sediment accumulation conditions. Besides rivers have taken various courses in the process of the delta formation. Under these circumstances, soil profiles show a plenty of variations longitudinally and latitudinally. Furthermore, the micro-topographical and sedimentological confusings caused by artificial irrigation have made the soil profiles complicate.

The main features of soils prevailing in the area could be characterized as follows:

a) All soils show well marked layers in the profile. Within one profile, the various layers differ by their texture, colour, structure, by the content of gypsum, soluble salts etc.

b) The separate layers usually differ considerably from each other and they seldom demonstrate horizontal continuity. Generally they have a form of prolonged lenses arranged at different angles.

c) The soils show an enormous horizontal difference, the kind of soil and soil conditions being determined by the geomorphological form of the alluvia.

d) The soils are affected by the groundwater level. A large portion of soils particularly near the marsh area belong to the hydromorphic group.

e) Rich micro-relief of the ground and intricate arrangement of permeable and impermeable layers create complicated water conditions.

f) The flatness of the area and small slope gradients result in poor conditions for natural drainage.

g) All layers contain considerable quantities of non-active lime, amounting around 20-35%.

h) Most soils contain moderate amount of gypsum, namely 0.1-2.0%, but in exceptional cases its contents reaches more than 10%.

i) Young irrigation deposits cover the previous bottoms of the marshes which contain humus distributed in a 10 to 20 cm thick layer.

j) There is a continuous accumulation of salts.

k) Genetic types of salinity found in the area are mainly internal solonchak and external solonchak and also some flooded solonchak, and sabakh soils.

l) The young alluvial deposits undergo the gradual natural soil forming process, but this process is hampered by sedimentation of new deposits over the older formations.

Almost all soils of the area in question are saline, and some of them to the extreme with salt crusts on the surface. In some others a marked accumulation of salt occurs only in the deeper layers. Generally highest soil salinity is to be found in the central portion of the area and it diminishes approaching the marsh areas.

Soil map of the Project area is shown in Fig. 3B-12. This map was made basing on the semi-detailed soil map of the Amara Irrigation Project after our checking in the field investigation.. And each area of soil distribution is summarized in Table 3B-17.

Soils in the area have been divided into the following groups based on the difference in sediment accumulation conditions;

1) River Levee Soils,
2) Silted Basin Soils,
3) Silted River and Irrigation Depression soils, and
4) Silted Hor Soils.

1) River Levee Soils

River levee soils occur in a narrow strip land in the western and of the investigated area along the Kahlaa river. They are about one meter higher than the usual water level in the river. New dikes have been recently constructed along the river, so the natural conditions of the levee could be hardly observed.

These soils consist of silty and/or loamy sediments, the upper layers having texture of silty clay loam which have been developed by sedimentation during irrigation practices. The deeper subsoil layers are lighter. The salinity is low in most of these soils, although limited stretches of flooded solonchak occur in some places. Internal solonchak dominates as the genetic type of salinity.

These soils belong to the best arable soils in the area. They are densely covered with date palm with orchards of such fig and pomegranate trees as well as with vegetable gardens of cucumbers, beans and lady-fingers. They are irrigated by pumping systems.

(1) ADLA series (mapping unit L11)

Soils belonging to this series consist of light grayish brown to brownish gray, silt loam, silty clay loam, sometimes with thin layers of silty clay. In soil profile, layers of light texture dominate. Usually the light textured layers, silty loam, silt or sometimes also very fine sandy loam do not differ very much from each other. These light textured soil layers are very characteristic for this series.

Soils of this series have a fine to medium angular blocky in heavier layers and crumb or granular structure in the lighter ones. All soils contain a high level of lime. They are moderately alkaline. Due to the considerable content of lime as well as to the presence of gypsum, these soils never show a tendency to alkalization. These soils have a low quantity of organic matter.

Owing to their location, considerable sloping and their medium light texture, most of these soils have well drainage conditions. The groundwater table ranges from 1.0 to 3.0 m, depending on the fluctuations of water level in the river. Generally the groundwater is moderately saline. The permeability is rather large. This is due to considerable stratification of soil profiles, to presence of layers of these soils.

Ll1: Adla series, medium light textured, moderately well drained phase.

These soils occur on river levees with low groundwater table. They are usually situated in the highest levees considerably elevated above the basins and rivers. They show rust sports at levels below 1.5m and gley spots below 2m and are the least saline of all soils in the area.

2) Silted Basin Soils

Most parts of the investigated area are occupied by these soils, though some depressions are distributed within this area. On the aspect of geomorphologic and pedologic considerations of the area, the high and low silted river basin soils are distinguished. The division was mainly determined on differences in;

a) The relative position of both geomorphological units in relation to river levees and the silted hors,

b) altitudes above sea level,

c) drainage conditions, and

d) land surface relief.

High silted basin soils are situated in the western part of the investigated area, between the river levees and the depressions or the low silted basins. They show a distinct slope from the levees towards the lower areas, with altitudes ranging from 4 to 6m above sea level. The drainage conditions are moderately good, moderate to imperfect. Owing to irrigation practices since long ago, the area has been covered by a dense network of canals, with marked irrigation levees. Within these silted basins a considerable number of outflowless irrigation depressions can be found. The adopted system of irrigation is predominantly to lift irrigation by pumps.

Low silted basins occur in eastern part of the area and are located between the high silted basins and the vast hors with altitudes ranging from 3 to 4.5m above sea level. The drainage conditions are usually moderate to poor. The surface is flat, often covered with a considerable number of irrigation canals with comparatively high dykes (1-1.5m). The depressions found within these basins are usually the partly unsilted bottoms of the ancient hors.

The high silted basin soils consist mainly of silty clay, silty clay loam or sometimes silt loam of the surface layer. Generally the deeper is the layer of heavier in its texture. Depending on their location these soils are moderately well to imperfectly drained and the groundwater table is observed at 1.0 to 3.0m.

(1) AL-GHERIBA series; B2(2)

Soils of this series are situated near the main irrigation canals and river levees. These soils were formed during the irrigation practices of long duration as a result of sedimentation of materials carried and deposited by the irrigation water. During irrigation, coarser particles are deposited near the canal bed while the finer sediments are carried further into the field. This process and the intensity of irrigation were more frequent near the canals than in the more distant areas, and which resulted in formation of a thick layer 1.0 - 2.0m of alluvial sediments in the vicinity of canal beds.

These soils have not a character of irrigation levees, as they are flat, vast and only slightly higher than other basin soils.

These soils consist mainly of light brownish gray silt or silt loam, sometimes with thin layers of silty clay loam, loam or very fine sandy loam. All layers, irrespective of texture, contain 20 - 30% of lime. Often spherically shaped gypsum concretions can be found throughout the subsoil profile. The gypsum content in surface layers and upper subsoil averages 0.5 to 1.1% and in the deeper subsoil and substratum 0.7 to 0.8%. Generally well irrigated and well drained soils of this series contain less gypsum than the ill-irrigated and saline ones.

In general the light textured surface layers overlay the silty clay loam or silty clay of the deeper subsoil and substratum originating from the former river basin. The surface and upper subsoil layers usually show a friable consistence and a good crumb or sometimes fine or very fine angular blocky structure. The porosity is good with micro-porosity predominating. The roots can easily penetrate down to 80 - 150cm. Soils of this series have generally a well internal drainage, except for local spots situated in the hollows which are poorly drained. The groundwater is strongly saline and its table level ranges from 1.5 to deeper than 3.0m.

These soils have a moderate content of nutrient elements. But due to intensive irrigation and leaching, these soils show a low content of nitrogen. Internal solonchak is the dominating type of salinity. The salt content of the upper layers is low, while the substratum and subsoil are highly saline.

These soils are used for cropping barley and sometimes wheat in the fallow system. These soils are subject to seasonal humidification and desiccation resulting in deep cracks up to 1.0 - 1.5m, even if the texture is not so heavy.

B2(2); Al-Gheriba series, medium light textured, moderately well to imperfectly drained phase, overlying a heavy textured deeper subsoil.

These soils consist of 0.5 to 1.0m thick irrigation sediments of light brown, light brownish gray to grayish brown silty loam with thin layers of silty clay loam, overlying silty clay of the old basin. Owing to their location and the compact deeper subsoil and substratum, these soils show poor drainage. The groundwater table ranges from 1.5 to 2.5m. Rust spots appear in the profile from below 50cm and gley spots below 1.0m.

By intense irrigation and lack of proper drainage, these soils would get quickly salinized. The time needed for their salinization depends on the depth of the compact substratum. A shallow substratum will enhance the salinization.

(2) AMARAH series; B32, B3(1), B33, B3(2)

Soils of this series are encountered in the old silted river basin. They occupy larger areas than other soil series in the investigated area. They spread over a flat plain, slightly undulated with gentle slopes. The plain is covered with a dense network of irrigation canals, along which sometimes narrow and highly saline levees have been formed. The surfaces of these soils in dry season show large shrinkage cracks forming regular polygon patterns with diagonals about 50cm. These polygons are in turn divided into lesser ones with diagonals about 5cm. These cracks are 50 - 100cm deep.

Soils of this series consist of young irrigation sediments and their uniformity has not been greatly affected by soil forming processes. Their surface layer and subsoil are light brownish gray to dark grayish brown and consist of silty clay, silty clay loam or silty loam. The structure varies from medium to coarse subangular blocky and is hard to distinguish from the pale brown to dark grayish brown substratum consisting of silty clay loam or silty clay. The subsoil structure is angular blocky, prismatic or sometimes compact. Thin layers of lighter material, that is, silty loam or very fine sandy loam are often found among layers mentioned above.

Throughout the profile of these soils, there are often found deep cracks filled up with material fallen down from surface layers. Due to the cracks, these soils have a moderate internal drainage in spite of their heavy texture. They are moderately porous with a dominating macro-pores. The vertical permeability amounts from 10^{-4} to 10^{-2} cm/sec. The groundwater table is observed at depth of 0.5 - 3m, depending on season, location as well as the conditions of internal drainage. The groundwater is stroughly or very strongly saline.

All soils of this series have a high lime content rating 25 - 30%. These soils have been cultivated for many years resulting in partial leaching. Gypsum has been usually leached down to the depth of 60cm. The gypsum content ranges from 0.2 - 0.4% in the upper layers, and it increases to 0.8% in the subsoil and 1.5% in the substratum. These soils are moderately or strongly saline. Internal solonchak dominates, but sabakh soils are also encountered.

B32; Amarah series, moderately heavy textured, moderately well to imperfectly drained phase

These soils consist of uniform, weakly stratified irrigation sediments, that is, light brown to grayish brown silty clay loam with medium to fine angular blocky structure overlying a grayish brown to brown silty clay substratum of the primary old river basin. This subsoil contains black humus spots and numerous spherical concretions of gypsum. In the whole profile of these soils, vertical cracks, root channels and thin horizontal layers of light textured material have been found.

The groundwater is strongly saline. Its table is generally observed at 2m, but it fluctuates within the range of 1.0 to deeper than 3.0m. During irrigation and in season of high water level in the river, the groundwater table rises to 0.5 - 1.0m and then gradually descends during the summer months until it finally falls below 3.0m. Mottlings appear at depth below 1.0m and the gley spots below 1.5m. The permeability of the subsoil is moderate and of the substratum is slow.

The content of salt in these soils varies from low to high. Internal solonchaks dominate on irrigated arable lands and on pasture grounds, in many cases, however, external solonchaks and sabakh soils are encountered due to the secondary salinization and lack of adequate drainage.

B3(1): Amarah series, moderately heavy textured, moderately well drained phase, overlying medium light textured deeper subsoil

These soils similarly to B32, consist of light brownish gray or grayish brown silty clay loam having a structure medium to coarse angular blocky overlying at a depth of 80 to 100cm, a lighter material of the deeper subsoil and substratum consisting of silt loam, sometimes stratified with very fine sandy layers. The groundwater is strongly saline. Its table ranges from 1.5 to deeper than 3.0m.

Contrary to the upper subsoil, the deeper subsoil and substratum show a rapid permeability, hence better drainage conditions than those of B32 soils. Mottlings occur at depths below one meter and gley spots at levels below 2.5m. These soils are usually less affected by salt than soils of the B32 phase.

B33: Amarah series, heavy textured, imperfectly drained phase

These soils are mainly located in lower parts of B32 and B3(1) phases. The subsoil is rather uniform, weakly stratified and consists of light brownish gray to brown silty clay or silty clay loam. Its structure is coarse angular blocky, sometimes medium prismatic or subangular blocky, Occasionally thin layers of very fine sand appear. It has been generally observed that in lower layers the texture becomes increasingly heavier.

The permeability is moderate to slow. The groundwater is strongly saline. Its table fluctuates from 0.5 to 2.0m. These soils are inundated by water during high water level in the river. During floods, they become wet and sticky. During dry season these soils desiccate, harden and sometimes show cracks up to one meter deep.

Due to slow permeability of the subsoil and substratum and to the slow runoff, these soils are subject to secondary salinization. Sabakh soils dominate in the strongly saline area, while the less saline soils belong to external solonchaks. These soils are used for cultivation of barley and wheat in the fallow system. Occasionally they consitute natural seasonal pasture.

B3(2): Amarah series, heavy textured, moderately well to imperfectly drained phase, overlying a medium light textured deeper subsoil

Similarly to B33 phase, the subsoil down to 80 - 120cm consists of light brownish gray or grayish brown silty clay with medium to coarse angular blocky structure. This layer is deposited on lighter textured, usually well stratified silt loam or very fine sandy loam. The silt loam is light grayish brown and the sandy loam is mainly dark brownish gray. These soils are often strongly affected by salt due to the capillary rise of strongly saline groundwater.

Soils of the low silted basin have a binary soil profile. The upper layers, 1.0 - 2.0m thick, consist mainly of light brown, brown or light grayish brown irrigation sediments of which texture is silty clay loam, or silty clay. They are often stratified with thin layers, 5 - 10cm thick, of loam, silty loam or very fine loamy sand.

These sediments directly overlay the bottom of the silted Hor which consists of dark brown or gray silty clay or silty clay loam with numerous black, blue and green spots. They layers usually contain numerous shells and shell fragments deriving from snails formerly living in the stagnant waters.

(3) AL-KHASIF series: B4(2), B4(3), B43, B4(4)

Soils of the series spread between the high silted basins and the Hor which are covered with marsh vegetation. They are situated 0.5 to 2.0m lower than the high silted basins and about 0.5 to 1.5m higher than the Hor. These areas constitute a vast plain crossed by numerous irrigation canals with their elevated banks. The lowest areas occupied by these soils, situated near the Hor are submerged during several months of the year. The water is provided by natural floods or by irrigation. In both cases, the whole soil profile is saturated with water. Numerous mottling and gley spots as well as black humus and manganese concretions seen in the profile confirm that water played considerable part in soil formation.

These soils consist of pale brown or dark grayish brown silty clay, or silty clay loam. The structure is angular blocky or prismatic, but sometimes the deeper subsoil layers show a massive, compact structure. Often between heavy textured sediments, thin light or medium textured layers, silt loam or sandy loam can be found. These layers may increase the horizontal permeability of the profile.

These soils always contain considerable quantities of gypsum ranging from 0.2 to 1.5%. The upper subsoil layers contain 25 - 30% lime and the deeper subsoil and substratum 30 - 35%. The soil profile shows numerous humus layers.

These soils have moderate to very poor drainage conditions. The groundwater table is usually found with fluctuation from 0 to 2.5m. The groundwater table level depends mainly on the location of soils and on irrigation intensity. The intensely irrigated soils are mainly water-logged. During fallow seasons the groundwater table falls, sometimes down to 3.5m.

B4(2) : Al-Khasif Series, moderately heavy textured, moderately well to imperfectly drained phase, overlying a medium light textured deeper subsoil

These soils occur in the highest areas within Al-Khasif series. They consist of silty clay loam, sometimes of silty loam. The deeper subsoil and the substratum (below 1.0-1.5m) consist of light textured silt loam or sandy loam with good crumb or very fine angular blocky structure. The groundwater is slightly saline. Its table level occurs at 2.0m with fluctuations from 1.0 to 3.0m. Mottlings are found at 0.5m and gley spots below 1.0m.

These soils belong to the most developed arable land of the investigated area. Barley or wheat is cultivated under fallow system.

B4(3) : Al-Khasif series, moderately heavy textured, imperfectly drained phase

The formation of these soils has been strongly influenced by irrigation. Due to irrigation practices, every year some 5cm layer of alluvial sediments has been deposited. These soils consist of silty clay loam with thin layers of lighter material. The whole profile shows an angular blocky or prismatic structure with occasional deep vertical cracks.

The horizontal permeability of the subsoil is considerably rapid, however a hard layer utterly impermeable is found occasionally. This layer is usually about 2.0m deep. The groundwater table fluctuates from 0.5 to 2.0m. Gley spots occur below 1.0m and mottlings appear below the plow layer.

These soils are occasionally submerged for several months. During inundation they show a tendency to humidification, while during dry season they split and form deep cracks.

B43 : Al-Khasif series, heavy textured, imperfectly drained phase

Although these soils consist of silty clay, owing to numerous thin layers of lighter material they show a moderately rapid horizontal permeability. Heavy textured layers usually show vertical cracks and angular blocky or prismatic structure. Some layers are compact and hard, which restrict to a considerable extend the water permeability.

Mottlings occur below 0.5m. Gley spots appear below 0.5m and become increasingly numerous in lower layers. When these soils are not irrigated and in season of low river water level, groundwater table falls below 2m. Riversely at high river level, it rises to 0.5m. The predominant types of soil salinity are internal and external solonchack. Sabakh soils appear in the lowest areas.

B4(4) : Al-Khasif series, heavy textured, poorly drained phase

These soils occupy areas lower than those of the B43 phase. Their subsoil consists of silty clay overlying a silty clay loam deeper subsoil and substratum. They show coarse angular blocky structure with several deep cracks filled with salt crystals, with gypsum. The soil profile has several hard compact layers of silty clay. Due to numerous impermeable layers the drainage conditions are poor. Groundwater is strongly saline and its table is usually found at shallow depth. Mottlings and numerous decomposed plant residue are found throughout the whole soil profile, and intense gley spots at levels below 0.5m.

3) Silted River and Irrigation Depression Soils

Two types of depressions can be distinguished in the area, that is, irrigation depressions and river depressions.

Irrigation depressions are associated with the development of irrigation systems, having the form of outflowless hollows in the irrigation basins. These depressions have been seasonally inundated by water during floods, but now they are submerged only after periods of heavy rains.

River depressions are associated with the development of deltas. These depressions have a form of prolonged hollows, seasonally submerged and covered with hydrophilous vegetation.

Being situated in the lowest areas, they absorb the excess of irrigation water.

(1) AL-ABITH series: D63, D64

These soils prevail on the irrigation depressions in the lowest areas of the silted basins, having the form of either flat depressions surrounded by somewhat higher river basin or prolonged hollow. They are usually 0.5 to 1.0m lower than the surrounding silted basin surface.

These soils consist of gray, dark gray or dark brown silty clay, silty clay loam with a coarse prismatic or angular blocky structure. In the soil profile numerous white, spheric gypsum or lime concretions as well as black spots of decomposed plant roots can be found. Shells and shell fragments are usually found in the whole soil profile and on the surface.

These soils have a tendency to becoming muddy. After drying-up they show polygonal cracks. In the effect of excessive humidification and desiccation as well as of strong expansion and contraction of the clay minerals contained in the soil, a particular micro-relief is being formed on the surface. This micro-relief, at the initial period of the soil formation, is similar to that of the takhyr-like soils and at later stages it assumes the pattern of the gilgai soils with distinct micro-hollows and micro-elevations.

These soils are almost saturated with water. The groundwater which is strongly saline is usually observed at one meter with fluctuation from 0.5 to 1.0m. The soil profile often shows mottlings from the surface, of which amount increases with depth. Reduction spots usually occur below 50cm. The permeability is generally slow in the upper subsoil and substratum.

Depending on the situation of these soils, and on the groundwater table, these soils are moderately saline in the upper layers and extremely saline in the deeper layers. At extreme soil salinity, the exchangeable sodium percentage is higher than 15%, while pH seldom exceeds 8.0.

D63: Al-Abith series, moderately heavy textured, imperfectly to poorly drained phase

These soils consist of clay loam with a medium prismatic or angular blocky structure subsoil, gradually changing to silt loam in the deeper subsoil and to lighter material in the substratum. The silt loam is in most cases considerably compact, structureless and impermeable.

Groundwater table is observed usually at 1.5m with fluctuations from 0.5 to 2.0m. Mottlings are encountered below 0.5m and gley spots below one meter. Numerous shells, humus and manganese concretions appear below 0.8m and their number rises with increasing depth. In seasons of strong desiccation, these soils split in polygonal fragments.

These soils usually constitute poor seasonal pasture lands or sometimes are sown with barley cultivated in the fallow system. Some areas are strongly saline with sabakh soils.

D64: Al-Abith series, heavy textured, poorly drained phase

These soils usually occupy areas lower than those of the D63 phase. They consist of silty clay with coarse prismatic or angular blocky structure. The soil profile often shows a layer of structureless, compact, impermeable clay. During floods, these soils get sticky and plastic. During the dry season, they get hard and they split in cracks resulting in a characteristic "gilgai relief". Deep and broad gutters becoming seasonal water ducts, can be observed on the surface.

The groundwater table is usually found at 1.0m with fluctuations from 0.5 to 1.5m. Mottlings together with humus and shells occur in the whole soil profile. Gley spots appear below 0.5m. These soils are rarely covered with vegetation. Desert halophytes grow in the cracks between polygons. These soils mainly constitute natural, seasonal pasture.

(2) ABU-JUWATHEL series: D75

These soils prevail in the prolonged meridional depressions situated between the low silted basins. They constitute natural outflow ducts often separated from the Hor by an artificial or natural earth barrier.

In the upper subsoil, they consist of pale brown, brown or dark grayish brown silty clay loam or silty clay, often stratified with thin layers of lighter material. These layers have a granular or crumb structure. They contain, specially in the surface layer, considerable amount of semi-decomposed organic matter.

The upper alluvial layers are deposited on deeper subsoil consisting of brown to dark brown silty clay sediments of the silted Hor. These deeper layers often contain considerable quantities of shells and shell fragments as well as numerous concretions of mucky humus. They show low porosity and are highly gleyish. The structure is very coarse angular blocky or prismatic.

Below the heavier textured layer, there are sometimes light textured layers of loam, silt loam or very fine sandy loam. These soils have a very poor internal drainage. The groundwater level is usually observed at 0.5m with fluctuations from zero to 1.5m. These soils are moderately saline in the whole soil profile. Internal solonchak dominates as the genetic salinity form. These soils are frequently covered with hydrophylous vegetation.

4) Silted Hor Soils

The marshes, locally named the "Hor" constitute vast, shallow depression areas. They are permanently or seasonally waterlogged or submerged under 0.5 to 1.5m deep of water. The marshes are usually covered with abundant hydrophylous vegetation consisting of sedges and Juncus sp. in less wet areas and of reeds, cattails sometimes papyrus in areas permanently submerged. The water submerging in the marshes is fresh as shown in Table 3B-22. The marshes flank the slightly elevated delta plain and the boundary between the delta deposits and the marsh depressions is rather ragged, with the delta arms well advanced into the hors.

During low water levels, the marsh areas become dry with the exception of deep silted depressions, which are submerged throughout the year. In spring, however, at high water level from March to June, the marsh areas become inundated. The constant flooding by waters carring considerable amounts of suspended materials results in intense sedimentation of the marshes. The old marsh bottom is being covered with layer of alluvial deposits by several centimeters every year. In general near the main delta arms the sedimentation process is quicker and the thickness of sediment layers is greater. Considering that the sedimentation plays such an important part in the formation of these areas, they have been given the name of silted Hor.

The soil profile of silted Hor consists of 3 layers.

a) The upper layer of young sediments o.5 to 1.5m thick, consits of silty clay or silty clay loam. The observed colours are dark brown, brown or gray with numerous concretions of decomposed muck, mottings and green or blue gley spots.

b) Thin layey, 2-10cm of decomposed muck with numerous snail shells.

c) Dendritic clayey sediments of the old Hor bottom.

No detailed investigation for the central parts of the silted Hor could be carried out due to their muddy condition.

1) MUMINAH series

These soils occupy the lowest areas in the investigated area of which altitude ranges from 2 to 4m above sea level. Depending on their location in relation to the silted basins, the texture of these soils varies silty clay, silty clay loam or silty loam. Near the silted basins where the sedimentation is most intense, the texture is lighter than that in the central parts of the silted Hor.

Both the subsoil and substratum layers show a weak angular blocky or prismatic structure, in some cases of light textured layers, it is crumb. In general, the compact, heavy layers are structureless and they become sticky and plastic during the floods, while they split into solid blocks in dry seasons when the groundwater table falls below subsoil layers.

Most of these soils are submerged at flood seasons when they play a role of natural water reservoir acquiring the excess water discharged by all the delta arms. The groundwater is slightly saline. Its table level ranges from several centimeters above surface at flood times to 0.5-1.0m below surface during the dry season.

Owing to the excess humidification, these soils show numerous, distinct and large mottlings in the whole soil profile, Gley spots are observed from the surface in wet silted Hor soils, and below 50cm in soils adjacent to the silted basins. There are numerous humus and manganese concretions, as well as thin layers of well decomposed Hor muck. There are abundant quantity of shells and shell fragments which are sometimes spread over the surface.

The more developed silted Hor soils where the hydromorphic processes have not been disturbed by intense sedimentation, show usually a humic dark gray layer with numerous shells. This layer gradually changes into the gleyish subsoil.

The lime content ranges from 25 to 30% in the subsoil and from 30 to 35% in deeper subsoil and in the substratum. The gypsum content averages 0.5 - 1.0%, being the greatest concentration observed in deeper subsoil layers. The higher marshes, situated in the drier areas show considerable capillary water rise resulting in very strong salinization.

H83: Muminah series, heavy textured, low phase

Most of these soils are constantly water-logged and are inundated for several months during the year. In dry season only some areas get desiccated and at that not deeper than 50cm. They consist of weakly stratified silty clay and are gray or grayish brown with numerous muck concretions, mottling and gley spots as well as shells. They are either structureless or have a structure of coarse angular blocky. The surface of these soils is distinctly "gilgai". Owing to bad structure and to poor permeability, these soils show very poor natural drainage conditions.

Groundwater table is generally observed at 0.8m. At flood season the soil surface is submerged under water by several centimeters. In dry season the table falls to one meter below surface. These soils are covered with hydrophylous vegetation consisting of reeds, cattails, high sedges etc.

H84 : Muminah series, various textured, very low phase

They are covered with hydrophylous vegetation. For greater part of the year, these soils are submerged under water, which throughout the year remains at least 0.5m deep.

Although the annual increment of organic matter of the hydrophylous vegetation is considerable, due to the high temperature, the decay of the organic matter is so quick, that no major layer of muck is observed.

In general, the surface layers and upper subsoil are humic, and creating good organo-mineral composition. In the deeper subsoil and in the substratum, mucky humus layers with numerous shells.

These soils have stratified layers of, silty clay or silty clay loam, and the heavier textured layers always predominate in the soil profile. These soils are structureless, sticky and plastic or stronghy compact and hard.

4. Soil Salinity

One of the major constraints in agricultural development involved in the soils of the Project Area is salinity. The water-logging is another constraint in the Area.

The saline soil is called the "Solonchak" in the international soil classification, whose original meaning is the soils containing much salts. The salinity of the upper layers of soils is one of the main factors to limit the growth of crops in the Project Area. In general, lands irrigated for a longer period are strongly affected by salts than lands that have been taken for cultivation later or just recently.

The main source of salinity in the irrigated lands is continuous accumulation of soluble salts brought by the irrigation water, which is called the secondary salinization. Water quality of the Kahlaa river is shown in Table 3B-22 comparing with that of the marshy water. Owing to a small slope gradient and relatively slow groundwater run-off, in many cases, the irrigation water evaporates completely, leaving all soluble salts in soils.

The additional causes of salts accumulation are as follows:

a) Continuous evaporation of water derived from a slow capillary rise of strongly saline groundwater, from the deeper marsh or salty depression layers through overlying younger alluvial deposits to furrow slice.

b) Considerable seepage of river and irrigation water from the river beds and irrigation canals. This results in the accumulation of salts in the surface layers along the respective water ducts.

c) Accumulation of salts in outflowless depressions after evaporation of spring flood water.

In determining the salinity of particular soil unit, it should be realized that the salinization processes in the investigated area directly related to the very complicated water conditions, considerable changes in the groundwater table and to the irrigation practices of a long period. All these processes create considerable variations in the salinity of soil surface layers, in the quantity and distribution of soluble salts in the soil profile as well as in the genetic type of salinity.

In general, most affected soils by salts are those in which the groundwater table for greater part of the year remains above the critical level. To this group would belong some areas of depression soils as well as of low silted basin soils. It should be furthermore included to this group the strongly saline soils situated along the irrigation canals where the high groundwater table is due by seepage from the canals. The latter soils occur in all calssification units.

Considerable areas of saline soils in the Area have been influenced by secondary salinization. The intensely irrigated soils with inadequate internal drainage and/or rapid capillary rise of the salty grounswater. These soils are strongly saline in the whole profile and sabakh soils are the characteristic type of their salinity. In the investigated area, they either form large uniform areas of saline soils or, more often, appear in narrow stripes between the salt free arable lands.

Most of the soils in the Area are slightly saline in the surface layers and in upper subsoil, and are strongly saline in the deeper subsoil and in the substratum. This group comprises first of all the arable soils continuously irrigated in the fallow system.

This group comprises some areas of the intensely irrigated river levee soils and high silted basin soils, which have a good natural runoff and drainage conditions. Here belong also the intensely irrigated soils of the paddy fields, which are leached with large quantities of water and which are continuously submerged in the summer seasons, namely, at the time of most intensive evaporation. After the harvesting of rice and the outflowing of surface water, they have a considerably high groundwater table, but owing to reduced evaporation do not get salinized. The composition of soluble salts in the investigated soils is closely related to their concentration and to the type of salinity.

Soils strongly affected by salts nearly always contain NaCl, with lesser quantities of $MgCl_2$ and $CaCl_2$. Soils slightly affected contain moreover Na_2SO_4, $MgSO_4$ and $CaSO_4 2H_2O$.

The division of saline soils into pedogenetic types is mainly based on differences in salinization processes and in respective morphology of the soil profile. Each type of saline soils has a particular morphology, evident mostly in the distribution of salts in the profile, a particular nature of salts crystals, structure of the surface layers and color. In the investigation area, the several pedogenetic soil salinity types have been distinguished.

These pedogenetic soil types seldom constitute larger uniform areas. Namely they usually form complex of salinity types. In some cases, 2 or 3 different types appear in neighbouring locations in other, the neighboring soils are of transitory nature showing feature particular to different solonchak.

Internal Solonchak Soils

These soils are very slightly saline or salt free in the surface layers or in subsoils, and they are strongly saline in deeper subsoils and in substratum. They are actually cultivated and leached by irrigation. In most cases, they do not constitute uniform area but occur in stripes of land between the more saline soils.

External Solonchak Soils

These soils are slightly or moderately saline throughout the whole profile. On the surface there is always salt efflorescence and sometimes thin salt crusts. They usually consists of NaCl or Na_2SO_4. In cases when these soils are cultivated, the soluble salts content rises with increasing depth of profile. When they are not under cultivation, most of the salt is found in the surface layers.

Flooded Solonchak Soils

These soils are submerged under water during intense rains or during flood season. Owing to a lack of natural outflow, water usually evaporates, leaving salt in the soil and/or on the surface.

Sabakh Soils

These soils are active and wet solonchaks. Their origin is related to the high table level of the saline groundwater and its considerable capillary rise. They occupy the largest areas of strongly saline lands. Considerable amounts of deliquescent salts, that is $CaCl_2$ and $MgCl_2$ are usually found in the surface layers. Owing to considerable amount of hydratation of bivalent cations, the surface of these soils is wet even in dry seasons. The soil surface becomes wet and gets dark brown color. During the day the surface dries up, gets hard and becomes light brown.

Groundwater Salinity

The groundwater in most of the Area is saline. In the investigated area, the groundwater table seems to be above the critical depth. These soils undergo a process of salinization of the surface layers. Only in soils of the paddy fields, actually under cultivation, the groundwater is free from salts.

The most saline groundwater is found in outflowless soils of the basin depressions and in those soils of the silted basins, which are affected with secondary salinization, while the least saline groundwater is to be found in the Hor soils and in the neighboring paddy fields.

The chemical composition of soluble salts in groundwater depends very much on its salinity and or the groundwater level. The groundwater quality is shown in Table 3B-23. Generally in the non-saline groundwater calcium ion predominate over magnesium, and sulphate ion over chloride. Reversely, in saline groundwater, magnesium ions over calcium and of chloride ions over sulphate and found. This predominance rises with increasing groundwater salinity.

Similar interdependence can be observed between sodium and the bivalent cations. This is presented in the form of sodium absorption ratio, SAR.

It could be noted that the main soil forming process is salinization. At present the total area infected with salt to such extent that it becomes out of cultivation amounts to about 6,120 ha which equals to about 75% of the total investigated area. This process is going on, and unless steps are taken to reverse this process, more land will be put out of cultivation as years go by. The composition of soluble salts in the soils is dominated by chloride and sulphate anions while the cations are composed mainly of sodium, calcium and magnesium.

All the soils have a very high lime content of about 20 to 35%, while the gypsum content of the top layer of the soil is very low, namely in most of the cases it is less than 0.2% although in few locations, it reaches as high as 2.0%. The pH value of the soils ranges between 7.5 and 8.0, while the salt content which is expressed in ECe, in the very saline parts reaches as high as 50 mmho/cm and even more. The exchangeable sodium in saline soils is more than 15%.

Soil Salinity Classification

Salinity Class		ECe (m.mhos/cm)	Area (ha)	(%)
Free	S0	0 - 4	2,041*/	25.0
Slightly affected	S1	4 - 8	1,892	23.2
Moderately affected	S2	8 - 16	1,196	14.6
Strongly affected	S3	16 - 25	805	9.9
Very strongly affected	S4	> 25	2,226	27.3
Total			8,160	100.0

Note: */ Including 702 ha of mash and depression areas.

5. Land Classification

The level and techniques of agricultural production in the Area are still primitive and the crop yields are low. This is due not so much to unfavorable soil properties as to primitive farming practices, that is, inadequate mechanical equipment, inadequate weed control, lack of fertilization, suitable crop rotation, etc. In such conditions, it is difficult to estimate the real maximum productivities for particular soils and their suitability for cultivation of respective crops, specially rice.

In one case, higher yields are possible only by introducing modernized farming methods. There is also another case when farmers try to introduce agricultural cultivation into areas of bad natural soil conditions such as silted marsh soils, silted basin depression soils and some heavy soils of silted basins. In these cases in spite of considerable farming efforts, the crop yields are still low. It is, therefore, necessary to distinguish cases of low yields caused by bad soil conditions from cases when low crop yields are due to imperfect farming methods.

Soil suitability for potential agriculture is based on estimates of the complex soil physical properties, upon which the future soil improvement of the area primarily depends. Topographical conditions and the necessity of surface levelling as well as soil properties, permeability of soil and possibility of leaching soluble salts were taken into consideration. It was assumed that the improvement of the whole areas would include the necessary drainage installation, the removal of salt from soils and improve farming management.

The land classification for agricultural use indicates that out of the total investigated area of about 8,160 ha, most of the area would be arable after land reclamation. These areas which are at present out of cultivation, could not be said that they are completely unfit for agriculture, that is, only their temporary unfitness can be spoken. Most of the areas which are out of cultivation is affected by salinity. A considerable portion is subjected at present to inundation when the water level in the Hor rises. A remaining portion is usually rough land with uneven surface which constitute the remains of former settlements or is intersected by a number of irrigation canals beside one another. These canals are bordered by high dikes, which were formed gradually by the sediments excavated from their beds, leave the canals in working condition.

The result of our land classification is summarized as shown below;

Land Classification

Land Class	Area (ha)	Percent (%)
Class 1	0	0.0
2	158	2.0
3	4,647	56.9
4	2,182	26.7
5	1,173	14.4
Total	8,160	100.0

FIGURE 3B-II LOCATION OF TEST PITS AND AUGER HOLES

Scale : 1 : 50,000

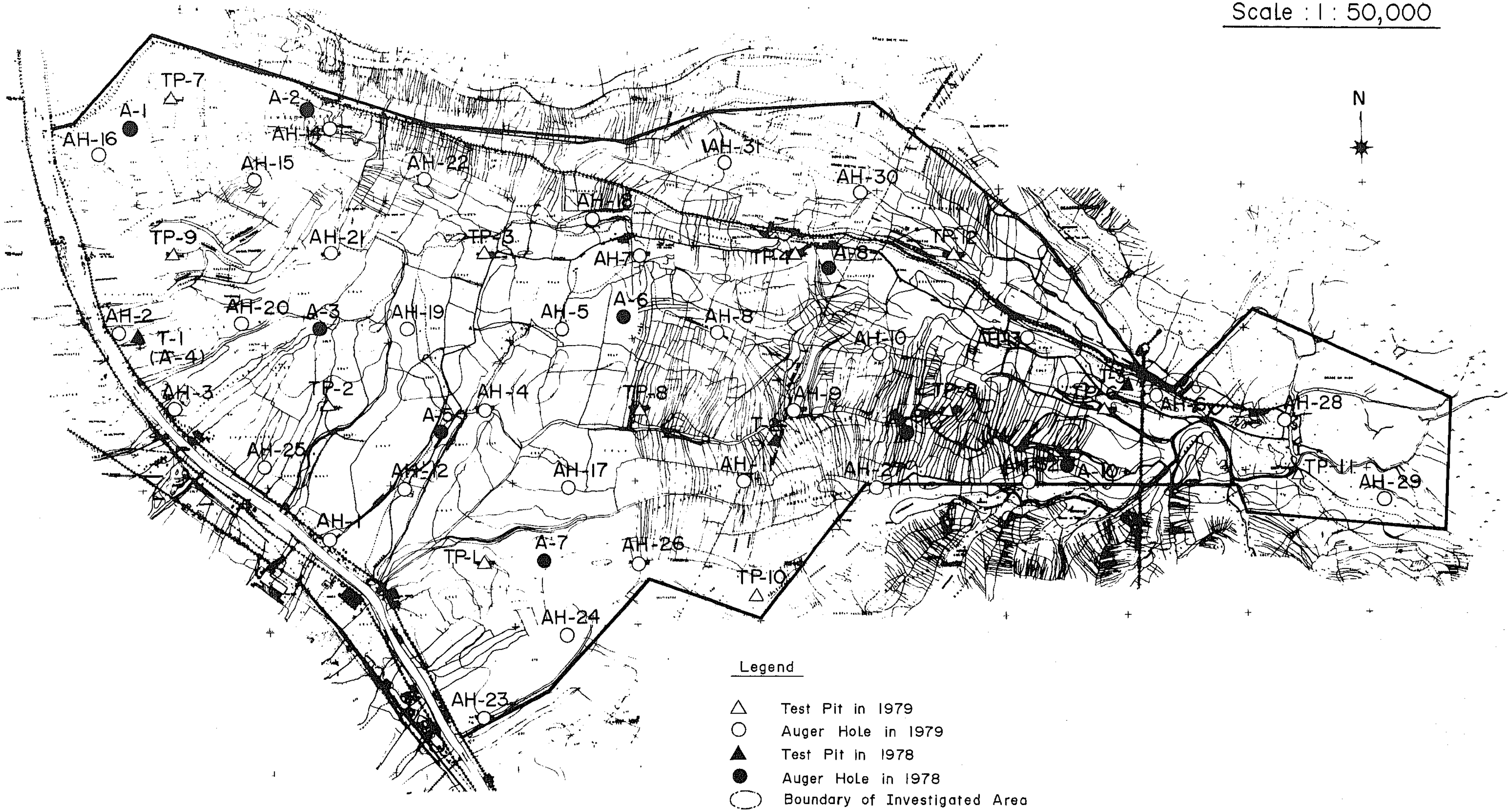
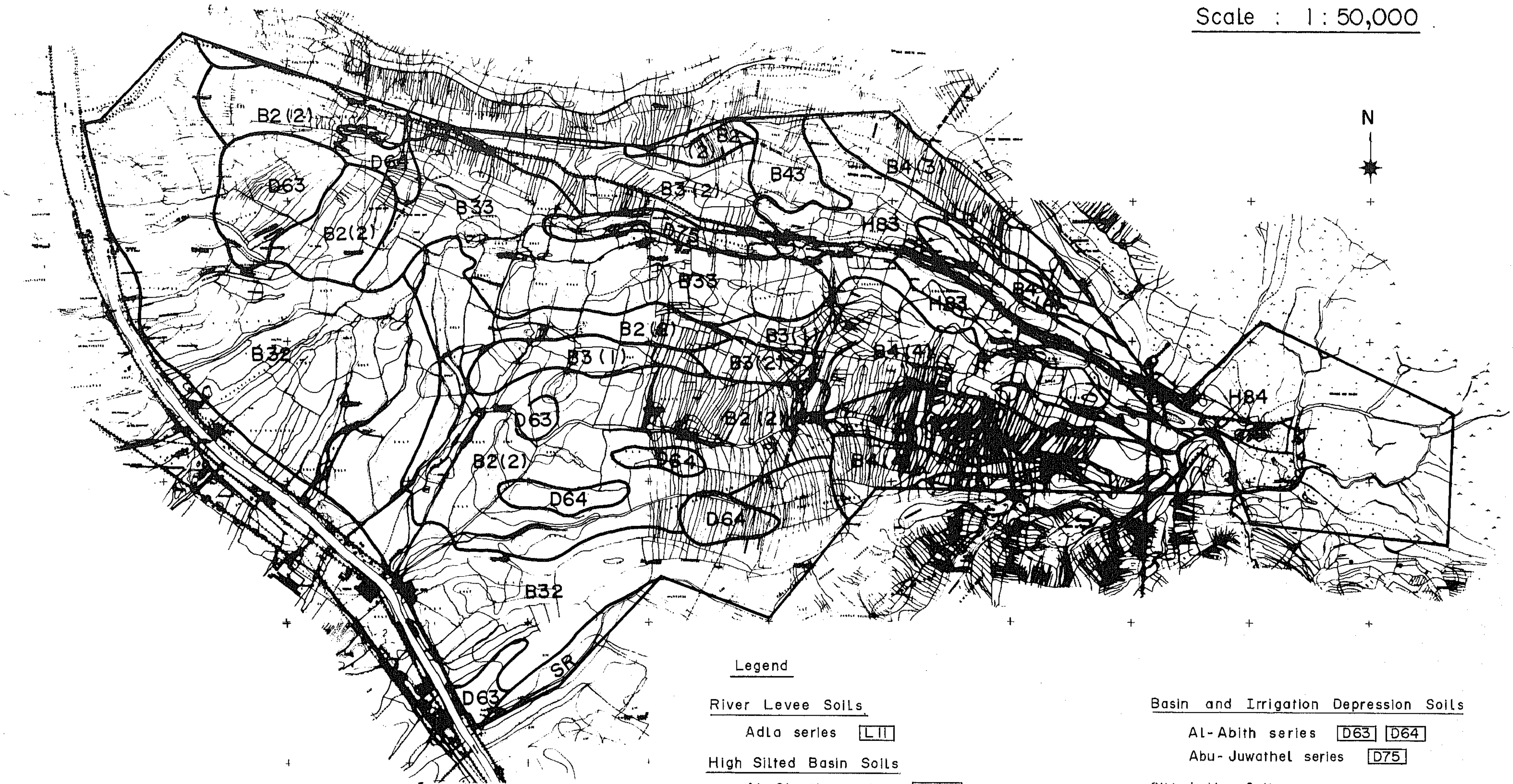


FIGURE 3B-12 SEMI-DETAILED SOIL MAP

Scale : 1 : 50,000



Legend

River Levee Soils

Adla series [L11]

High Silted Basin Soils

Al-Gheriba series [B2(2)]

Amarah series [B32] [B3(1)] [B3(3)] [B3(2)]

Low Silted Basin Soils

Al-Khasif series [B4(2)] [B4(3)] [B43] [B4(4)]

Basin and Irrigation Depression Soils

Al-Abith series [D63] [D64]

Abu-Juwathel series [D75]

Silted Hor Soils

Muminah series [H83] [H84]

Miscellaneous Soils

Argub soils [SR]